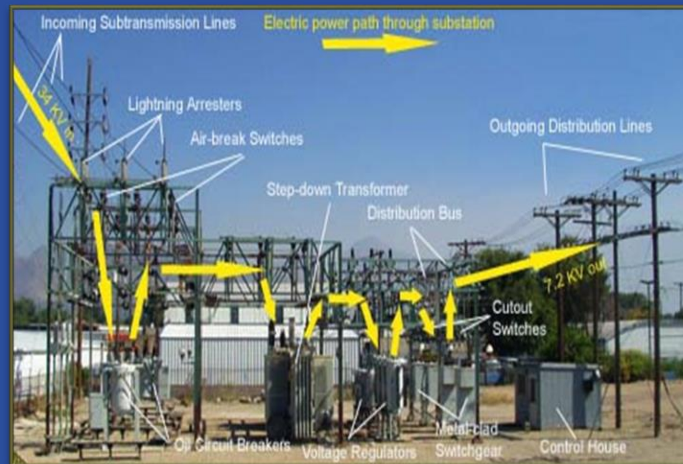
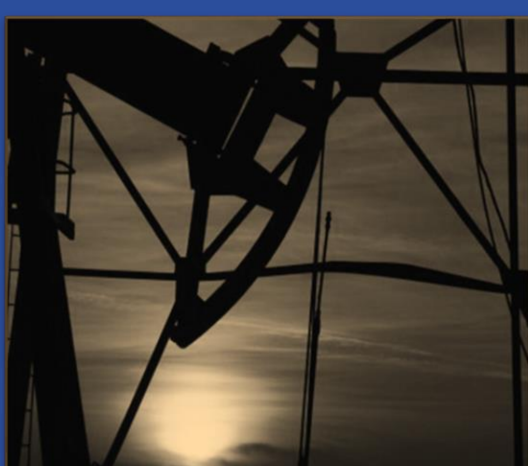
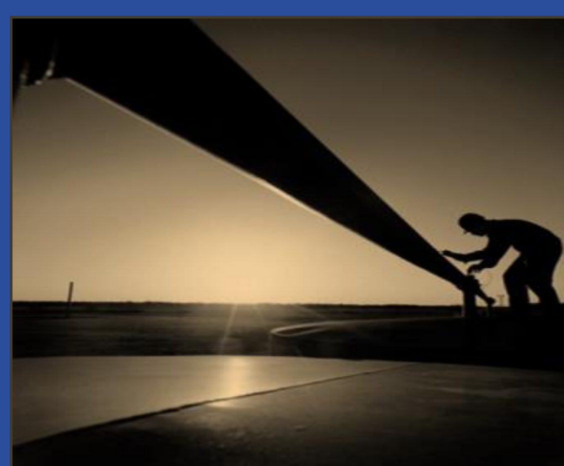


2022

GLOSSARY OF ELECTRIC AND NATURAL GAS INDUSTRY TERMS AND CONCEPTS

Terms and Concepts used by State Regulatory Commissions, the Federal Energy Regulatory Commission, Regional Transmission Organizations / Independent System Operators, the Electric Industry, and the Natural Gas Industry. These include Reliability, Economic, Legal, Accounting, Engineering, Environmental, Statistical, and Financial Terms





INDIANA UTILITY REGULATORY COMMISSION

UPDATED AND REVISED February 2022

Utilities and their customers are separated by the same language.

Paraphrase from George Bernard Shaw – 1877

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CLOTHED WITH A PUBLIC INTEREST

Munn v. Illinois 1877

"We find that when private property is '*affected with `a public interest, it ceases to be juris privati only*.' This was said by Lord Chief Justice Hale more than two hundred years ago, in his treatise De Port ib us Maris . . . and has been accepted without objection as an essential element in the law of property ever since. Property does become *clothed with a public interest* when used in a manner to make it of public consequence, and affect the community at large. When, therefore, one devotes his property to a use in which the public has an interest, he, in effect, grants to the public an interest in that use, and must submit to be controlled by the public for the common good, to the extent of the interest he has thus created. He may withdraw his grant by discontinuing the use; but, so long as he maintains the use, he must submit to the control." Chief Justice Waite writing for the Majority

Acknowledgements:

This glossary was prepared for the Indiana Utility Regulatory Commission to reduce barriers to understanding the engineering, economic, accounting, legal, and regulatory complexities of the electric power industry. This glossary is intended to be a foundation for future updates.

I want to thank my colleagues at the IURC for their assistance and input. In particular, I want to express my appreciation to Dr. Brad Borum, Mr. Jeremy Comeau, and Mr. Bob Veneck for their review and comment. My colleagues at the State Utility Forecasting Group (SUFG) provided several suggestions. I particularly want to thank Dr. Doug Gotham and Dr. David Nderitu. I also want to thank Dr. Dan O'Neill and Mr. Charlie Fijnvandraat for their input regarding the electric distribution system and reliability indices.

Dedicated to my son Daniel Morgan Pauley

Morgan Robert (Bob) Pauley

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Above-the-Line (Accounting) (see also Below-the-Line): Revenue or expenses, incurred by a utility, that the regulatory commission approves for recovery and are included in rates.

Accelerated Deferred Income Tax (ADIT see also EDIT)**:** Under H.R. 1 (a.k.a. "Tax Cuts and Jobs Act)" would require companies, under *Accounting Standards Codification* (ASC- 740 Income Taxes), to recognize the effects of changes in tax laws and rates on deferred tax assets and liabilities and the retroactive effects of changes in tax laws (including the one-time transition tax) in the period in which the new legislation is enacted. Under US *Generally Accepted Accounting Principles* (GAAP), these financial statement effects of changes in tax law are recorded as a discrete item and part of tax expense or benefit in continuing operations, regardless of the category of income or loss to which the deferred taxes relate. Under *International Financial Reporting Standards* (IFRS), the tax effects related to deferred taxes must be backwards traced to the component of income to which they relate.

Accelerated Depreciation: Any method of calculating depreciation charges where the larger expense occurs in the earlier years and charges become progressively smaller each period. Examples are double-declining-balance and sum-of-the-years'-digits methods.

Accrual Accounting (see also Cash-Basis Accounting)**:** A method of recognizing revenues and expenses as goods are sold (or delivered) and as services are rendered; independent of the time when cash is received. Expenses are recognized in the period when the related revenue is recognized, independent of the time when cash is paid out.

Accumulated Deferred Income Tax: Deferred income taxes are those reductions in income taxes resulting from the use of deductions which will not be fully reflected in the determination of book net income until subsequent periods. Most commonly, they arise from accelerated depreciation for tax purposes instead of straight-line or other depreciation.

Accumulated Deferred Investment Tax Credit: Generally, it is the net unamortized balance of investment tax credits (ITC) spread over the average useful life of a specific property or equipment. However, the ITCs could be spread over a shorter period. This balance sheet account is built up by charges against income in the years in which such credits are realized and is reduced subsequently through credits to income.

Accumulated Depreciation (Depreciation Reserve): Amount of plant depreciation, used and accumulated to date. Accumulated Depreciation is deducted from total plant (investment) to arrive at the water company's rate base.

ACE (Area Control Error): The instantaneous difference between net actual and scheduled interchange, taking into account the effects of frequency bias including a correction for meter error.

Achievable Potential: The portion of technical potential expected to be realized over the planning horizon considering the non-financial barriers, (e.g., lack of knowledge, renter vs. owner, product availability) that may prevent consumers from adopting energy efficiency measures and practices. It is an estimate of the amount of savings within a specified time frame under the assumption that all available mechanisms (e.g., utility programs, codes, standards and market transformation) are deployed. (LBL)

Acid Gas Removal (AGR): Acid gases produced in gasification processes mainly consist of hydrogen sulfide (H_2S), carbonyl sulfide (COS), and carbon dioxide (CO_2). Syngas exiting the particulate removal and gas conditioning systems, typically near ambient temperature at 100°F, needs to be cleaned of the sulfur-bearing acid gases to meet either environmental emissions regulations, or to protect downstream catalysts for chemical processing applications. For integrated gasification combined cycle generating units (IGCC) applications, environmental regulations require that the sulfur content of the product syngas be reduced to less than 30 parts per million by volume (ppmv) in order to meet the stack gas emission target of less than 4 ppmv sulfur dioxide (SO_2). In IGCC applications, where selective catalytic reduction (SCR) is required to lower NOx emissions to less than 10 ppmv, syngas sulfur content may have to be lowered to 10 to 20 ppmv in order to prevent ammonium bisulfate fouling of the heat recovery steam generator's (HRSG) cold end tubes. For fuels or chemical production, the downstream synthesis catalyst sulfur tolerance dictates the sulfur removal level, which can be less than 0.1 ppmv. Conventional processes for removing acid gases typically involve their countercurrent absorption from the syngas using a regenerative solvent in an absorber column. This process approach of gas-liquid contacting to remove acid gases is very commonly used in a wide range of process industries, including refining, chemicals, and natural gas production. However, because of the significantly different required degrees of acid gas removal that depend on the application, the choice of solvents varies significantly. National Energy Technology Laboratory (NETL)

Acid Rain: In the early 1970s, northeastern states became concerned about acid rain that they attributed to power plants primarily located in the Midwest. In 1989, Congress passed amendments to the Clean Air Act. Title IV established the Acid Rain Program and a *Cap and Trade* system to reduce emissions of sulfer dioxide and nitrogen oxides. Phase 1 begin in 1995. The occurrence of acid rain was attributed to high levels of sulfur dioxide (SO_2) being emitted from mostly coal-fired electric generating plants across the Midwest and, when mixed with water, creating *sulfuric acid* (H_2SO_4 - smells like rotten eggs). Beginning in 2000, the sources were capped at 9.5 million tons of SO_2 (compared to 1980 emission levels of 17.3 million tons) and the plants were held responsible for lowering their levels to those standards from 1995 until 2000. The EPA then issued each plant a certain number of credits, or allowances equal to one ton of SO_2 emissions. At the end of every year, each plant would have to report to the EPA whether or not they had enough credits for their emissions, (i.e. a plant that emitted 6,000 tons of SO_2 would need to hold 6,000 credits). Those under the CAP could save their excess credits for the future, or sell them to other plants that were in danger of going over their limit. This trading aspect gave the electric plants financial incentives to lower their emissions because each credit held a monetary value on the free market. If a plant exceeded their limit and was unable to purchase or trade for other credits, they would have to pay a fine to the EPA for each additional ton of SO_2 emitted into the atmosphere. The Acid Rain Program lowered the annual SO_2 emissions from 17.3 million tons in 1980 to an estimated 8.95 million tons in 2010.

Acquisition Premium: An Acquisition premium is the difference between the estimated real value of a company and the actual price paid to obtain it. Acquisition premium represents the increased cost of buying a target company during a merger and acquisition. For good public policy, commissions may determine that it is not appropriate to allow recovery of an acquisition premium; particularly if the net benefits are very low or negative.

Activated carbon injection is *powdered activated carbon* (PAC) which is pneumatically injected from a storage silo into the flue gas ductwork of a power plant or industrial facility. The powdered activated carbon adsorbs the vaporized mercury in flue gases the PAC is then collected (along with fly ash) in the plant's particulate collection system. Activated carbon/*dry sorbent injection* systems are among the most powerful and cost-efficient mercury abatement methods for treating coal-fired boiler flue gas in power plants and cement kilns. Dry sorbent injection has been proven effective in a variety of applications, and, when properly calibrated, can provide mercury abatement up to 90% or better.

Actual Load: Electric distribution company's (EDC) total load in their EDC Zone.

Ad Valorem Tax: A state or local tax based on the assessed value of the real or personal property.

Adaptive Generation Resources (AGR): AGRs are technologies that convert mechanical work to electric energy to facilitate the integration of intermittent resources (or Variable Energy Resources) into the bulk power market for voltage regulation, grid stabilization, and load balancing. These technologies may also be useful in distribution systems to achieve similar benefits.

Adequacy (Electric): The ability of the electric system to supply the aggregate electrical demand and energy requirements of the end-use customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements. (NERC definition). This is used for ***Resource Adequacy*** and along with System Security comprises "Reliability." A Planning Reserve Margin is the primary measure of long-term Resource Adequacy.

Adjacent Balancing Authority: A balancing authority that is interconnected to another Balancing Authority Area either directly or via a multi-party agreement or transmission tariff.

Adjusted R^2 (Statistics): Adjusted R^2 is a modification of R^2 that adjusts for the number of explanatory terms in a model. Unlike R^2 (general *goodness of fit),* the adjusted R^2 increases only if the new term improves the model more than would be expected by chance. The adjusted R^2 can be negative, and will always be less than or equal to R^2. Adjusted R^2 does not have the same interpretation as R^2. As such, care must be taken in interpreting and reporting this statistic. Adjusted R^2 is particularly useful in the Feature selection stage of model building. Adjusted R^2 is not always better than R^2: adjusted R^2 will be more useful only if the R^2 is calculated based on a sample, not the entire population. For example, if our unit of analysis is a state, and we have data for all counties, then adjusted R^2 will not yield any more useful information than R^2.

Adjusted Net Interchange (ANI): The difference between a market participant's resources and liabilities at a location, measured in megawatt-hours. Resources include generation entitlements, cleared increment offers, external purchases of electric energy, and internal bilateral purchases for electric energy. Liabilities include load obligation, cleared decrement bids, external sales of electric energy, and internal bilateral sales for electric energy.

Adjustment Bid: A bid auction conducted by the RTO / ISO to redirect power flows when congestion is anticipated.

Advanced Asset Management (AAM): AAM is intended to enhance the utilization of transmission and distribution (T&D) assets and more effectively managing these assets' life cycle. AAM requires "smart sensors" to provide operational and asset condition information to significantly improve asset management. The *Energy Independence and Security Act* (EISA) of 2007, the National Institute of Standards and Technology (NIST) has "primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems…" In April of 2009, NIST announced a Three-Phase Plan for Smart Grid Standards. Effective interoperability is built upon a unifying framework of interfaces, protocols, and consensus standards. The newest release, (Smart Grid Interoperability Standards Framework, Release 2.0) was issued in October, 2011.

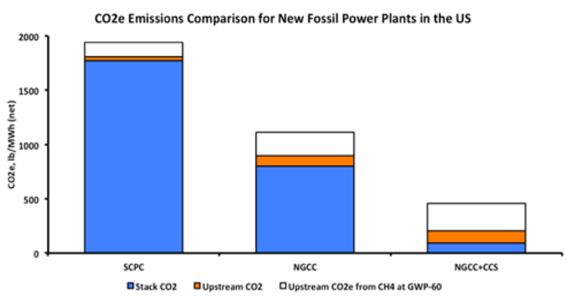
Advanced Distribution Management System (ADMS)**:** An integrated system that includes Geospatial Information System (GIS), Outage Maintenance System (OMS), Supervisory Control and Data Acquisition (SCADA), and CIS. ADMS can be used to support Volt Var Optimization (VVO), Conservation Voltage Reduction (CVR), 3 phase unbalanced power flow analysis, manage distribution system automated switching, fault location, isolation, and service restoration (FLISR), CVR. Estimates of 2% – 3% reduction in customer use are possible.

Advanced Distribution Operations (ADO): ADO uses Advanced Metering Infrastructure (AMI) communications to collect distribution information and improve operations. ADO includes sensors, distributed intelligence, outage management capability, and distribution automation technologies.

Advanced Generation: Advanced utility-scale power generation technologies are being developed that have the potential to nearly double the energy conversion efficiencies of existing coal, oil and natural gas power generating plants to 60% (from the current average efficiency of around 35%) by using waste heat that is currently exhausted to the atmosphere to operate a secondary power generation loop. Another advantage this technological advancement offers allows heavy metals and other pollutants to be captured more easily in the stack, since the final exhaust heat is much cooler.

Advanced Generation Natural Gas Combined Cycle (AG-NGCC): The most recent (in-service dates after 2016) AGNGCC are designed to have faster ramping capability to better match the load shape without negatively affecting turbine life expectancy. These units have an oversized compressor that adds generation in excess of the baseload power, even when ambient temperatures are high. Significant amounts of power can be quickly ramped up and down when renewable generating sources are cycling. The response time is enhanced because the bottoming cycle is already warm and the steam turbine will automatically follow the gas turbine. The result is a quick-responding gas turbine that then produces a fast-responding combined cycle. The plants will be able to generate power within 10 minutes of startup and reach full combined cycle output within an hour. The "Stonewall Energy Center" in Virginia (2017) is a 778 MW advanced natural gas generating facility with an estimated cost of $800 million, about a 30 month construction schedule, and will employ about 30 employees.

Advanced Generation Natural Gas Combined Cycle with Carbon Capture & Sequestration (AG-NGCC/CCS or CCUS): Natural gas combined cycle units with *carbon capture, utilization and sequestration or storage* (CCUS), may use 1: *Post-Combustion Capture technology* (PCC) or 2) Oxy-combustion (a natural gas oxy-combustion system separates oxygen from nitrogen prior to the combustion process. Oxy-combustion units combust natural gas with a mixture of oxygen and recycled CO_2, which results in a flue gas that is primarily CO_2 and water. Oxy-combustion R&D challenges include higher flame temperatures than experienced when using air during combustion). By way of context, emissions from natural gas power systems have a higher oxygen content and lower CO_2 content relative to coal-based systems. This lower CO_2 content requires a larger solvent-based absorber and demands more energy and surface area for a membrane-based capture system. According to the not-for-profit Clean Coal Task Force, using carbon capture and sequestration technology, a natural gas power plant would emit only about 5 percent of the carbon dioxide of a new conventional coal power plant without CCS. In August 2016, the Energy Information Administration (EIA) reported that, for the first time since 1972, U.S. energy-related carbon dioxide (CO_2) emissions from all uses of natural gas exceeded those from coal. This change in emissions sources was due to increases in natural gas consumption and decreases in coal consumption in the past decade. In addition to natural gas-fired power plants and natural gas used for heating, natural gas is also consumed in the industrial sector. Major industrial sources of CO_2 emissions in the US include natural gas processing, refineries, metals and cement production and lime manufacturing. Advanced CO_2 capture technologies are being developed by DOE that can be directly applied to natural gas power plants.



Advanced Grid Integration: Fosters the deployment of smart grid systems and technologies to enhance the reliability, efficiency, and security of the electric power grid. Since 2009, under the American Recovery and Reinvestment Act of 2009 (ARRA), DOE and the electricity industry have jointly invested over $7.9 billion in 99 cost-shared Smart Grid Investment Grant (SGIG) projects involving more than 200 participating electric utilities and other organizations to modernize the electric grid, strengthen cyber-security, improve interoperability, and collect an unprecedented level of data on smart grid operations.

Advanced Load Forecasting: With advancements in computing capabilities, Advanced Metering Infrastructure, and Smart Grid it becomes increasingly possible to integrate very discrete load data (e.g., 1 to 5 minutes) into load forecasts, Energy Efficiency, Demand Response, Distributed Energy Resources, planning analysis, and rate designs that are more accurate, efficient, and less controversial into traditional forecasting methods. This discrete customer usage data (especially if accompanied by quality information about end-uses / appliances and demographic information) should facilitate more accurate Evaluation, Measurement, and Verification (EM&V) of Energy Efficiency and Demand Response. Additionally, with increased penetration of Distributed Energy Resources and the potential for more electrification of cars and transportation, this discrete data can be used to develop more accurate load shapes that can facilitate more credible assessments of potential ramifications. Advanced load forecasting may also make more extensive use of probabilistic analysis to provide additional insights than those provided traditional scenario analysis. To be clear, probabilistic analysis is regarded as another tool but not a replacement for scenario-based analysis.

Advanced Materials and Superconductors: Additional research and testing is ongoing into improvements in throughput of electricity over existing transmission corridors by using advanced composite materials for new overhead conductors and high-temperature ***superconducting cables***.

Superconducting cables are cooled cryogenically to remove the resistance to the flow of electricity, cutting down on the losses that typically occur during transmission. Superconducting fault current limiters (FCLs) can dissipate a surge of current on utility distribution and transmission networks. Under normal circumstances, these FCLs are invisible to the system, having nearly zero resistance to the steady-state current; however, when there is an excess of electricity, the FCL intervenes and dissipates the surge, thus protecting the other transmission equipment on the line.

Research and testing is also ongoing in developing a high-strength, high-temperature overhead conductor. One example is aluminum conductor composite reinforced, which can increase the current-carrying capacity of a transmission line by 1.5 to 3 times over that of conventional conductors, without the need for tower modification or re-permitting.

Advanced Process Control (APC): Advanced process control refers generally to large-scale computer systems used to monitor and control processing plants such as oil refineries. APC systems is used to optimize operations while maintaining the necessary reliability and safety.

Advanced Pulverized Coal: Advanced pulverized coal combustion systems are being studied to produce a more compact, high-intensity combustion of coal that will reduce capital costs of the boiler and increase boiler efficiency. Two methods have emerged that may improve boiler efficiency: oxygen enrichment of air and firing coal in a mixture of oxygen and recycled flue gas (O_2-recycle combustion). Both methods receive elevated concentrations of oxygen in the main combustion zone, which leads to at least partial char combustion in regions of high O_2. In addition, the O_2-recycle combustion method entails combustion in a gas mixture dominated by carbon dioxide (CO_2), rather than nitrogen (N_2). See work done by the U.S. Department of Energy- Office of Fossil Energy, National Energy Technology Laboratory (NETL). Previous work on Advanced Pulverized Coal Combustion by NETL included pilot programs of Low Emission Boiler System (LEBS), a highly advanced pulverized coal-fired power plant, and High Performance Power Systems (HIPPS), highly efficient systems based on the indirectly fired combined cycle. Lawrence A. Ruth "Advanced Coal-Based Power and Environmental Systems" '98 Conference Morgantown, WV July 21-23, 1998.

Advanced Reactor Concepts (ARC): program supports the research of advanced reactor subsystems and addresses long-term technical barriers for the development of advanced nuclear fission energy systems utilizing coolants such as liquid metal, fluoride salt, or gas. Most of the six systems employ a closed fuel cycle to maximize the resource base and minimize high-level wastes to be sent to a repository. Three of the six are *fast neutron reactors* (FNR) and one can be built as a fast reactor, one is described as epithermal, and only two operate with slow neutrons like today's plants. Only one is cooled by light water, two are helium-cooled and the others have lead-bismuth, sodium or fluoride salt coolant. The latter three operate at low pressure, with significant safety advantage. The last has the uranium fuel dissolved in the circulating coolant. Temperatures range from 510°C to 1000°C, compared with less than 330°C for today's light water reactors, and this means that four of them can be used for thermochemical hydrogen production.

Advanced Small and Modular Reactors (aSMR)**:** aSMRs are designed from advance concepts using non-LWR coolants such as liquid metal, helium or liquid salt, may offer added functionality and affordability. This program element will support laboratory, university, and industry projects to conduct R&D on capabilities and technologies that are unique and support development of advanced SMR concepts for use in the mid- to long-term.

Advanced System Monitoring, Visualization, and Control (Including Phasor Measuring Units - PMUs and Synchrophasors): Research and development is ongoing into tools to improve advanced system monitoring, visualization, control, and operations to ease congestion and provide a greater degree of security. These systems will enable grid operators to react swiftly before a local disturbance can cascade into a larger problem, using sensors for measuring system conditions and computerized monitoring equipment that enables system operators to "see" the grid in real time and make necessary adjustments.

In particular, ***synchrophasor*** technology is expected to offer automated controls for transmission and demand response as well as great benefits for integrating renewable and intermittent resources, increasing transmission system throughput, and improving system modeling and planning. Synchrophasors are precise electrical grid measurements of values such as voltage or power that are available from monitors called ***phasor measurement units (PMUs)***. These measurements are taken at high speed (30 observations per second), and each measurement is time-stamped according to a common time reference.

Time stamping allows synchrophasors from different areas to be time-aligned and combined together, providing a detailed and internally consistent operational picture of the entire interconnection. This picture can help grid operators detect disturbances that would have been impossible to see with older SCADA systems, which typically collect one measurement every 2-4 seconds.

Advanced Transmission Operations (ATO): ATO is intended to improve transmission reliability and efficiency, while managing congestion on the transmission system. ATO includes substation automation, advanced protection and control, modeling, simulation and visualization tools, advanced grid control devices (e.g., “flexible AC transmission systems” or FACTS) and materials, (such as superconductors) and their integration with distributed generation markets. (wind, solar, hybrids, storage, etc.).

Adverse Opinion: An auditor's report stating that the company’s financial statements are not appropriate or are not in consistent with Generally Accepted Accounting Principles (GAAP).

Adverse Reliability Impact: The effect of an event that results in frequency-related instability; unplanned tripping of load or generation; or uncontrolled separation or cascading outages that affects a widespread area of the interconnection.

Adverse System Impact: According to the FERC, this mean negative effects due to technical or operational limits on conductors or equipment being exceeded that may compromise the safety and reliability of the electric system.

Affiliate: An entity directly or indirectly owned, operated, or controlled by another entity.

Affiliate Rules: The basic public policy issue is how to develop affiliate rules that balance the expected benefits and costs of separating regulated utilities from their unregulated affiliates and, in some instances, from regulated affiliates in other jurisdictions. Because there is a strong likelihood that a utility, left to its own judgment, will favor its affiliates where these affiliates are providing services in competition with other, non-affiliated entities, there is a potential for anticompetitive behavior. Similarly, there is a strong incentive for regulated utilities or their holding companies to subsidize their competitive activity with revenues or intangible benefits derived from their regulated monopoly businesses.

The potential benefits to consumers from preventing discriminatory transactions and cross-subsidization between regulated distribution utilities and their unregulated affiliates can take several forms. First, discrimination and cross-subsidization may artificially increase the costs of the regulated utility as costs incurred for the benefit of the affiliate are shifted to the regulated firm. Under a rate-of-return regulatory regime, higher costs will result in increased prices in the regulated market. Second, such conduct may increase costs in unregulated markets by displacing innovative, lower-cost suppliers and entrants with a higher-cost affiliate of the local regulated distribution utility. Third, this displacement also may eliminate or reduce the process and product innovations that the displaced firms would have provided to consumers.

The aforementioned concerns should be balanced against the potential for customers to be deprived of lost economies of vertical integration. Additionally, participation by affiliates may increase competition in relevant markets; particularly in incipient markets where the technology is being developed and penetration of the technology is limited.

For competition to take hold quickly and effectively, it may be particularly important to dispel potential entrants' perceptions that the utility affiliate will disadvantage new competitors. As a result, commissions to advance good public policy may require rules to ensure affiliates operate independently in fact and perception. Among other things, utilities should be required to engage in competitive and arms-length bidding for services to ensure utility purchases do not favor their affiliates. (See also Codes of Conduct and Standards of Conduct).

AFUDC (Allowance for Funds used During Construction): An amount recorded by a company to represent the cost of those funds used to finance construction work in progress.

Aggregate Demand: In macroeconomics, aggregate demand (AD) or domestic final demand (DFD) is the total demand for final goods and services in an economy at a given time. AD specifies the amounts of goods and services that will be purchased at all possible price levels (a demand curve). This is the demand for the *gross domestic product* of a country. It is often called *effective demand*. An aggregate demand curve is the sum of individual demand curves for all sectors of the economy. The aggregate demand is usually described as a linear sum of four separable demand sources: AD=C+I+G+(X-M) where: C = consumer spending, I = investment, G = government spending, and Net Exports = Exports (X) – imports (M).

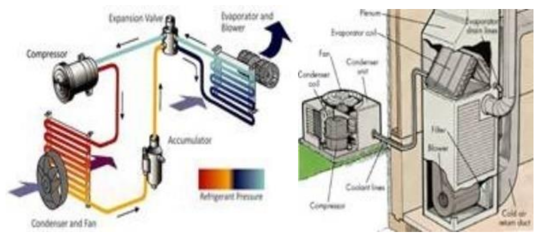
Aggregator: Any marketer, broker, public agency, city, county, or special district that combines the loads of multiple end-use customers in negotiating the purchase of electricity, the transmission of electricity, and other related services for these customers.

Aggregators of Retail Customers (ARCs): ARCs are established to obtain greater participation from customers capable of providing demand response. ARCs allow for the aggregation of resources over relatively large areas, reducing costs and increasing the economic incentive for potential Market Participants. FERC approval of MISO's October 2009 filing on the incorporation of ARCs into the markets allows for ARC participation as sanctioned by each individual state.

Air Conditioners (AC): central air conditioners, heat pumps, residential room AC, and a variety of AC options for large buildings.

Central air conditioners (AC) Circulate cool air through a system of supply and return ducts and registers. As the cooled air becomes warmer due to circulation though the home or business, it flows back to the central AC through return ducts and registers. Air conditioners help dehumidify the home or business. A central AC is either a split system or a package unit. In a split system, the central AC has an outdoor cabinet that contains the *condenser* (cools refrigerant to cause it to change from a gas to a liquid and removes the thermal energy from the system) *and compressor* (uses electric power to increase the pressure of the refrigerant) and an indoor cabinet contains the *evaporator* (cooling coils heats refrigerant and cools air, refrigerant changes back to gas and adds thermal energy to the system). The indoor cabinet may also contain a furnace or the indoor part of a heat pump. A packaged central AC the evaporator, condenser , and compressor are all located in one cabinet (usually on a roof). Packaged AC units often have heading coils or a natural gas furnace which eliminates the need for a separate furnace indoors. Effective January 2015, air conditioners (standard for split systems) will have a *Seasonal Energy Efficiency Rating* (SEER) of 14 or above. Also beginning in 2015, central AC units installed in the Southwest (CA, AZ, NM, and NV) will also have to meet the new Energy Efficiency Ratio (EER) standard that varies by cooling capacity.

Heating, Ventilating, and Air Conditioning (HVAC) for large buildings are more complex and varied in engineering. The air conditioning component includes cooling, heating, dehumidification, and humidification. Ventilation includes filtration of recirculated air and exhaust of undesirable air (e.g., toilets, kitchen, laboratories). The two primary types of cooling use either refrigerant (similar to a car AC, the refrigerant evaporates and condenses continuously within a cycle. Since refrigerant has a low boiling point, it makes it ideal for HVAC systems) or *evaporative cooling*. In addition to rooftop A/C systems, large buildings may employ gas fired chillers, centrifugal chillers, reciprocating chillers, screw chillers, scroll chillers, gas fired engine-driven rooftop AC.



Air Conditioning Intensity: The ratio of air-conditioning consumption or expenditures to square footage of cooled floor space and cooling degree-days (base 65 degrees F). This intensity provides a way of comparing different types of housing units and households by controlling for differences in housing unit size and weather conditions. The square footage of cooled floor space is equal to the product of the total square footage times the ratio of the number of rooms that could be cooled to the total number of rooms. If the entire housing unit is cooled, the cooled floor space is the same as the total floor space. The ratio is calculated on a weighted, aggregate basis according to this formula: Air-Conditioning Intensity = Btu for Air Conditioning/(Cooled SquareFeet * Cooling Degree-Days) - FERC definition

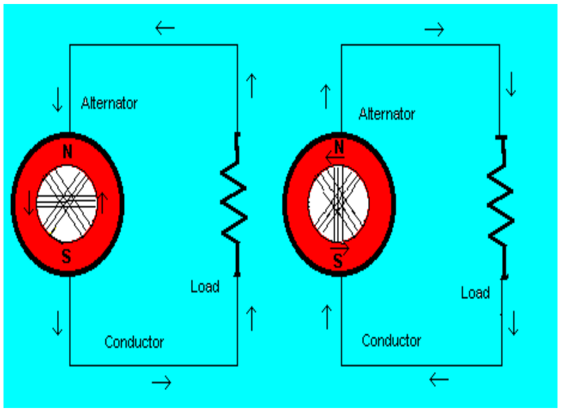
Air Separation Unit (ASU): Air separation plants are used to supply oxygen for coal gasification generating units (also for metals production). Separation of atmospheric air into its primary components; typically nitrogen and oxygen. Sometimes argon and other rare inert gases also are separated. The most common method for air separation is fractional distillation. Cryogenic air separation units (ASUs) are built to provide nitrogen or oxygen and often co-produce argon. Other methods such as membrane, pressure swing adsorption (PSA) and vacuum pressure swing adsorption (VPSA), are commercially used to separate a single component from ordinary air. High purity oxygen, nitrogen, and argon used for semiconductor device fabrication requires cryogenic distillation. Similarly, the only viable sources of the rare gases neon, krypton, and xenon is the distillation of air using at least two distillation columns.

Allocation: (Cost-of-Service term - see also Classification, Functionalization, and Revenue Requirement): For an electric utility, allocation is the assignment of the functionalized and classified costs to specific customers or classes of customers so that the total cost recovered from all customers equals the utility's revenue requirement. Allocation may be based on *coincident peak(s)- CP* or *non-coincident peak – NCP.* The allocation methods could include, by way of examples, a One CP (based on the customer's contribution to the electric utility's maximum peak demand during the year. The rationale for a 1 CP allocation is that the utility plans its resources – including adequate reserves – to meet the maximum peak demand and customers should pay their fair share of that cost. At the other end of the spectrum, a 12 CP (meaning the customer is assigned costs for their contribution to the electric utility's monthly coincident peak for the entire year. A local distribution natural gas utility will have a similar allocation function to assign costs associated with the commodity and customer costs to each type of customer. Industrial customers typically are not subject to retail rates of a local distribution gas company.

Alpha Hypothesis Test or *Significance Level* (Statistics – see also T-Value, P-Value, Null Hypothesis, and Confidence Interval): The alpha level is the probability of rejecting the ***null hypothesis*** when the null hypothesis is true. *That is, it is the probability of making a wrong decision*. Typically, most studies set a alpha level at .005 or .010. If more precision is required, a lower alpha value is required. As with all probabilities, alpha ranges from 0 probability to 1 (certainty).

Alternating Current (AC): A flow of electricity that is uncontrollable as to direction and amount.

AC stands for Alternating Current. Notice that as the wires in the center of the generator rotate past the North and South poles of the (red) magnet, the direction in which the electrons flow in the circuit reverses. This "alternation" happens many times each second. The "frequency" of this change is measured in cycles per second or "Hertz."



Alternative-Fuel Vehicle (AFV): A vehicle designed to operate on an alternative fuel (e.g., compressed natural gas, methane blend, electricity). The vehicle could be either a dedicated vehicle designed to operate exclusively on alternative fuel or a non-dedicated vehicle designed to operate on alternative fuel and/or a traditional fuel.

Ambient Adjusted Ratings (AAR – see Dynamic Line Ratings): AAR is a means of altering transmission ratings affected by ambient air temperatures which, in turn, affect power flows and the resulting price and reliability. PJM and ERCOT frequently adjust the AAR to better reflect the transmission capability. The development of Dynamic Line Ratings and Real Time Thermal Ratings are being considered as alternatives to automatically reconfigure the power flow to reduce congestion and improve reliabilty.

American National Standards Institute (ANSI): A private, non-profit organization that administers and coordinates the U.S. voluntary standardization and conformity assessment system.

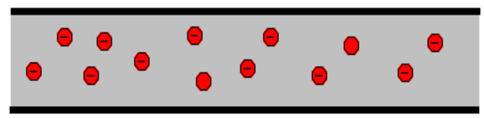
AMI (Advanced Metering Infrastructure): A term denoting electricity meters that measure and record usage data at a minimum, in hourly intervals, and provides usage data to both consumers and energy companies at least once daily.

AMI Communication Technologies: Broad-band over Power Line (BPL), Power Line Communications (PLC), Fixed Radio Frequency (RF) networks, and public networks (e.g., landline, cellular, paging) The meter data are received by the AMI host system and sent to the Meter Data Management System (MDMS) that manages data storage and analysis to provide the information in useful form to the utility. AMI enables two-way communications, so communication from the utility to the meter could also take place.

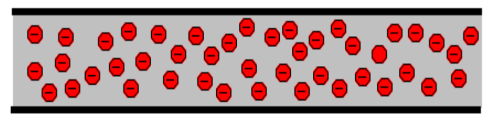
Amortization: Perhaps most often used as a statement of the reduction in some loan or liability (e.g., a mortgage). In utility accounting, it refers to the process of allocating acquisition cost of assets to either the periods of benefit as expenses or to inventory accounts as product costs. Called depreciation for plant assets and amortization for intangibles.

Ampacity Studies: This analysis calculates the maximum current-carrying capacity of a conductor. The ampacity of a conductor is affected by ambient temperature; therefore, ampacity ratings under different temperatures are usually given and used by Electric Distribution Planning (EDP) engineers when designing feeders and line sections. Overhead lines may sag when overheated, creating safety and operational problems, especially if they have a possibility of coming in contact with vegetation or structures. Underground lines may be damaged if overheated and will face premature failure. Conductors of sufficient size should always be used when designing a feeder in order to prevent the lines from overheating. The current through each line in a feeder can be calculated and compared with the rating of the line. If a line is overloaded on a continuous basis, damage may occur, and replacement of the line by one with a larger rating will be considered or switching operations may be used to move loads to adjacent feeders. Overhead line ampacities usually come from tables provided by the conductor vendor, and may be adjusted by the utility for local climate conditions. The ampacities of power cables in underground installations are more limiting and more difficult to calculate than for overhead line conductors, due to the effects of ductwork and soil properties. Source: Grid Modernization Laboratory Consortium, U.S. Department of Energy

Amps or Ampere: An Amp is a measure of the amount of current flowing in a circuit. The more current flowing, the higher the amps. More technically, an AMP is proportional to the quantity of electrons flowing through a conductor past a given point in one second (one amp is produced by an electric force of 1 volt acting across a resistance of 1 ohm, or one coulomb passing in one second).



Few Electrons Flowing = Low Amps



Many Electrons Flowing = High Amps

AMR (Automated Meter Reading): A term denoting electricity meters that collect data for billing purposes only and transmit this data one way, usually from the customer to the distribution utility. (EIA)

Anaerobic Decomposition (see also Biomass): Decomposition in the absence of oxygen, as in an anaerobic lagoon or digester, which produces CO_2 and CH_4. Anaerobic digestion of biomass waste consists of the breakdown of organic wastes by microorganisms in an oxygen deficient environment that produces biogas that can be burned as an energy source. Just like traditional fossil fuels, biogas can be used as a transportation fuel through an internal combustion engine or to generate electricity through a combustion turbine or a steam turbine. An additional benefit to converting biogas to energy is that it prevents the methane from being emitted into the atmosphere. Because methane is over 20 times more potent than carbon dioxide as a heat trapping greenhouse gas, its conversion to energy provides an added environmental benefit

Analog Control: A signal which, with respect to time, varies continuously in proportion to the measured quantity.

Ancillary Services: Ensure reliability and support the transmission of electricity from generation sites to customer loads. Such services may include: scheduling and dispatch, load regulation, spinning reserve, non-spinning reserve, replacement reserve, voltage support, black-start. In the context of the RTOs / ISOs, Ancillary Services are essential Inter-connected Operations Services identified by the FERC (Order No. 888 issued 04/24/96) as necessary to affect a transfer of electricity between purchasing and selling entities and which a transmission provider must include in an open access transmission tariff. Including

1. Scheduling, system control and dispatch
2. Reactive supply and voltage control
3. Regulation and frequency response service
4. Energy imbalance service
5. Operating reserve – synchronized
6. Operating reserve – supplemental

Annual Capacity Recovery Factor (CRF): Is the ratio of a constant annuity to the present value of receiving that annuity for a given length of time: $I\,(1+I)^{n} / (1+I)^{n} - 1$ Where I is the interest rate i, and n = number of annuities received.

Annual Depreciation Accrual: Through the utilization of the *Average Remaining Life* technique, the Company will recover the un-depreciated fixed capital investment in the appropriate amounts as annual depreciation expense in each year throughout the remaining life of the property. The procedure incorporates the future life expectancy of the property, the vintage surviving plant in service, and estimated net salvage, together with the book depreciation reserve balance to develop the annual depreciation rate for each property account. Accordingly, the ARL technique meets the objective of providing a straight line recovery of the un-depreciated fixed capital property investment.

Annual Energy Outlook (AEO): A publication of the United States Energy Information Administration that provides yearly projections of a wide range of energy industry trends into the future.

Anode: The positive pole or electrode of an electrolytic cell; anodes are attached to steel pipelines to prevent corrosion.

Antitrust: The Sherman Act (named for Senator John Sherman the brother of Union Civil War General William T. Sherman) is the primary antitrust law. The Sherman Act was prompted by concerns for various business combinations called "Trusts" in such industries as oil, steel, and tobacco. President Theodore Roosevelt was known as the "Trust Buster" for his role in the enactment of the Sherman Antitrust Act. These laws, as enforced by the United States Department of Justice and the Federal Trade Commission, are intended to prevent the exercise of market power or other abusive actions that are detrimental to competition and consumers. These include, but are not limited to, the following more frequently employed statutory authorities:

Section 5 of the Federal Trade Commission Act, which prohibits "unfair methods of competition."

Section 1 of the Sherman Act, which outlaws "every contract, combination..., or conspiracy, in restraint of trade."

Section 2 of the Sherman Act, which makes it unlawful for a company to "monopolize, or attempt to monopolize," trade or commerce.

Section 7 of the Clayton Act, which prohibits mergers and acquisitions the effect of which "may be substantially to lessen competition, or to tend to create a monopoly."

Section 7A of the Clayton Act (added in 1976 by the Hart-Scott-Rodino Antitrust Improvements Act), which requires companies to notify antitrust agencies before certain planned mergers.

Other provisions of the Clayton Act, including the Robinson-Patman Act, which prohibits certain forms of price discrimination that are found to be anticompetitive;

Section 3 of the Clayton Act, which proscribes certain types of tying exclusive dealing arrangements; and Section 8 of the Clayton Act, which proscribes interlocking directorates and officers.

Antitrust applied to Electric and Natural Gas Utilities: Historically, electric utilities have been partially immune to antitrust laws due to pervasive retail regulation and, to a lesser extent, federal regulation. For states with traditional retail regulation, the State Action Doctrine (see Parker v Brown 1943, Cantor v Detroit Edison Co 428 U.S. 579) provides some immunity from antitrust liability where state regulatory law allows utilities to engage in behaviors that might not be legal absent the notion that electric utilities are natural monopolies and have other characteristics that make competition uneconomic or problematic.

The courts' historic deference to cooperative federalism allows the State Action Doctrine to, arguably, permit utilities to engage in some forms of anticompetitive behavior. For utilities that have deregulated or unbundled their services to promote retail competition, there is the potential for increased antitrust concerns. It is important to note, however, that The Commerce Clause of the Constitution necessitates a dual jurisdictional regulatory scheme. EPAct 05, for example, gives the Federal Energy Regulatory Commission (FERC) authority over reliability. Reliability is defined as "security" and "adequacy." Historically, states have ensured resource adequacy so to ensure reliability, both federal and state commissions should, where possible, act in concert. Antitrust laws (such as the Sherman Antitrust Act of 1890 – 15 U.S.C. §§ 1-7, the Clatyon Act 15 U.S.C. §§ 12-27, and the Federal Trade Commission Act 15 U.S.C. §§ 41-44 are intended to prevent market power from diminishing competition such as by engaging in 1) Refusal to deal (or wheel – transmit power from competitors), 2) Price Squeeze, 3) Tying Arrangements.

1. **Refusal to Deal**: Otter Tail Power Co. v. United States, 410 U.S. 366 (1973). In Otter Tail Power, the utility was found to have engaged in anticompetitive practices, including refusing to transmit power for a competitor to preserve its sole provider status. The U.S. government claimed the conduct was a violation of the Sherman Act. The utility claimed that it was immune from antitrust liability because, it was regulated by the federal government under the Federal Power Act (FPA). The Court, however, disagreed and held antitrust laws were applicable to the FPA. The Court also held that problems related to losing customers did not excuse a utility from antitrust conduct they must rely on lower costs and superior service to protect their business rather than illegally suppressing competition.
2. **Price Squeeze** (or margin squeeze): In Conway, under section 2 of the Sherman Act, the Supreme Court held that Conway as a vertically integrated electric utility sold power under retail rates that was priced sufficiently low to prevent competing firms from supplying power sold to end-users. The Supreme Court held that the Federal Power Commission could consider allegations of price squeeze by a state regulate utility even though retail rates are not within the jurisdiction of the FPC. FPC v. Conway Corp., 426 U.S. 271 (1976)
3. **Tying Arrangements**: Tying" refers to the practice of forcing customers to purchase one product or service as a condition to receiving the product or service that the customer actually desires. See SULLIVAN, supra note 26, at 431. Forced bundling or tying, if done for anti-competitive reasons—e.g., to leverage a company's dominance in one product into dominance in another product—is considered a per se violation of antitrust laws.

Utilities have faced anticompetitive issues with selling and/or maintenance of appliances / end-uses (for example light bulbs Detroit Edison). Utility ownership, leasing, maintenance of resources such as solar, wind, combined heat and power (CHP), microgrids, etc. may – under certain conditions - be regarded as anticompetitive if the courts are persuaded that the utility was using its market power in a manner intended to unduly limit competition. Similarly, unduly discriminatory rates may also be a source of antitrust liability.

Appalachian Basin Coal: Appalachian coal and petroleum resources are still available in sufficient quantities to contribute significantly to fulfilling the nation's energy needs, according to a March 2015 study by the U.S. Geological Survey entitled: Appalachian Basin Energy Resources -- A New Look at an Old Basin. The Appalachian basin includes the Appalachian coal fields and the Marcellus Shale which covers parts of Alabama, Georgia, Kentucky, Maryland, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia and West Virginia. The Appalachian basin region have been major contributors to the Nation's energy supplies over much of the last three centuries. Appalachian coal and petroleum resources are still available in sufficient quantities to contribute significantly to fulfilling the Nation's energy needs. Although both conventional oil and gas continue to be produced in the Appalachian basin, most new wells in the region are drilled in shale reservoirs to produce natural gas.

Apparent Power: The product of the voltage (in volts) and the current (in amperes). It comprises both active and reactive power. It is measured in "volt-amperes" and often expressed in “kilovolt-amperes” (kVA) or “megavolt-amperes” (MVA).

Appliance Efficiency Index: A relative comparison of trends in new-model efficiencies for major appliances and energy-using equipment. The base year for relative comparisons was 1972 (1972=100). Efficiencies for each year were efficiencies of different model types that were weighted by their market shares. (EIA)

Appliance Efficiency Standards: The National Appliance Energy Conservation Act of 1987 established minimum efficiency standards for major home appliances with continued increases over time. The standards address furnaces, central and room air conditioners, refrigerators, freezers, water heaters, dishwashers, and heat pumps. Most of the standards took effect in 1990. The standards for clothes washers, dishwashers, and ranges took effect in 1988, because they required only minor changes in product design, such as eliminating pilot lights and requiring cold water rinse options. The standards for central air conditioners and furnaces took effect in 1992, because it took longer to redesign these products. Standards for refrigerators took effect in 1993. (EIA)

Appliance Saturation Survey: Load research (hourly or sub-hourly customer electric use) is often supplemented with appliance / end-use saturation studies to facilitate construction of consumption data profiles. Ideally, the survey should be conducted by experts and in the homes or businesses. The survey instrument should include detailed information on major appliances and end-uses (e.g., connected electric load, condition, age), information about the premises (e.g., insulation, lighting, square footage), and demographic information (e.g., number of people, ages, and – ideally - income). The combination of appliance / end-use data with detailed load research is used to support a bottom-up load forecast and for Evaluation, Measurement, and Evaluation (EM&V) of DSM programs; typically as integral components of Integrated Resource Planning (IRP). Smart Grid and Advanced Metering Infrastructure (AMI) facilitate data collection. RTO / ISO markets have near real-time pricing that, when used with AMI, can provide dynamic pricing, a wealth of information to improve the credibility of load forecasts, and better tailor DSM to the utility’s customers’ needs, and instill greater confidence in the utility’s long-term resource planning, as well as transmission and distribution system planning.

Arbitrage: The simultaneous purchase and sale of identical or similar assets across two or more markets in order to profit from a temporary price discrepancy.

Arc Flash: An arc flash is the light and heat produced from an electric arc supplied with sufficient electrical energy to cause substantial damage, harm, fire, or injury. Electrical arcs experience negative incremental resistance, which causes the electrical resistance to decrease as the arc temperature increases. Therefore, as the arc develops and gets hotter the resistance drops, drawing more and more current (runaway) until some part of the system melts, trips, or evaporates, providing enough distance to break the circuit and extinguish the arc. Electrical arcs, when well controlled and fed by limited energy, produce very bright light, and are used in arc lamps (enclosed, or with open electrodes), for welding, plasma cutting, and other industrial applications. One of the most common examples of an arc flash occurs when an incandescent light bulb burns out. When the filament breaks, an arc is sustained across the filament, enveloping it in plasma with a bright, blue flash. Most household lightbulbs have a built-in fuse, to prevent a sustained arc-flash from forming and blowing fuses in the circuit panel.

Area Contol Error (ACE): ACE measures the difference (imbalance) between scheduled and actual net interchange to control small fluctuations in load.

Area Regulation Signal: Generated by the dispatch authority (e.g., the RTO) and sent to generators to provide regulation to make small changes in generation output quickly to keep ACE within allowable limits.

Ash: Impurities consisting of silica, iron, alumina, and other noncombustible matter that are contained in coal. Ash increases the weight of coal, adds to the cost of handling, and can affect its burning characteristics Ash content is measured as a percent by weight of coal on an "as received" or a "dry" (moisture-free, usually part of a laboratory analysis) basis. (EIA)

Asphalt Shingles Typically fiberglass sheets soaked with asphalt for waterproofing and covered with granules (crushed rock, often colored) to shield the asphalt from ultraviolet light. It is one of the most widely used residential roofing materials in the U.S. (LBNL)

Asset Condition Rating (ACR): There is not unanimity on how best to collect, analyze and present this information. Though many use age as a proxy for asset condition, experience suggests that age alone can lead to unintended suboptimal decisions regarding asset replacement cycles. However, the time required to ascertain the condition of all assets (*i.e.* health indexing, condition monitoring and reviews of maintenance and operating history) may render an approach as rudimentary as asset age necessary.

Asset Management System (AMS): All utilities have a list of generation, transmission and distribution projects that must be done such as new connections, outage restoration, public improvement, and safety related programs. Asset Management is intended to go beyond making sure these immediate and on-going projects are accomplished. Asset Management assigns priorities to projects needed for enhanced reliability; some of which may have been elements that frequently failed, or in imminent danger of failure, or are aging and have a higher probability of failure. Renewal and replacement is a major element of preventative maintenance. In some instances, they are needed for modernization and improved efficiency. **Life-Cycle Management (LCM)** and development of **life-cycle plans** is integral to Asset Management**.**

While it is impossible to provide perfect reliability, in an effort to balance the customers' needs for reliable and safe power with the cost of making improvements, utilities may find it increasingly necessary to continuously track the ramifications of outages. Of course, it difficult to quantify the benefits of reliability and quality of service enhancements (e.g., the cost of recovery and repair costs, economic losses to families and businesses, and injuries and deaths would provide the needed justification.

In 1999, Commonwealth Edison (Chicago) had severe distribution system reliability problems that led to the dismissal of top executives. In 2007, ComEd began revamping its approach to asset management with the introduction of health indices and risk scores. Health indices assess the condition of individual assets rather than targeting equipment by age or model. Assets with poor health scores are reviewed with the appropriate engineering team and projects are developed to address the identified issues. These projects are then assigned risk scores to provide a measure of criticality that can be used for prioritizing work across the service territory. These asset health and project risk scoring frameworks have continued to evolve as ComEd incorporates its lessons learned over time into these analyses.

ISO 55000 (2014): ISO 55000 provides an overview of the subject of asset management and the standard terms and definitions. ISO 55000, combined with **PAS55,** maturity assessment are standards used in Asset Management to provide a risk management framework that results in more robust planning, prioritization, minimization of costs - subject to effective outcomes, reduce waste and inefficiencies, and to do so with a transparent audit trail of the rationale for actions taken. **ISO 55001** establishes requirements for asset management systems.

Associated Gas (Also referred to as wet gas. See also Natural Gas which includes dry and wet gas and Natural Gas Liquids): Gas production that is produced as a byproduct of the production of crude oil. Associated gas reserves are typically developed for the production of petroleum products (including gasoline, fuel oil, lubricating fluids, kerosene etc. these various hydro carbons produced along with natural gas result in the phrase wet gas), which pays for the field development costs. The reserves typically produce at peak levels for a few years and then decline. **Non-associated gas** reserves are developed primarily to produce natural gas.

Asymmetric Information: Where one party has access to information that the other party to a transaction does not have.

Atomic Mass: The total mass of protons and neutrons in an individual atom or isotope. Is typically measured in atomic mass units (amu) using carbon 12 which is equal to 12 amu as a benchmark to measure other atoms.

Atomic Number (z): is the number of protons in a nucleus the number of electrons in a neutral atom. For isotopes, atoms of a single element (same atomic number) that differ in the number of neutrons in the nuclei (different *atomic masses*).

Atomic Weight: Weight is a force and is measured in Newtons. Atomic weight is the average mass of all naturally occurring isotopes of an element which is approximately equal to 12.01 rather than *Atomic Mass* which is equal to 12 amu.

Auctions: Especially if there are a large number of active participants, auctions provide a good market mechanism to establish a market clearing price for a good or service because participants are more likely to reveal the maximum value they place on the good or service. Security constrained economic dispatch utilized by Regional Transmission Organizations / Independent System Operators, rely on auctions. There are a variety of different auction formats (e.g., first and second price auctions are common. There are also English Auction - or absolute auction- and Dutch Auctions. An English auction is often called an *absolute auction* because there is no *reserve price* allowing the item to be sold to the highest bidder regardless of the amount of the bid. A Dutch Auction is may involve a clock which indicates an initial high price for the object. A the clock slowly decreases the price until a bidder indicates a willingness to pay. This auction format was used for selling tulips in Holland. A second price auction may take the form of a *sealed bid* (or *blind auction*) in which bidders submit bids simultaneously to prompt bidders to express their maximum bid.

Auction Revenue Rights (ARRs) (see also Financial Transmission Rights or FTRs): An Auction Revenue Right is a Market Participant's entitlement to a share of revenue generated in annual Financial Transmission Rights auctions and, therefore, provides something of a hedge against the cost of acquiring FTRs. The ARRs are intended to hold existing Transmission Customers whole compared to their firm historical use of the Transmission System with respect to congestion-related charges under MISO Energy and Operating Reserve Market operation to the extent possible given the requirement of simultaneous feasibility, and to meet the reasonable needs of LSEs. In the Midcontinent ISO (MISO), for example, a Market Participant's firm historical usage of MISO's transmission system determines its share of ARRs (based on MISO's running of a *Simultaneous Feasibility Test* using *power flow modeling* to determine how many ARRs can be granted), and depending upon the FTR auction clearing price of an ARR path, the share could result in revenue or a charge. Unlike an FTR, ARRs do not protect the holder against day-ahead or real-time congestion charges.

Authority Governing Interconnection Requirements (AGIR): **"**A cognizant and responsible entity that defines, codifies, communicates, administers, and enforces the policies and procedures for allowing electrical interconnection of DER to the area Electric Power System (EPS). This may be a regulatory agency, public utility commission, municipality, cooperative board of directors, etc. The degree of AGIR involvement will vary in scope of application and level of enforcement across jurisdictional boundaries. This authority may be delegated by the cognizant and responsible entity to the Area EPS operator or bulk power system operator." (NERC)

Autocorrelation (Statistics): Autocorrelation is the correlation (relationship) between members of a time series of observations, such as weekly share prices or interest rates, and the same values at a fixed time interval later. More technically, autocorrelation occurs when residual error terms from observations of the same variable at different times are correlated.

Automated Demand Response (ADR): Preprogrammed technical control strategies at a customer site. ADR involves installation of advanced control and communication programs where an automated signal from the dispatcher to trigger a pre-defined response from the customer's end-use. LBL 2018

Automatic Adjustment Clauses (e.g., A "trackers"): State commissions in the 1970s and 1980s, in response to frequent and, often, overlapping rate cases (pancaking of rate cases) adopted mechanisms to pass-through certain costs to customers with limited regulatory scrutiny. Generally, costs were that were considered to be outside the control of a utility (e.g., the fuel adjustment clauses allowed fuel and the energy portion of purchased power to be passed through with limited review) were included in such clauses. However, commissions required that costs be *prudently incurred* (e.g., arm's length transactions – trading with Affiliates poses concerns such as those in the "Ohio Power Gap" case, no imprudent operations or maintenance). Additionally, the cost recovery does not permit the utility to earn a profit on the transactions. Utilities, to further minimize risks to customers, engage in hedging strategies (such as Financial Transmission Rights (FTRs, alternative fuel suppliers, diversity of purchased power contracts) as an insurance against unexpected but, potentially expensive, outcomes (e.g., a disruption in fuel supply). The objective of automatic adjustment clauses is to provide the lowest cost reasonably possible. Allowance for Funds Used During Construction (AFUDC) and Construction Work in Progress (CWIP) are additional examples. For utilities that participate in

Regional Transmission Organizations (RTOs / ISOs) there are a number of cost categories that are routinely passed through to utilities from the RTOs. These costs are often passed through to wholesale and retail customers because they are outside the control of the utilities, the Federal Energy Regulatory Commission has approved the costs and are presumed to be prudently incurred, and utilities do not profit from the pass-through of these costs.

Automatic Generation Control (AGC): Equipment that automatically adjusts generation in a Balancing Authority Area from a central location to maintain the Balancing Authority's interchange schedule, plus Frequency Bias. AGC may also accommodate automatic inadvertent payback and time error correction.

Automatic Islanding and Reconnection (see also Backfeed): *Unintentional Islanding* refers to the condition in which a distributed generator (DG) continues to power a location even though electrical grid power from the electric utility is no longer present. Islanding can be dangerous to utility workers, who may not realize that a circuit is still powered, and it may prevent automatic re-connection of devices. For that reason, distributed generators must detect islanding and immediately stop producing power; this is referred to as *anti-islanding*. The common example of islanding is a grid supply line that has solar panels attached to it. In the case of a blackout, the solar panels will continue to deliver power as long as irradiance is sufficient. For this reason, solar inverters that are designed to supply power to the grid are generally required to have some sort of automatic anti-islanding circuitry in them. *Intentional islanding*, occurs with microgrids that are an integrated energy system consisting of loads and distributed energy resources that are able to operate in parallel with the grid or as an island by disconnecting from the grid.

Automatic Meter Reading (AMR): The process of collecting meter data remotely through a communications system that sends the data through an automated system. Advanced Metering Infrastructure (AMI) seems to have comparative advantages.

Automatic Response Rate (ARR): For generating resources that are providing regulation service, the amount of the resource's output, in megawatt-minutes, that a market participant is willing to change between the resource's regulation high limit and regulation low limit.

Autoregressive Integrated Moving Average (ARIMA): in very simplistic terms ARIMA, when used as a short-term forecast method, posits that the immediate past will resemble the future. It is a regression time series model. The AR refers to the use of a dependent variable's relationship to an obeservation or lagged observations). The Integraton (differencing step to make the model better fit the data) occurs when one observation is subtracted from an observation in a previous period (this makes the time series stationary). The Moving Average incorporates the dependency between an observation and a residual error from a moving average model applied to lagged observations showing that the values of the error terms occurred occurred at various times in the past or contemporaneously. See also Box-Jenkins.

Seasonality occurs when data shows regular or predictatable patters that repeat over the course of a year which would negatively affect the regression model.

Auxiliary Generator: A generator at the electric plant site that provides power for the operation of the electrical generating equipment itself, including related demands such as plant lighting, during periods when the electric plant is not operating and power is unavailable from the grid. A black start generator used to start main central station generators is considered to be an auxiliary generator.

Auxiliary Power Supply: The power required for operation of generation station accessory equipment necessary for the operation of a generating station.

Availability: A measure of time a generating unit, transmission line, or other facility is capable of providing service, whether or not it actually is in service. Typically, this measure is expressed as a percent available for a period under consideration.

Available: State in which a unit is capable of providing service, whether or not it is actually in service, regardless of the capacity level that can be provided.

Available Hours (AH): AH is the Sum of all Service Hours (SH) **+** Reserve Shutdown Hours (RSH) **+** Pumping Hours **+** Synchronous Condensing Hours.

Available Flowgate Capability: A measure of the flow capability remaining on a Flowgate for further commercial activity over and above already committed uses. It is defined as Total Flowgate Capability less Existing Transmission Commitments (ETC), less a Capacity Benefit Margin, less a Transmission Reliability Margin, plus Postbacks, and plus counterflows. (NERC)

Available Resource: The sum of existing generating capacity, plus new units scheduled for service, plus the net of equivalent firm capacity purchases and sales, less existing capacity unavailable due to planned outages.

Available Transfer Capability (ATC): A measure of the transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses. ATC is defined as the Total Transfer Capability (TTC), less the Transmission Reliability Margin (TRM), less the sum of existing transmission commitments (which includes retail customer service) and the Capacity Benefit Margin (CBM).

Average (Statistical see "Mean"): Average is a measure of central tendency like "Median" and "Mode". It is calculated by taking the sum of the numbers and dividing by the number of observations. For example, the average of 2, 8, 10 is (2+8+11)/3 = 21/3=7. Typically, the form of the equation is

$$\overline{x} = \frac{(n_1 + n_2 + n_3 \ldots)}{n}.$$

Average and Excess Demand (AED cost-of-service allocation method, see also System Peak Responsibility): Average Excess Demand is calculated as a class's "excess demand" which is the difference between that class's non-coincident peak (NCP) demand and that class's average demand. Like any cost allocation method, it should reflect how the utility is actually planned and operated – including contribution to system peak - and reflect cost causation. One factor to consider is that the system is typically planned to meet the forecast maximum coincident peak demand. Resource adequacy (Reserve Margins) are predicated on the utility's system peak demand.

Average Cost: The revenue requirement of a utility is divided by the utility's sales (kWh) to calculate the average cost. The revenue requirement typically includes the costs of existing power plants, transmission, distribution lines, other facilities used by a utility to serve its customers, operating and maintenance expenses, and taxes. Average cost rates are derived by dividing a company's revenue requirement for serving each class of customer – including an approved return – by the kWhs sold to each class of customers.

Average Remaining Life: This is a depreciation method that is based upon recovering the net book cost (original cost less book reserve) of the surviving plant in service over its estimated remaining useful life. Any variance between the book reserve and an implied theoretical calculated reserve is compensated for under this procedure. As the Company's book reserve increases above or declines below the theoretical reserve at a specific point in time, the Company's average remaining life depreciation rate in subsequent years will be increased or decreased to compensate for the variance, thereby, assuring full recovery of the Company's investment by the end of the property's life. The use of the Average Remaining Life technique results in charging the appropriate annual depreciation amounts over the remaining life of the property to insure full recovery by the end of the life of the property. The annual expense is calculated on a *Straight Line* method rather than by the previously mentioned, "sum of the years digits" or "double declining balance" methods, etc. The "group" refers to the method of calculating annual depreciation on the summation of the investment in any one depreciable group or plant account rather than calculating depreciation for each individual unit.

Average Service Availability Index (ASAI - see also SAIDI, SAIFI, CAIDI, MAIFI, and other reliability indices): This is the Average Amount of time electricity is Available to Customers:

ASAI = [1 – (Σ(ri * Ni) / (NT * T))] * 100

Where:

- T = Time period,
- ri = Restoration time in hours,
- Ni = Total number of customers interrupted, and
- Nt = Total number of Customers.

Also see the following Distribution System Reliability Indicies:

- Customer Average Interruption Duration Index (CAIDI),
- System Average Interruption Duration Index (SAIDI),
- System Average Interruption Frequency Index (SAIDI),
- Customer Average Interruption
- Frequency Index (CAIFI),

- Worst CKAIDI (Circuits with the worst circuit-level Average Interruption Duration Index),
- Worst CKAIFI (Circuits with the worst circuit–level Average Interruption Frequency Index),
- Momentary Average Interruption Frequency Index (MAIFI).

Avoidable Cost Rates (ACR): In the PJM markets, avoidable costs are the incremental costs of being a capacity resource. Avoidable costs are the fixed annual operating expenses that would not be incurred if a unit were not a capacity resource for a year. Operationally, it is the projected PJM market revenues for any generation capacity resource to which the avoidable cost rate is applied shall include all actual unit-specific revenues from PJM energy markets, ancillary services, and unit-specific bilateral contracts from such generation capacity resource, net of marginal costs for providing such energy (i.e., costs allowed under cost-based offers.

Avoided Costs: Avoided Cost calculations can be short or long-run. **Short Run Avoided Cost** is calculated to reflect the incremental costs of producing (or purchasing from any source) one more kWh at any instant in time and at any location. This could include energy efficiency and demand response. These short run avoided costs vary dynamically due to economic dispatching and distribution system operations. As the information develops, avoided costs should also consider reductions in congestion, losses, voltage support, and other aspects that enhance reliability and / or reduce the delivered cost to customers. **Long-Run Avoided Costs** are intended to reflect the type and costs of the next resource (generation of any type, transmission, demand response, energy efficiency, and other DERs) that would be constructed (or purchased) to meet expected demand. As interactions and transactions between the T&D systems increase to become more seamless and reliable, this will entail very complex engineering (e.g., protection schemes) to facilitate reliability and mitigate congestion.

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Back Casting: This technique is sometimes used as a credibility assurance check on load forecasting and planning. That is, back Casting might be regarded as *reverse engineering* of load forecasts and planning. Instead of using *independent variables* to estimate values of a *dependent variable* in forecasting, the *independent variables* are now known and, ideally, will result in a close approximation of the original dependent variable. As a caution, back casting should not be used only as an indicator rather than an assessment of the credibility of the forecast or plan. Assumptions, data, scenarios, and sensitivities that were used appropriately in the development of the original forecast or plan may have changed dramatically and unexpectedly. It is often difficult to isolate the affects of all of the potential changes.

Back Swing: After a fault occurs in power system, the electromagnetic torque of synchronous generator has unidirectional components and alternating components which oscillate with rated frequency and its double frequency. These alternating components make the generator swing angle move to backward for a short while after fault and the acceleration starts after this. This phenomenon is called back swing.

Backfeed: A condition when voltage is present on a conductor or associated equipment after it has been disconnected from its normal source and electric power flows in the opposite direction from its usual flow from power supplied from the electric utility. A backfeed may occur with distributed generation such as a portable generator or a solar installation(s). The primary hazard of backfeed is the erroneous assumption that the conductor or equipment is de-energized when in fact, it is not.

Backup Power: Power provided by contract to a customer when that customer's normal source of power is not available.

Balance of Plant (BOP – sometimes referred to as Electrical Balance of Plant (EBoP)**:** This is a phrase used to refer to all the supporting components and auxiliary systems of a power plant needed to integrate the generating unit into a comprehensive power system to deliver energy; other than the generating unit itself (e.g., the prime mover, waste heat recovery, gas turbine, steam turbine, waste heat boiler). The BOP applies to all forms of electric generating resources.

Balance Sheet: Statement of financial position that shows total assets = total liabilities + owners' equity.

Balance of Systems for Solar (BOS) a term that includes inverters, switches, mounting system, batteries but does not include the panels.

Balancing: Matching the flows (volume) of electricity into or out of the grid to the volume of electricity scheduled in the day-ahed or intra-day markets.

Balancing Accounts: Regulatory Assets or Regulatory Liabilities which reflect amounts due from, or due to, customers through adjustment clauses.

Balancing Authority (BA): The responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing Authority Area, and supports Interconnection frequency in real time. The Balancing Authority Area: The collection of generation, transmission, and loads within the metered boundaries of the Balancing Authority. The Balancing Authority maintains load resource balance within this area. (NERC)

Balancing Contingency Event: Any single event described in Subsections (A), (B), or (C) below, or any series of such otherwise single events, with each separated from the next by one minute or less. A. Sudden loss of generation: a. Due to i. unit tripping, or ii. loss of generator Facility resulting in isolation of the generator from the Bulk Electric System or from the responsible entity's System, or iii. sudden unplanned outage of transmission Facility; b. And, that causes an unexpected change to the responsible entity's ACE; B. Sudden loss of an Import, due to forced outage of transmission equipment that causes an unexpected imbalance between generation and Demand on the Interconnection. C. Sudden restoration of a Demand that was used as a resource that causes an unexpected change to the responsible entity's ACE. (NERC)

Balancing Energy Market (see also Ancillary Services Market): Matches the power output of the generators within the electric power system(s) – such as an RTO / ISO - and energy purchased from entities outside the electric power system(s), with the load within the electric power system(s).

Balancing Operating Reserves: Generation and demad response resources requested by the RTO to recover the costs of their offer amounts through balancing reserve credits that are charged to market participants. These "make whole" payments are performed on a daily basis for both the day-ahead and real-time energy market. These are *out of market* and are not included in the pricing signals since they are unpredictable and can not be hedged on a forward basis.

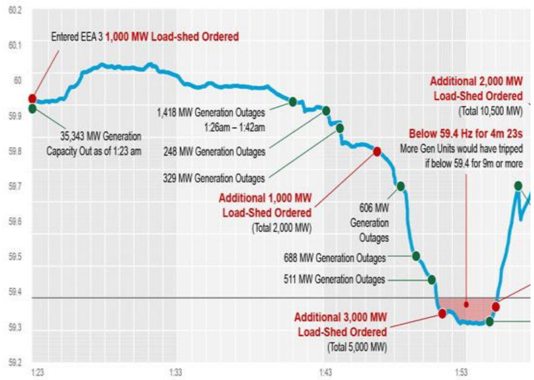
Bankruptcies affecting the Electric Industry: Bankruptcy law is the province of the federal government. Energy companies typically file under Chapter 11 Bankruptcy (There are four other types of bankruptcy, Chapter 7 – Liquidations; Chapter 9 – Municipalities; Chapter 12 – Family Farmers; and Chapter 13 – Wage Earners). Until Public Service of New Hampshire filed for bankruptcy protection in 1988, no utility had filed for bankruptcy since the Great Depression.

1. **Enron**, in 1985, started life as a small natural gas pipeline company - the merger of Houston Natural Gas and InterNorthand - became the world's largest energy trader by using the new technology of the internet to buy and sell natural gas and electricity. By 2000, ENRON was worth $101 billion and employed approximately 20,000 staff. ENRON engaged in a wide ranging and systematic fraud involving market manipulation to *game* the electric markets (Retail Competition and the modern Regional Transmission Organizations were in their infancy so ENRON used *game theory* to develop "Fat Boy," "Thin Man," and other colorful names to take advantage of the new markets). ENRON also took undue advantage of accounting methods such as "mark to market" with inflated future values, use of shell corporations to hide losses, and other questionable or fraud financial practices. Before its bankruptcy on December 2, 2001, ENRON was named by Fortune magazine as America's Most Innovative Company. During 2001, after a series of revelations involving irregular accounting procedures bordering on fraud perpetrated throughout the 1990s involving Enron and its accounting company Arthur Andersen, Enron suffered the largest Chapter 11 bankruptcy in history (since surpassed by those of Worldcom (2002) and Lehman Brothers (2008) and PG&E (2019).
2. **Energy Future Holdings** (formerly Texas Utilities Corporation or TXU) became the largest power producer in Texas after their acquisition of TXU. TXU's was taken over by the *private equity* consortium of Kohlberg Kravis Roberts, TPG Capital and the private equity arm of Goldman Sachs. TXU was unable to sustain $45 billion in debt and falling revenues due to a natural gas boom and lower natural gas prices. The Company filed for bankruptcy April 29, 2014.
3. **Pacific Gas and Electric Company** (PG&E) California's largest utility filed for bankruptcy on April 6, 2001. One major factor was the legal requirement for PG&E to divest its generating units as a result of restructuring the State's electricity markets. A second major factor was the Western Energy Crisis. PG&E had to rely on power purchases that were very high priced and had large fluctuations in prices. After signing long-term purchased power contracts, the wholesale price of electricity declined and PG&E emerged from bankruptcy.
4. **Dynegy Inc.** Dynegy filed for bankruptcy protection on November 7, 2011. Dynegy came close to bankruptcy in 2002 due to accounting irregularities. On May 1, 2002, the U.S. Securities & Exchange Commission opened a formal investigation into how Dynegy's "Project Alpha", allegedly inflated income from natural gas transactions and illegally structured business partnerships to avoid income. Two weeks later, the New York Times reported that Dynegy's Illinova subsidiary was part of the investigation.The Company emerged from bankruptcy October 1, 2012. On November 5, 2012, the FERC settled a decade-old lawsuit which alleged that Dynegy had manipulated the California energy market. NRG Energy

subsequently agreed to pay $20 million in refunds to consumers as well as spend more than $100 million to install 200 fast-charging electric vehicle stations and 10,000 plug-in stations throughout California. Twenty percent of the stations were required to be in low-income neighborhoods.

5. **FirstEnergy Solutions Corp** (FES) filed for bankruptcy March 31, 2018 due to the dramatic changes in fuel prices, low load growth, increasing penetration of renewables. FES asked the DOE to invoke an emergency declaration that would direct the PJM Interconnection to ensure full cost recovery for FES's at-risk coal and nuclear plants in the region and after FES notified the PJM it will retire its three nuclear plants next two to three years.
6. **Edison Mission Energy** (a unit of Edison International) filed for bankruptcy on December 17, 2012 and May 2, 2013 for certain subsidiaries. On December 22, 2016, the Court entered the Final Decree.
7. **El Paso Electric** (EPE) filed for Chapter 11 bankruptcy protection in January of 1992. El Paso Electric has been hurt by investments in the Palo Verde nuclear plant near Phoenix and commercial real estate and thrifts. It owes creditors about $500 million. EPE emerged from bankruptcy in 1996.
8. **Public Service of New Hampshire** (PSNH) filed for bankruptcy in 1988 due in large part to the $2.1 billion cost of the Seabrook Nuclear power plant. PSNH completed their reorganization in May 1991.
9. **Cajun Electric Power Cooperative** filed for bankruptcy protection in 1994. Cajun exited bankruptcy on August 31, 1999. Cajun Electric has accumulated debt of $4 billion partly because of its investment in the River Bend nuclear power plant. The Rural Utilities Service (RUS), urged the cooperative to invest in the River Bend plant in the 1980's as an economical way to increase capacity -- and offered Federal financing. After Cajun bought a 30 percent stake in River Bend, the demand for electricity began to stagnate and construction delays and cost overruns made the plant more expensive. The cooperative began to increase its rates to cover the servicing of its debt, but the Louisiana Public Service Commission ordered Cajun to lower rates, which put the cooperative in default on its debt to the Rural Utilities Service. NY Times, JUNE 27, 1996
10. **Westinghouse's** (Toshiba corporation) bankruptcy filing on March 29, 2017 was seen as a set-back to the nuclear power industry. Westinghouse's problems stem, in large part, to problems in the construction of the Vogtle nuclear power plant for Georgia Power (a unit of Southern Company) and the Virgil C. Summer plant in South Carolina. The construction cost over-runs at Vogtle (estimates of the final cost are in excess of $8 billion), combined with the low cost of natural gas, makes nuclear power more tenuous and dampens the feasibility of Toshiba's goal of installing 45 new reactors by 2030.
11. **Pacific Gas and Electric:** California's largest utility filed, again, for Chapter 11 bankruptcy on January 29, 2019 due to the wildfires in 2017 and 2018. On June 19, a federal judge approved a $58 billion plan to emerge from bankruptcy. PG&E is expected to increase its debt by $40 billion to improve its infrastructure and mitigate the incidence of rolling blackouts that adversely affected nearly 3 million customers.
12. **Brazos Electric Power Cooperative,** Just Energy Group, Brilliant Energy, Entrust Energy, and Griddy Energy filed for bankruptcy in March and April 2021 due to the Polar Vortex event of Feb. 12 -17, 2021 due to a combination of record winter demand, generation unit outages, and natural gas price and availability problems cascaded throughout ERCOT. In Texas, 4.5 million Texans sustained outages resulting in 111 deaths and a cost in excess of $129 billion. The effects extended to SPP, MISO, and CASIO. ERCOT's planning for this event ERCOT was based on the 2011 event rather than the more extreme events of 1989.

    ERCOT's real-time prices averaged $6,579.59/MWh. Feb. 14-19 the prices were at the $9,000/MWh compared to January where prices averaged $20.79/MWh. Dr. David Patton, the Market Monitor, concluded there were excess charges of $16 billion. Other suppliers in Texas may also have financial issues.



Bankruptcies in the Natural Gas and Coal Markets:

1. **Texaco** was founded in 1901 as Texas Fuel Company and merged with Chevron in 2001. A legal battle with Pennzoil in 2001 resulted in Texaco's bankruptcy – the largest in U.S. history at the time.
2. **Calpine Corporation**, at the time of its bankruptcy filing on December 20, 2005, was the nation's largest operator of natural gas-fired electric generation. High natural gas prices caused the Company to incur $22.5 billion in debt.
3. **ATP Oil and Gas** filed for bankruptcy on April 17, 2012 was largely a victim of the British Petroleum Company's "Deepwater Horizon" disaster in the Gulf of Mexico. The massive oil spill resulted in a moratorium on off-shore drilling.
4. **Patriot Coal** after losing money each year from 2010, on July 9, 2012, the Company filed for bankruptcy after recording 198.5 million in losses in 2012.
5. **James River Coal** first filed for bankruptcy in 2004 and then on April 8, 2017. James River was forced to close a dozen of its mines due to poor market conditions.
6. **Columbia Gas Systems** filed for bankruptcy protection in 1991.

The largest municipal power default ($2.25 billion) was the Washington Public Power Supply System (WPPSS) in January 1982 as it halted construction on nuclear plants 4 and 5 as the total cost was expected to exceed $24 billion. Plants 1 and 3 were never finished either, but their costs were backed by the *Bonneville Power Administration* (BPA) and the power it generated from the Columbia River Dams Planners expected that the demand for electricity in the Northwest would double every 10 years, beyond the capacity of hydropower. On December 24, 1988, the parties in the various lawsuits reached a settlement of $753 million. Some of the system's approximately 75,000 bondholders would receive 40 cents on every dollar invested; others got as little as 10 cents. Because the bankruptcy court found that some of the bond monies for Plants 4 and 5 were spent on Plants 1 and 3, participants in those projects were held liable for the default. Seattle's share was $50 million, of which $43.2 million came from insurance companies. The last settlement was reached in 1995. In addition to the default by the WPPSS, Several rural electric cooperative utilities have filed for Chapter 11 bankruptcy including: Wabash Valley Power Association (In), Big Rivers Corporation (KY), Colorado-Ute Electric Association, and Eastern Maine Electric Cooperative. A few other cooperatives, such as Sunflower Electric Cooperative (Ks), defaulted on loans.

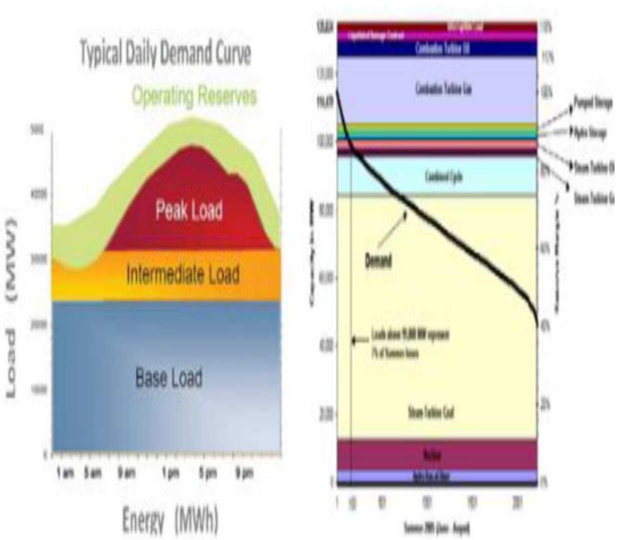
In January 2020, according to the law firm Haynes and Boone, bankruptcy filings among oil and gas producers in the U.S. have jumped since the 2014 crude oil price downturn. After an initial wave of 114 bankruptcy filings between 2015 and 2016, filings picked up in 2019. From January through September, 33 oil and gas producers filed for bankruptcy.

Base Case: (Sometimes referred to a "Business as Usual" or "Reference Case" see Business as Usual Case for a definition).

Base Line Projects: For transmission, baseline projects address reliability metrics including short circuits, voltage, stability, and thermal concerns. Generally, a baseline is a fixed point of reference (datum) used for comparison purposes.to measure success or change.

Base Load: The minimum amount of electric power delivered or required over a given period at a constant rate. (NERC)

Base load Generation: The generating equipment that is normally operated to meet demand on a 24-hour basis. The North American Electric Reliability Corporation (NERC) characterization of Base Load: *There is a distinction between baseload generation and the characteristics of generation providing reliable "baseload" power. Baseload is a term used to describe generation that falls at the bottom of the economic dispatch stack, meaning [those power plants] are the most* *economical to run. Coal and nuclear resources, by design, are designed for low cost O&M [operation and maintenance] and continuous operation […] However, it is not the economics nor the fuel type that make these resources attractive from a reliability perspective. Rather, these conventional steam-driven generation resources have low forced and maintenance outage hours traditionally and have low exposure to fuel supply chain issues. Therefore, "baseload" generation is not a requirement; however, having a portion of a resource fleet with high reliability characteristics, such as low forced and maintenance outage rates and low exposure to fuel supply chain issues, is one of the most fundamental necessities of a reliable BPS. These characteristics ensure that "baseload" generation is more resilient to disruptions.* *Staff Report to the Secretary on Electricity Markets and Reliability*, Page 5, August 2017. It has been suggested that the term "baseload" generation is no longer a meaningful distinction since natural gas combined cycle facilities (NGCC), in particular, are increasingly displacing traditional large coal and nuclear generating units in economic dispatch. Renewable resources may also displace traditional baseload units in economic dispatch due to lower operating costs. The NGCC units also provide quicker start-up, ramp rates, and operational flexibility than traditional baseload units. However, the NERC discussion makes compelling arguments. The following graphic shows the traditional dispatch of baseload generation in relation to other resources.



Base Residual Auction (BRA): The BRA is integral to the PJM's Resource Planning Model. The Auction is conducted by PJM three years in advance of the Delivery Year to procure unforced capacity to satisfy the RTO/LDA Reliability Requirements on behalf of LSEs.

Basis (Natural Gas): The price differential for a commodity (such as natural gas) between two locations. In the case of natural gas, basis can refer to the difference between the NYMEX futures contract price at Henry Hub (the main U.S. natural gas hub) and the cash price at other locations. Basis can also refer to the difference in the cash price at two locations. Natural gas basis reflects the transportation costs, as well as regional supply and demand factors.

Basis Points (PBS): A common unit of measure for interest rates and other percentages in finance. One basis point is equal to 1/100th of 1%, or 0.01%, or 0.0001.

Bass Diffusion: The Bass model has been widely used in forecasting, especially for new products' sales such as electric vehicles. forecasting and the basic Bass diffusion is a Riccati equation with constant coefficients. This may include innovation of technologies. NREL uses this modeling technique.

Battery Electric Vehicles (BEVs): an electric vehicle that utilizes chemical energy that is stored in rechargeable battery packs. Electric vehicles use electric motors instead of, or in addition to, internal combustion engines. Vehicles using both electric motors and internal combustion engines are called hybrid vehicles which are usually not considered pure BEVs.

Battery Specifications: *Cell, modules, and packs* – Hybrid and electric vehicles have a high voltage battery pack that consists of individual modules and cells organized in series and parallel. A cell is the smallest, packaged form a battery can take and is generally on the order of one to six volts. A module consists of several cells generally connected in either series or parallel. A battery pack is then assembled by connecting modules together, again either in series or parallel. *Battery Classifications* – Not all batteries are created equal, even batteries of the same chemistry. The main trade-off in battery development is between power and energy: batteries can be either high-power or high-energy, but not both. Often manufacturers will classify batteries using these categories. Other common classifications are High Durability, meaning that the chemistry has been modified to provide higher battery life at the expense of power and energy. *C- and E- rates* – In describing batteries, discharge current is often expressed as a C-rate in order to normalize against battery capacity, which is often very different between batteries. A C-rate is a measure of the rate at which a battery is discharged relative to its maximum capacity. A 1C rate means that the discharge current will discharge the entire battery in 1 hour. For a battery with a capacity of 100 Amp-hrs, this equates to a discharge current of 100 Amps. A 5C rate for this battery would be 500 Amps, and a C/2 rate would be 50 Amps. Similarly, an E-rate describes the discharge power. A 1E rate is the discharge power to discharge the entire battery in 1 hour. *Secondary and Primary Cells* – Although it may not sound like it, batteries for hybrid, plug-in, and electric vehicles are all secondary batteries. A primary battery is one that can not be recharged. A secondary battery is one that is rechargeable. (MIT- Dec 2008)

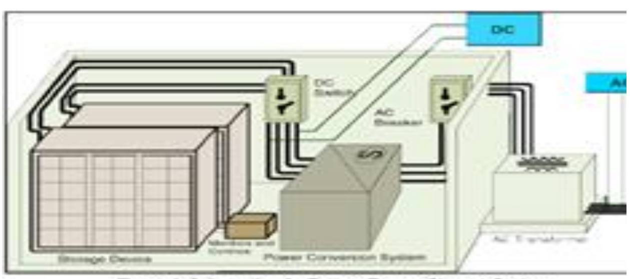


Figure 1. Schematic of a Battery Energy Storage System (Source: Sandia National Laboratories)

Types of batteries include: 1) Lead-Acid, 2) Nickle-Metal Hybrid or NiMH, 3) Lithium Ion sometimes referred to as LIB or Li-Lon (a) Lithium Cobalt Oxide - $LiCoO_2$,, b) LMO or Lithium Manganese Oxide -$LiMn_2O_4$, c) LiFP Lithium Iron Phosphate -$LiFePO_4$), d) LNMC or Lithium Nickel Manganese Cobalt Oxide - $LiNiMnCoO_2$, e) Lithium Titanate or LTO - $Li_4Ti_5O_{12}$, f) Lithium Sulfur Batteries or Li-S), Redox Flow, and Sodium Sulfur.

Bayes' Theorem or Rule (statistical, see also Conditional Probability, Joint Probability, and Marginal Probabilities): Bayes' theorem: an equation that allows manipulation of conditional probabilities. For two independent events, A and B, Bayes' theorem provides a method for solving p(B|A) to p(A|B) if the *marginal probabilities* of the outcomes of A and the probability of B, given the outcomes of A.

Behind the Meter (or Back of the Meter) **Generation** (BTMG): Generation that is physically located behind the retail customer's meter and does not participate in the wholesale market as a generation resource.

Behind-the-Meter Storage (BTMs)**:** Energy storage devices such as batteries that are on the customer's premise and metered electrical system. These devices are owned and operated by the customer or a third party that has been contracted by the customer. This is in contrast to utility- or grid-scale storage that is owned and operated by a utility provider.

Below-the-Line (see also Above the Line): All income statement items of revenue and expense that a regulatory commission deems should not be included in determining operating income. If the item falls below the net operating income line of the *income statement*, it is labeled a below-the-line item. Operating income is the "line" referred to. These items are usually not included directly in the ratepayers' rates.

Benchmarking, is a technique in which a utility (any organization) measures its performance over time from a specific datum. Benchmarking can also be used to make comparisons with other utilities and to do so over time. Often the comparison is made to reasonably comparable utilities (may include a Peer Group) and in comparison to the best utilities. Benchmarking may also be used to assess the utility's compliance with public policy over time and in relation to other utilities. Benchmarking determines how the company achieved their performance levels and uses the information to improve its own performance. Subjects that can be benchmarked include strategies, operations and processes. Benchmarking is the process of measuring products, services, and processes and identifying improvements.

Best Available Control Technology (BACT): The Environmental Protection Agency (EPA) has taken a broad approach to the definition of BSER. As a result, there is no precise definition for BSER. Rather, BSER is specific to the pollution that is being controlled. In Section 111(d) of the Clean Air Act (CAA), EPA identifies the BSER as the best system available to address pollution from existing sources through performance standards adopted after public comment (*emissions guidelines).* In the Clean Power Plan (CPP) for example, the EPA chose to interpret the word "system" to encompass:

1. emissions rate reductions at coal plants,

2. shifting generation from coal to natural gas,
3. increasing generation from renewables, and
4. improving end use energy efficiency. This definition allows environmental regulators broad discretion in determining BSER.

Best System of Emission's Reduction (BSER): (see Best Available Control Technology)

Bias (Statistical): In statistics, the term *bias* is used for describing several different concepts:

A biased sample is one in which some members of the population are more likely to be included than others.

Spectrum bias consists of evaluating the ability of a diagnostic test in a biased group of patients, which leads to an overestimate of the sensitivity and specificity of the test.

The bias of an estimator is the difference between an estimator's expectation and the true value of the parameter being estimated.

Omitted-variable bias is the bias that appears in estimates of parameters in a regression analysis when the assumed specification is incorrect, in that it omits an independent variable that should be in the model.

In statistical hypothesis testing, a test is said to be ***unbiased*** when the probability of rejecting the null hypothesis exceeds the significance level when the alternative is true and is less than or equal to the significance level when the null hypothesis is true.

Systematic bias or systemic bias are external influences that may affect the accuracy of statistical measurements.

Bias Correction (Statistical): In statistics, Bessel's correction is the use of $n - 1$ instead of just the "n" in the formula for the sample variance and sample standard deviation, where n is the number of observations in a sample. This method corrects the bias in the estimation of the population variance and some, but not all of the bias in the estimation of the sample standard deviation. It is not possible to find an estimate of the standard deviation which is unbiased for all population distributions, as the bias depends on the particular distribution.

Bi Directional Metering: Meters capable of measuring the flow of electricity in two directions. It measures how much energy comes from the utility – "kWh delivered." It also measures the difference between the generators production and the customers load demand – "kWh received."

Bids (See also "Offers"): Loads submit to the system operator bids to purchase power at a particular node for a maximum acceptable purchase price – that is, they inform the market what they are willing to pay for electricity as transmitted.

Bid Rigging: This is a price fixing scheme requiring a conspiracy where other participants agree not to bid against each other. This likely illegal activity may take the form of other bidders placing exorbitant bids leaving one bidder with a relatively reasonable bid or other bidders just not participating in the bidding.

Bilateral Agreement: A written contract signed by two parties that specifies the terms for exchanging energy.

Bilateral Transaction: An agreement between two entities for the sale and delivery of a service.

Binding Hours: Those elements when a transmission element is at its maximum safe operating limit; as a congestion metric, the percentage of time during a year that the element is loaded to its limit.

Binding Hours Shadow Price (see also Shadow Price): A congestion metric that equals the average value of the shadow prices in those hours when a transmission element operates at its limit; the *shadow price* equals zero when the element is below its limit.

Biodiesel: A fuel typically made from soybean, canola, or other vegetable oils; animal fats; and recycled grease. It can serve as a substitute for petroleum-derived diesel or distillate fuel. For EIA reporting, it is a fuel composed of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated B100, and meeting the requirements of ASTM (American Society for Testing & Materials) D 6751.

Biofuels: Liquid fuels and blending components produced from biomass feedstocks, used primarily for transportation.

Biogenic: Produced by biological processes of living organisms. Note: EIA uses the term "biogenic" to refer only to organic non-fossil material of biological origin.

Biomass (see also anaerobic digestion) Organic non-fossil material of biological origin constituting a renewable energy source. Biomass, including agricultural crop residues, is expected to play a significant role in the energy supply portfolio in the U.S. in the future. One of the characteristics that makes biomass a very attractive source of renewable energy is its ability to be converted both to electricity and to fuel for the transportation industry. Biomass, including energy crops, can be converted into energy in the following ways: 1) D*irect combustion* in a boiler to produce steam to drive a turbine. This may be done with co-firing. This produces lower sulfur and nitrogen oxides. 2) *Biochemical conversion* where the material is broken down into sugars and fermented to make ethanol. 3) *Thermochemical conversion* where the heat is used to break down the biomass to produce synthetic gas.

Biomass-Based Diesel Fuel: Biodiesel and other renewable diesel fuel or diesel fuel blending components derived from biomass, but excluding renewable diesel fuel co-processed with petroleum feedstocks.

Biomass Gas: A medium Btu gas containing methane and carbon dioxide, resulting from the action of microorganisms on organic materials such as a landfill.

Biomass Waste: Organic non-fossil material of biological origin that is a byproduct or a discarded product. "Biomass waste" includes municipal solid waste from biogenic sources, landfill gas, sludge waste, agricultural crop byproducts, straw, and other biomass solids, liquids, and gases; but excludes wood and wood-derived fuels (including black liquor), biofuels feedstock, biodiesel, and fuel ethanol. *Note*: *EIA "biomass waste" data also include energy crops grown specifically for energy production, which would not normally constitute waste.*

Bituminous Coal: A dense coal, usually black, sometimes dark brown, often with well-defined bands of bright and dull material, used primarily as fuel in steam-electric power generation, with substantial quantities also used for heat and power applications in manufacturing and to make coke. Bituminous coal is the most abundant coal in active U.S. mining regions. Its moisture content usually is less than 20 percent. The heat content of bituminous coal ranges from 21 to 30 million Btu per ton on a moist, mineral-matter-free basis. The heat content of bituminous coal consumed in the United States averages 24 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter).

Black Liquour: A waste product from the kraft process when digesting pulpwood into paper pulp removing lignin, hemicelluloses and other extractives from the wood to free the cellulose fibers.

Blackouts (see also Cascading Blackout and Rolling Blackout): At the extreme it's the uncontrolled successive loss of system elements.

On November 9, 1965, "the Great Northeast Blackout" occurred. This blackout was the impetus for the creation of the North American Electric Reliability Council (NERC - now Corporation). This blackout affected not only the northeastern United States but also southeastern Ontario, Canada. The blackout affected 30 million people and interrupted more than 20,000 MW of electrical load for up to thirteen hours. The blackout was caused by the tripping of a 230 kV transmission line near Ontario, Canada, which caused several other heavily loaded lines also to fail. An initial protective relay tripped (due to incorrect settings) when a transmission line was overloaded. This also caused several other relays to operate on other transmission lines, which resulted in a power surge that overwhelmed the transmission system in western New York. Several generators also tripped off-line according to design because they were unable to transmit their power due to the overloaded transmission lines.

A July 13, 1977 New York City blackout occurred when two 345-kV lines on a common tower in Northern Westchester County, New York were struck by lightning and tripped out. With the loss of power imports ordinarily carried by these lines, generation in New York City was not sufficient to serve the load in the city, leading to load loss. The event affected nine million people, with 6,000 MW of load lost. Outages lasted for up to 26 hours.

December 22, 1982, a blackout of the West Coast occurred. This disturbance began when high winds caused the failure of a 500-kV transmission tower. This ultimately resulted in the loss of 12,350 MW of load and affected over 5 million people in the West.

During the summer of 1996 (July 2-3, and August 10), the West Coast suffered two other blackouts. On June 25, 1998, there was a blackout of Ontario and parts of the Northeast U.S. In the summer of 1999, the Northeastern U.S. experienced another blackout.

On August 14, 2003 a blackout emanated from Ohio (a generator near Cleveland tripped offline and high temperatures caused power lines to sag into trees and tripped off) and cascaded into Canada and the Northeast United States. The outage affected an estimated 50 million people and 61,800 MW of electric load was lost in the states of Ohio, Michigan, Pennsylvania, New York, Vermont, Massachusetts, Connecticut, New Jersey and the Canadian province of Ontario. Although utilities successfully restored power to most customers within hours, some areas in the United States did not have power restored for several days. Parts of Ontario suffered rolling blackouts for up to two weeks before full power was restored. Estimates of total costs in the United States ranged between $4 billion and $10 billion; in Canada, gross domestic product was down 0.7 percent in August. A U.S.-Canada Power System Outage Task Force, Interim Report: Causes of the August 14, 2003 Blackout in the United States and Canada (2003). This blackout led to reforms in the Energy Policy Act of 2005 that, for the first time, gave the FERC explicit authority to ensure the reliability (security and adequacy) of the power system and put the North American Electric Reliability Corporation (no longer “Council”) under the authority of the FERC. It is important to note that the Regional Transmission Organizations were not fully formed to have the situational awareness to limit the cascading blackout.

There have been more localized blackouts. The most significant were blackouts initiated by Pacfic Gas & Electric to mitigate fire hazards in 2097 through 2019.

Black-Scholes Commodity Modeling (see also Two Factor Modeling): The B-S model attempts to estimate the price variation over time for financial instruments such as stocks. The model assumes the price of heavily traded assets follows a geometric Brownian motion (“random walk”) with constant drift and volatility. When applied to a stock option, the model incorporates the constant price variation of the stock, the time value of money, the option's strike price, and the time to the option's expiration. Investopedia.

Black Start Capability: A documented procedure for a generating unit or station to go from a shutdown condition to an operating condition delivering electric power without assistance from the electric system. This procedure is only a portion of an overall system restoration plan.

Black Swan Event (statistics and planning)**:** A black swan event is a metaphor to describe a low probability event with major significance. For utility planning, it is useful to *stress* the system to evaluate the potential ramifications of a low probability event that would have significant ramifications. Because it is unrealistic and prohibitively expensive to try to plan a utility with no probability of failure, it would seem unlikely that any utility would be planned on the basis of a black swan event. The *Polar Vortex* of 2013 / 14 might be regarded as a black swan event. It is also possible that the precipitous drop in natural gas prices in recent years would have been regarded as a black swan event prior to the widespread use of fracking. The term is based on an ancient saying which presumed black swans did not exist, but the saying was rewritten after black swans were discovered in the wild.

Block Chain: The definition of block chain is evolving, complex, and uncertain. Some of the characteristics include databases that are shared across a network of computers. Block chain was originally used to facilitate cyber currencies such as Bitcoins to expedite and keep track of the details of specific transactions. Unfortunately, correcting databases seems to be a problem. Computer database records are bundled into blocks that are then made part of the chain. It may have future applications for inventory management, medical records, and other transactions, especially if errors can be readily remedied.

Block-Rate Structure: An electric rate schedule with a provision for charging a different unit cost for various increasing blocks of demand for energy. A reduced rate may be charged on succeeding blocks.

Blow Down: A Boiler blowdown is done to remove water from a boiler. Its purpose is to control boiler water parameters within prescribed limits to minimize scale, corrosion, carryover, and other specific problems. Blowdown is also used to remove suspended solids present in the system.

Bluefield Water Works Co. v. West Virginia Public Service Commission. (1923 – see also FPC v Hope1944, Munn v Illinois 1877, and Smyth v Ames 1898): In Bluefield, the Court held rates which are not sufficient to yield such a return are "*unjust, unreasonable, and confiscatory, and their enforcement deprives the public utility company of its property in violation of the 14th Amendment*." Once the "value of utility property used and useful in the public interest" was determined, the Commission was charged with the task of fixing a "reasonable return" on that value. In defining what constituted a "reasonable return," the Court said that a public utility was *entitled* to a return on its investments equal to that generally being made on investments in other businesses where there are corresponding risks. For a return on shareholders' investments to be "reasonable" it should be "sufficient to assure confidence in the financial soundness of the utility, and should be adequate, under efficient and economical management, to maintain and support its credit and enable it to raise the money necessary for the proper discharge of its public duties."

Boiler: A device for generating steam for power, processing, or heating purposes; or hot water for heating purposes or hot water supply. Heat from an external combustion source is transmitted to a fluid contained within the tubes found in the boiler shell. This fluid is delivered to an end-use at a desired pressure, temperature, and quality.

Boiler Fuel: An energy source to produce heat that is transferred to the boiler vessel in order to generate steam or hot water. Fossil fuel is the primary energy source used to produce heat for boilers.

Boiling-Water Reactor (BWR): A light-water reactor in which water, used as both coolant and moderator, is allowed to boil in the core. The resulting steam can be used directly to drive a turbine.

Bonbright's Principles of Ratemaking (1962): The original 1962 text had 8 principles. Note Dr. Bonbright said "The sequence of the eight items is not meant to suggest any order of relative importance.

1. The related, "practical" attributes of simplicity, understandability, public acceptability, and feasibility of application.
2. Freedom from controversy as to proper interpretation.
3. Effectiveness in yielding total revenue requirements under the fair-return standard.
4. Revenue stability from year to year
5. Stability of the rates themselves, with a minimum of unexpected charges seriously adverse to existing customers. (Compare "The best tax is an old tax.")
6. Fairness of the specific rates in the apportionment of the total costs of service among the different consumers.
7. Avoidance of "undue discrimination" om rate relationships.
8. Efficiency of the rate classes and rate blocks in discouraging wasteful use of service while promoting all justified types and amounts of use.
    a. In the control of the total amounts of service supplied by the company;
    b. In the control of the relative uses of alternative types of service (on-peak versus off-peak electricity, Pullman travel versus coach travel, single-party telephone service versus multi-party line, etc.)

After the death of Dr. James Bonbright, his widow allowed two additional principles to be added as well as some *clarifications:*

1. **Effectiveness in yielding total revenue requirements** under the fair-return standard without any socially undesirable expansion of the rate base or socially undesirable of product quality and safety.
2. **Revenue stability and predictability** with a minimum of unexpected changes seriously adverse to utility companies.
3. **Stability and predictability** of the rates themselves, with a minimum of unexpected changes seriously adverse

to ratepayers and with a sense of historical continuity.

4. **Static efficiency** of the rate classes and rate blocks in discouraging wasteful use of service while promoting all justified types and amounts of use:
    a. In the control of the total amounts of service supplied by the company;
    b. In the control of the relative uses of alternative types of service by ratepayers (on-peak versus off-peak service or higher quality versus lower quality service).
5. **Reflection of all of the present and future private and social costs and benefits** occasioned by a service's provision (i.e., all internalities and externalities).
6. **Fairness of the specific rates** in the apportionment of total cost of service among the different ratepayers so as to avoid arbitrariness and capriciousness and to attain equity in three dimensions:
7. **Avoidance of undue discrimination** in rate relationships so as to be, if possible, compensatory (i.e., subsidy free with no inter-customer burdens).
8. **Dynamic Efficiency** in promoting innovation and responding economically to changing demand and supply patterns.
9. The related, practical attributes of simplicity, certainty, convenience of payment, economy of collection, understandability, public acceptability, and feasibility of application.
10. **Freedom from controversies as to proper interpretation.**

Bond Default Rates: In percent:

Rating Categories	Moody's		S&P	
	Municipal	Corporate	Municipal	Corporate
Aaa/AAA	0.00	0.52	0.00	0.60
Aa/AA	0.06	0.52	0.00	1.50
A/A	0.03	1.29	0.23	2.91
Baa/BBB	0.13	4.64	0.32	10.29
Ba/BB	2.65	19.12	1.74	29.93
B/B	11.86	43.34	8.48	53.72
Caa-C/CCC-C	16.58	69.18	44.81	69.19
Investment Grade	0.07	2.09	0.20	4.14
Non-Invest Grade	4.29	31.37	7.37	42.35
All	0.10	9.70	0.29	12.98

Bond Market Ratings Risk and Scandal: A bond is considered investment grade or IG if its credit rating is BBB- or higher by Standard & Poors or Baa3 or higher by Moody's. Generally they are bonds that are judged by the rating agency as likely enough to meet payment obligations that banks are allowed to invest in them. Bonds that are not rated as investment-grade bonds are known as high yield bonds or more derisively as junk bonds. The risks associated with investment-grade bonds (or investment-grade corporate debt) are considered significantly higher than those associated with first-class government bonds. The difference between rates for first-class government bonds and investment-grade bonds is called *investment-grade spread*. The range of this spread is an indicator of the market's belief in the stability of the economy. The higher these investment-grade spreads (or risk premium) are, the weaker the economy is considered. Until the early 1970s, bond credit ratings agencies were paid for their work by investors who wanted impartial information on the credit worthiness of securities issuers and their particular offerings. Starting in the early 1970s, the "Big Three" ratings agencies (S&P, Moody's, and Fitch) began to receive payment for their work by the securities issuers for whom they issue those ratings, which has led to charges that these ratings agencies can no longer always be impartial when issuing ratings for those securities issuers. Securities issuers have been accused of "shopping" for the best ratings from these three ratings agencies, in order to attract investors, until at least one of the agencies delivers favorable ratings. This arrangement has been cited as one of the primary causes of the *subprime mortgage crisis* (which began in 2007), when some securities, particularly mortgage-backed securities and *collateralized debt obligations* (CDOs) rated highly by the credit ratings agencies, and thus heavily invested in by many organizations and individuals, were rapidly and vastly devalued due to defaults, and fear of defaults, on some of the individual components of those securities, such as home loans and credit card accounts.

Bond Rating: A bond rating is a grade given to bonds that indicates their credit quality. Independent rating services (Standard &

Poor's, Moody's Investors Service and Fitch Ratings Inc.) provide evaluations of a bond issuer's financial strength, or its the ability to pay a bond's principal and interest in a timely manner. Higher rated bonds, known as investment grade bonds, are seen as safer and more stable investments that are tied to corporations or government entities that have a positive outlook. Investment grade bonds contain “AAA” to “BBB-“ (or Aaa to Baa3 for Moody’s rating scale) ratings and will usually see bond yields increase as ratings decrease. Most of the most common "AAA" bond securities are in U.S. Treasury Bonds. Non-investment grade bonds or “junk bonds” usually carry ratings of “BB+” to “D” (Baa1 to C for Moody’s) and even “not rated.” Bonds that carry these ratings are seen as higher risk investments that are able to attract investor attention through their high yields. However, investors of junk bonds should note the implications and risks that are involved with investing in bonds that are issued by companies with liquidity issues.

Bond Ratings for S&P, Moody’s, and Fitch

Moody's		S&P		Fitch
Long-term	Short-term	Long-term	Short-term	Long-term
Aaa	P-1	AAA	A-1+	AAA
Aa1		AA+		AA+
Aa2		AA		AA
Aa3		AA−		AA−
A1		A+	A-1	A+
A2		A		A
A3	P-2	A−	A-2	A−
Baa1		BBB+		BBB+
Baa2	P-3	BBB	A-3	BBB
Baa3		BBB−		BBB−
Non-Investment Grade Ba1	Not prime	BB+	B	BB+
Ba2		BB		BB
Ba3		BB−		BB−
B1		B+		B+
B2		B		B
B3		B−		B−
Caa1		CCC+	C	CCC
Caa2		CCC		
Caa3		CCC−		
Ca		CC		
		C		
C		D	/	DDD
/				DD
				D

BOND RATING COMPANIES – A Brief History

John Moody published the first publicly available bond ratings (mostly concerning railroad bonds) in 1909. Moody's firm was followed by Poor's Publishing Company in 1916, the Standard Statistics Company in 1922, and the Fitch Publishing Company in 1924. In 1936, the Office of the Comptroller of the Currency prohibited banks from investing in "speculative investment securities," as determined by "recognized rating manuals" (i.e., Moody's, Poor's, Standard, and Fitch). "Speculative" securities were bonds that were below "investment grade," thereby forcing banks that invested in bonds to hold only those bonds that were rated highly (e.g., BBB or better on the S&P scale) by these four agencies. In effect, regulators had endowed third-party safety judgments with the force of law. In the following decades, insurance regulators and then pension fund regulators followed with similar regulatory actions that forced their regulated financial institutions to heed the judgments of a handful of credit rating agencies.

In 1975, the SEC designated Moody's, S&P, and Fitch as "Nationally Recognized Statistical Rating Organizations" (NRSROs). In effect, the SEC endorsed the ratings of NRSROs for the determination of the broker-dealers' capital requirements. Other financial regulators soon followed suit and deemed the SEC-identified NRSROs as the relevant sources of the ratings required for evaluations of the bond portfolios of their regulated financial institutions. It is important to note that, in place of the "investor pays" model established by John Moody in 1909, the agencies converted to an "issuer pays" model during the early 1970s whereby the entity that is issuing the bonds also pays the rating firm to rate the bonds. This change opened the door to potential conflicts of interest: A rating agency might shade its rating upward so as to keep the issuer happy and forestall the issuer's taking its business to a different rating agency.

To a large extent, subprime lending fueled the U.S. housing boom that began in the late 1990s and ran through mid-2006. The securitization of the subprime mortgage loans, in collateralized debt obligations (CDOs) and other mortgage-related securities, encouraged subprime lending and led to the development of other financing structures, such as "structured investment vehicles" (SIVs), whereby a financial institution might sponsor the creation of an entity that bought tranches of the CDOs and financed its purchase by issuing short-term "asset-backed" commercial paper (ABCP). If rating agencies rated the CDO tranches in an SIV favorably, that favorable rating concomitantly meant high ABCP ratings (interest-rate risk and liquidity risk were apparently ignored in the ratings). Hence, the agencies' favorable ratings of mortgage-related securities were crucial for the securitization process. Lawrence J. White, Robert Kavesh Professor of Economics, New York University, October 2009.

Bond Rating Tier Definitions

Moody's	Standard & Poor's	Fitch	Credit Worthiness
Aaa	AAA	AAA	An obligor has EXTREMELY STRONG capacity to meet its financial commitments.
Aa1	AA+	AA+	An obligor has VERY STRONG capacity to meet its financial commitments. It differs from the highest-rated obligors only to a small degree.
Aa2	AA	AA	
Aa3	AA−	AA−	
A1	A+	A+	An obligor has STRONG capacity to meet its financial commitments but is somewhat more susceptible to the adverse effects of changes in circumstances and economic conditions than obligors in higher-rated categories.
A2	A	A	
A3	A−	A−	
Baa1	BBB+	BBB+	An obligor has ADEQUATE capacity to meet its financial commitments. However, adverse economic conditions or changing circum-stances are more likely to lead to a weakened capacity of the obligor to meet its financial commitments.
Baa2	BBB	BBB	
Baa3	BBB−	BBB−	
Ba1	BB+	BB+	An obligor is LESS VULNERABLE in the near term than other lower-rated obligors. However, it faces major ongoing uncertainties and exposure to adverse business, financial, or economic conditions which could lead to the obligor's inadequate capacity to meet its financial commitments.
Ba2	BB	BB	
Ba3	BB−	BB−	
B1	B+	B+	An obligor is MORE VULNERABLE than the obligors rated 'BB', but the obligor currently has the capacity to meet its financial commitments. Adverse business, financial, or economic conditions will likely impair the obligor's capacity or willingness to meet its financial commitments.
B2	B	B	
B3	B−	B−	
Caa	CCC	CCC	An obligor is CURRENTLY VULNERABLE, and is dependent upon favourable business, financial, and economic conditions to meet its financial commitments.
Ca	CC	CC	An obligor is CURRENTLY HIGHLY-VULNERABLE.
	C	C	The obligor is CURRENTLY HIGHLY-VULNERABLE to nonpayment. May be used where a bankruptcy petition has been filed.
C	D	D	An obligor has failed to pay one or more of its financial obligations (rated or unrated) when it became due.
e, p	Pr	Expected	Preliminary ratings may be assigned to obligations pending receipt of final documentation and legal opinions. The final rating may differ from the preliminary rating.
WR			Rating withdrawn for reasons including: debt maturity, calls, puts, conversions, etc., or business reasons (e.g. change in the size of a debt issue), or the issuer defaults.
Unsolicited	Unsolicited		This rating was initiated by the ratings agency and not requested by the issuer.
	SD	RD	This rating is assigned when the agency believes that the obligor has selectively defaulted on a specific issue or class of obligations but it will continue to meet its payment obligations on other issues or classes of obligations in a timely manner.
NR	NR	NR	No rating has been requested, or there is insufficient information on which to base a rating.

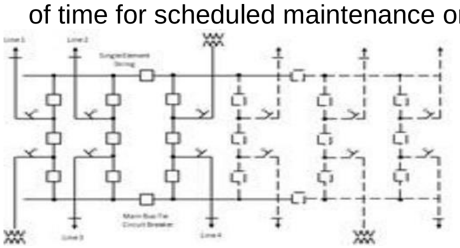
Book Value: The amount shown in the company's books (or in the accounts) for an asset, liability, or owners' equity item. Generally used to refer to the net amount of an asset or group of assets shown in the account, which records the asset and reductions, such as for depreciation or amortization, in its cost.

Bottom Ash: Residue mainly from the coal burning process that falls to the bottom of the boiler for removal and disposal. (EIA)

Bottoming Cycle: A waste-heat recovery boiler recaptures the unused energy and uses it to produce steam to drive a steam turbine generator to produce electricity.(EIA)

Box – Jenkins (statistical forecasting): Like other forecasting techniques, the Box-Jenkins approach attempts to help decision- makers better anticipate the potential ramifications of changes in the business environment (e.g., new technologies, regulations, input cost changes). The Box-Jenkins method was developed in about 1967 as a time-series method by applying Autoregressive Moving Average (ARMA) or Autoregressive Integrated Moving Average (ARIMA) models to find the best fit of a time-series model to past values of a time series. Box-Jenkins is as an efficient and credible use of historical data with relatively low computational requirements. The technique is capable of developing multi-variable stochastic-dynamic models in which the behavior of the variable of primary interest (the endogenous variable - the variable we wish to forecast) is related not only to its past behavior, but to the behavior of other (exogenous) variables as well. The Box-Jenkins approach can also be as uncomplicated as a simple smoothing method (i.e., determine some sort of "average" value around which the observations appear to be fluctuating. Two examples of smoothing procedures are the moving average method and exponential smoothing). or involve a number of economic variables. The purely stochastic Box-Jenkins model is relatively simple. That is, the current observation is represented by a linear combination (weighted average) of previous observations, plus an error term associated with the current observation, plus a linear combination of error terms associated with previous observations. The error terms have zero mean, constant variance, and are uncorrelated with each other. The portion of the model involving the observations is called the *autoregressive* part of the model, and the portion involving the error terms is called the *moving average* part of the model. The problem of building a stochastic Box-Jenkins model is determining the number of terms and the value of those terms in the autoregressive and moving average parts of the model.

Breaker-and-a-Half (see also Bus, Ring Bus and Straight Bus): The breaker-and-a-half configuration is composed of two main buses connected by element strings (bays). Each element string is composed of circuit breakers, transformers or line elements as shown below. When multiple strings are installed, it is recommended that bus-sectionalizing breakers are installed such that no more than two strings are grouped on the same bus section. Note that all elements in a breaker-and-a-half scheme terminate between breakers with no elements connected directly to the main buses. In addition, each element is connected to the bus via a disconnect switch or circuit switcher. This would ensure that the bus stays intact while one or more of the elements connected to the bus stay out of service for an extended period of time for scheduled maintenance or repairs.



Breakeven Price: The break-even point (BEP) in economics, business, and cost accounting, is the point at which total cost and total revenue are equal: there is no net loss or gain, and one has "broken even." A profit or a loss has not been made, although opportunity costs have been "paid", and capital has received the risk-adjusted, expected return. For a regulated utility, the breakeven point may also be where the benefits to customers exceed the costs to customers. For example, at what point does the cost of a new power point equal the financial benefits (broadly speaking) to customers.

Brown-Out: A system voltage reduction in response to a shortage of power relative to demand; though service is not disrupted completely, causes, for example, a dimming of light.

Brownfield Pipeline Expansion (Natural Gas): The addition of a compression facility and/or compression looping to an existing pipeline.

Brownfield Site: A site that was previously developed and has been set aside for renewed development or restoration is called a "brownfield site." In some cases, brownfield sites may be easier to obtain environmental approvals and may also already have infrastructure such as generation facilities, natural gas pipeline, or rail lines needed by utilities for development of their transmission and / or generation facilities and on a more cost-efficient basis.

BTU (British Thermal Unit): Btu is a measure of the heating value of a fuel. It is the amount of heat energy required to raise the temperature of one pound of water one degree Fahrenheit. Electricity has 3,413 Btus/kWh. Natural Gas has 1,000 Btus per cubic foot, coal (subbituminous) has 8,800 Btus per pound.

Bubbling Fluidized Bed Reactor (BFB): Bubbling Fluidized Bed technology may be used to repower an existing generating facility, recovery boiler conversions, or when changing fuel of an existing boiler. Typical fuels include primary and secondary sludge, bark, and wood waste products (such as paper mills). BFB can burn a wide range of fuels. Requires less maintenance, and produce less NOx and SO_2 emissions and may reduce landfill requirements. BFB may also be less capital intensive and have lower operating expenses. This process has been used by the petro-chemical industry for years.

Built-Environment Wind Turbine (BEWT): According to NREL, BEWT are wind energy projects that are constructed on, in, or near buildings. These projects present an opportunity for distributed, low-carbon generation combined with highly visible statements on sustainability, but the BEWT niche of the wind industry is still developing and is relatively less mature than the utility-scale wind or conventional ground-based distributed wind sectors.

Bulk Power System (BPS) Also referred to as the **Bulk Electric System** (BES): An electric system's generation resources, system control and high voltage transmission components. As defined by the Regional Reliability Organization, the electrical generation resources, transmission lines, interconnections with neighboring systems, and associated equipment, generally operated at voltages of 100 kV or higher. Radial transmission facilities serving only load with one transmission source are generally not included in this definition. (See more expansive NERC definition)

Bulk Power Transactions: The wholesale sale, purchase, and interchange of electricity among electric utilities. Bulk power transactions are used by electric utilities for many different aspects of electric utility operations, from maintaining load to reducing costs.

Bundled Utility Service (Electric): A means of operation whereby energy, transmission, and distribution services, as well as ancillary and retail services, are provided by one entity.

Burden: Operation of the Bulk Electric System that violates or is expected to violate a System Operating Limit in the Interconnection Reliability Operating Limit, or that violates any other NERC Regional Reliability Organization, or local operating reliability standards or criteria. (NERC)

Bus: Electrical conducting devise use to connect multiple power system equipment elements.

Bushing: A cylindrical insulating component, usually made of ceramic, that houses a conductor. It enables a conductor to pass through a grounded enclosure such as the shell of a transformer, a wall or other physical barrier, to connect electrical installations. In the case of a transformer, bushings protect the conductors that connect a transformer's core to the power system it serves through channels in the transformer's housing.

Business as Usual (BAU) (Sometimes referred to a "BAU" or "Reference Case"), should be regarded as the most likely future and largely as an extension of the status quo which constitutes existing resources, laws, polices as well as the best estimate of forecasted electrical requirements, fuel price projections, economic factors, and other factors affecting the long-term provision of electric service. The Base Case constitutes a datum upon which to construct an objective judgement and analysis of the resources required over a planning horizon (e.g., 20 years) to reliability and economically satisfy electrical needs. For robust consideration of potential risks, alternative scenarios should be constructed and compared to the Base Case. The Base Case should include existing federal environmental laws, current state laws such as renewable energy requirements and energy efficiency laws, and present policies such as tax incentives for resources that are certain. With exercising care, a Base Case may also include laws and policies that have a high probability of being enacted or continuing throughout at least some portion of the planning horizon and, if deemed to be appropriate, eliminated or altered thereafter. Future laws, policies, and resources that are not certain or have a very high probability within 3 to 5 years should not be included in the Base Case unless a compelling argument can be made for their inclusion. Since the objective of the Base Case in resource planning is to find the optimal resources to meet the most likely electricity requirements, there is a rebuttable presumption, but not prohibition, against inclusion of potential resources, laws, or policies beyond three to five years to prevent an undue bias of the analysis that would adversely affect the objectivity and credibility of the Base Case and its value as a comparison against other potential futures (scenarios).

Policies as Usual. In this construct, the BAU case means that the existing federal and state laws continue in place without change throughout the foreseeable planning horizon. For example, existing RPS' that differ from state to state are assumed to continue without modification; carbon regulation is not in place; current best available economic projections are applied; currently approved transmission and generation (e.g. <u>known</u> resources) are a part of the base projections. In other words, it would be inconsistent with a "business as usual" case to construct a business as usual case that included carbon regulation since there are no rules in place. We hope that every Planning Authority has a consistent definition.

> Policies as Usual does NOT need to mean Balkanized planning Practices as Usual, however. Rather, once the BAU assumptions are understood by all, the long range generation and transmission optimization is performed on an interconnection-wide basis.

Practices as Usual. In this construct, the same existing policies are applied as in the Policies as Usual approach, but the existing planning practices of each region or utility are assumed to continue without the benefit of an interconnection-wide common view-point. The sub-optimally developed regional plans are then rolled together and "rationalized" to address inconsistencies.

This process, while comfortable and efficient at the regional level, does not take advantage of the benefits of the interconnection-wide perspective except as an afterthought in making sure things "fit together" at the end of the roll-up.

Buy and Sell All: (BASA): For customers owning renewable energy resources, the utility chanrges and compensates the owners at below retail rates.

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California Deregulation: California led the way in trying to promote retail competition in the electric markets. Partial deregulation of the electric markets was enacted in 1996 by the California Legislature (AB 1890) and signed into law by Governor Pete Wilson. [see also the Western Energy Crisis of 2000-2001]. Following the blackouts, brownouts, and market manipulation problems in California, retail deregulation and retail competition efforts stalled and, in some instances, were reversed.

California Independent System Operator (CASIO):

Calorimeter: Devices used extensively in measuring the quantity of the heat content of natural gas.

CANDU: A nuclear reactor of a Canadian design in which the fuel is unenriched uranium oxide clad in zircaloy and the coolant and moderator is heavy water.

Cap and Trade (see also Carbon Tax); A government-mandated but market-based approach to controlling pollution by providing economic incentives for achieving reductions in the emissions of pollutants. In contrast to command-and-control environmental regulations such as best available technology (BAT) standards and government subsidies, cap and trade (CAT) provides greater flexibility in compliance with environmental regulations by allowing organizations to decide how best to meet policy targets. A central authority (usually a governmental body) allocates or sells a limited number of permits to discharge specific quantities of a specific pollutant per time period. Polluters are required to hold permits in amount equal to their emissions. Polluters that want to increase their emissions must buy permits from others willing to sell them. Financial derivatives of permits can also be traded on secondary markets. In theory, polluters who can reduce emissions most cheaply will do so, achieving the emission reduction at the lowest cost to society.

Capacitance (see also Capacitor): The ability of a device to store an electrical charge (electrical charge is what flows in electric current).

Capacitor: A device that stores electrical charge and is used to improve power factor and/or help with voltage regulation.

Capacitor Banks: Can be used to increase the reactive power at a system bus to return voltage levels to nominal operating values. This method of increasing reactive-power support is often used to minimize voltage support problems and improve system stability.

Capacity: The rated, continuous load-carrying ability of generation, transmission or other electrical equipment (expressed in megawatts, megavolt-amperes or megavolt-amperes-reactive).

Capacity Benefit Margin (CBM): The amount of firm transmission transfer capability preserved by the transmission provider for Load-Serving Entities (LSEs), whose loads are located on that Transmission Service Provider's system, to enable access by the LSEs to generation from interconnected systems to meet generation reliability requirements. Preservation of CBM for an LSE allows that entity to reduce its installed generating capacity below that which may otherwise have been necessary without interconnections to meet its generation reliability requirements. The transmission transfer capability preserved as CBM is intended to be used by the LSE only in times of emergency generation deficiencies. (NERC)

Capacity Charge: An element in a two-part pricing method used in capacity transactions (energy charge is the other element). The capacity charge, sometimes called *Demand Charge*, is assessed on the amount of capacity being purchased.

Capacity Credit: The *Capacity Credit* should be calculated for renewable generation, demand response, energy efficiency, and customer owned resources to contribute to resource adequacy. However, RTOs / ISOs and utilities differ on how to calculate the capacity credit. Capacity credits might be calculated in several ways. One would be to base the capacity credit on the credits offered by other RTOs / ISOs or utilities or empirical research. The capacity credit might also be estimated by using the *net capacity factor* by taking the amount of generation in peak periods or hours with the greatest *loss of load probability,* divided by the total net rated capacity during those periods. A third approach would be to calculate the *Exceedance Probability* which is the probability that a resource's net capacity factor will exceed a specified level during peak demand periods. A fourth approach might be described as a *Probability-Based Approach.* This would be the marginal effect of a resource on local or system *loss of load probability, with the effective load carrying capacity* ELCC.

Capacity Emergency: A capacity emergency exists when a Balancing Authority Area's operating capacity, plus firm purchases from other systems, to the extent available or limited by transfer capability, is inadequate to meet its demand plus its regulating requirements. NERC

Capacity Emergency Transfer Limit (CETL): CETL is the capability of the transmission system to support deliveries of electric energy to a given area experiencing a localized capacity emergency.

Capacity Emergency Transfer Objective (CETO - PJM): PJM's current Reliability Pricing Model ("RPM") modeling practices direct all external Firm Point-to-Point transmission resources to the Rest of RTO, even when the historic external Firm Point-to-Point transmission sinks at the constrained zone. PJM uses this transfer capability in the Capacity Emergency Transfer Objective/Capacity Emergency Transfer Limit ("CETO/CETL") calculation without allocating the benefits of such transfer capability to the transmission holder into the constrained Zone/Locational Delivery Area ("LDA").

Capacity Expansion Models CEM): simulate the economic dispatch of both the existing and potential future power systems. These computer simulation models are used by utilities and other parties to determine when new resources need to be added to the existing power system to maintain reliability. These models evaluate alternative resource development plans to identify the mix of resources that best meets specific objectives, such as minimizing cost, limiting risk or reducing emissions. The objective of most of these models is to determine the optimum capacity expansion schedule that maintains system reliability and, typically, minimizes the present value of capacity and operating cost. (LBL)

Capacity Factor: The ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full power operation during the same period.

$$Capacity\ factor = \frac{(actual\ energy\ produced\ or\ supplied\ in\ time\ T)}{maximum\ plant\ rating \times T}$$

$$Annual\ capacity\ factor = \frac{actual\ annual\ energy\ generation}{maximum\ plant\ rating\ \times 8760}$$

Capacity Margin (CM) (see also Reserve Margin): It is a measure of resource adequacy. It is the percentage difference between rated capacity and peak load divided by rated capacity. In other words, it is the margin of capability available to provide for scheduled maintenance, emergency outages, system operating requirements, and unforeseen loads, calculated as the difference between net capability and system maximum load requirements (peak load):
While Reserve Margin and Capacity Margin are definitions of Resource Adequacy, the two measures produce different results. An 18.9 percent reserve margin is equivalent to a 15.9 percent capacity margin. Note the numerators are the same but the more often used Reserve Margin is divided by Peak Demand while the Capacity Margin is divided by Capacity.

Capacity Margin = [(Capacity-Peak Demand)/Capacity]

Reserve Margin = [(Capacity-Peak Demand)/Peak Demand]

Capacity Market: A market that provides economic incentives to attract investment in new and existing supply-side, and often demand-side, capacity resources as needed to maintain bulk power system reliability requirements (see also Forward Capacity Market, Installed Capacity Market used by New England ISO, and Reliability Pricing Model used by the PJM).

Capacity Performance Resource: A generating unit or DER that has obligated itself to be dispatched by the RTO when it is needed.

Capacity Planning (see Integrated Resource Planning): Fully integrated resource (capacity) planning is **t**he process of determining the amount, type, and timing of future resources which should be more expansive than traditional resource planning that often excluded transmission planning and customer-owned resources. By including DSM, customer-owned resources, storage, and some new technologies, capacity planning should also include distribution planning. Capacity Planning should address a set of specified constraints such as resource adequacy and at the lowest delivered cost to customers reasonably feasible over for long time-planning horizons (e.g., a few years to multiple decades). Increasingly, capacity planning may address *resiliency* as a specified constraint. Hopefully, resiliency can be operationally defined and quantified (e.g., in addition to operational characteristics of different resources, resiliency seems to conceptually include the value of fuel reliability as well as diversity of resources, loads, inertia, and locational diversity).

Increasing computer capabilities fosters the development of the next generation of software tools that, along with higher quality data and significantly expanded databases, would enable planners to integrate chronological, hourly (and sub-hourly) time steps for demand, wind, and solar, and unit-level operational details within long-range capacity planning models. Historically, reliance on models that used *Load Duration Curves*, while computationally efficient, lost the chronological details required to accurately model certain resources (e.g., demand response, intermittent resources, and storage technologies. Storage technologies present a unique modeling challenge in long-term planning since the devices' ability to charge or discharge power in any given period is a direct function of its state in the previous period. Retaining chronological detail is therefore imperative in accurately modeling the value storage can add to a power system.

Spatial resolution of capacity models is also important. For individual utilities, resource decisions may be increasingly influenced regional resource decisions – including transmission. Regional or, even, interconnection-wide planning typically requires trade-offs that sacrifice detail due to computational limitations. For example, large regions may opt for a simplified representation of power flow based on a transmission system that is characterized by *copper sheeting* to represent interregional trade without constraints. Broad regional planning may opt for detailed power flow and make simplifying assumptions about retirements, uprates, new resources, DSM, and customer-owned resources. In contrast, a utility's plan may provide considerable detail on their system's load and resources but largely ignore inter-regional trade by utilizing a simplified *pipe and bubble* representation that ignores actual power flow. Hopefully, future models may reduce these trade-offs that reduce the credibility of the results.

Capacity Release Market: Where natural gas shippers may offer the rights of some or all of their firm capacity in exchange for revenue credits.

Capacity Resource: A generating resource, demand response, energy efficiency or other Distributed Energy Resource (DER) that has obligated itself to be dispatched as needed by the RTO.

Capacity Transaction: The acquisition of a specified quantity of generating capacity from another utility for a specified period of time. The utility selling the power is obligated to make available to the buyer a specified quantity of power.

Capacity Utilization: Capacity utilization is computed by dividing production by productive capacity and multiplying by 100.

Capital Budget: The utility's plan for proposed acquisitions and replacements of long-term assets and their financing.

Capital Cost Normalization: A utility is allowed to recover prudently incurred costs – including capital costs – that are incurred during a *Test Year.* The test year is regarded as being representative of normal or typical expenses incurred. Extraordinary costs that are prudently incurred and might be required by legislative and regulatory requirements (e.g., changing environmental requirements) are often considered outside of the test year but included in rates. In many instances, these are constructed as "trackers." Throughout much of the 1990s – 2017, there were very few rate cases. The fact that utilities rarely came in for rate cases during this period suggests rates may have been too high which allowed utilities to realize revenues in excess of the amount the utilities said they needed at the time the rates were set.

Capital Expenditure (CapEx): Funds used by a company to acquire or upgrade physical assets such as property, industrial buildings or equipment. It is often used to undertake new projects or investments by the firm. This type of outlay is also made by companies to maintain or increase the scope of their operations. These expenditures can include everything from repairing a roof to building, to purchasing a piece of equipment, or building a brand new factory. In Asset Management, for example, CAPEX that closely matches depreciation is a means of addressing *renewal* and *replacement* of infrastructure or equipment.

Capital Recovery Factor (CRF) (see also Discount Rate): A CRF is the ratio of a constant annuity to the *present value* (PV) of receiving that annuity (equal amounts) for a given length of time at a specific *discount rate*.

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

Where:

i is the interest rate; and n is the number of annuities received.

Capital Structure: Is the amount of debt and equity capital used to fund utility operations. This combination of debt and equity capital is called the capital structure and is often determined by the historic or embedded levels of different capital types. An optimal capital structure seeks to minimize the cost of financing for a utility. Of course, the dynamics of the financial markets make it impossible to determine the optimal capital structure with certainty. Some companies use their *Weighted Average Cost of Capital* (WACC) if the project's risk profile is similar to that of the company. However, if the project's risk profile is substantially different from that of the company, the *Capital Asset Pricing Model* (CAPM) may be used to calculate a project-specific discount rate that more accurately reflects its unique risk.

Capitalization and Capitalization Ratio: Capitalization is the company's long-term debt, preferred stock, and owners' equity. The capitalization ratio is the *p*ercentage of long-term debt, preferred stock, and common stock equity to total capitalization.

Captive Coal (see also Ohio Power Gap case)**:** A generator at the electric plant site that provides power for the operation of the electrical generating equipment itself, including related demands such as plant lighting, during periods when the electric plant is not operating and power is unavailable from the grid. A black start generator used to start main central station generators is considered to be an auxiliary generator.

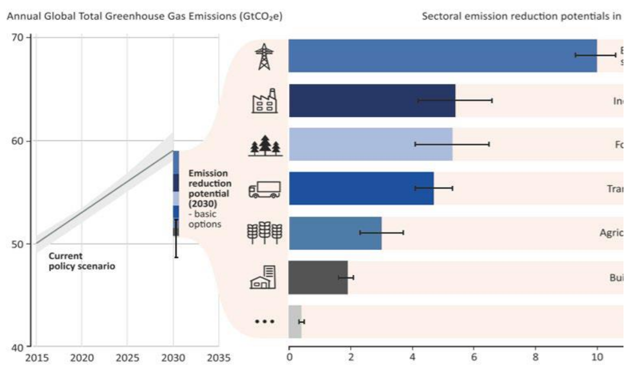
Carbon Budget: The balance of the exchanges (incomes and losses) of carbon between carbon sinks (e.g., atmosphere and biosphere) in the carbon cycle. see Carbon sink. (EIA)

Carbon Cycle: All carbon sinks and exchanges of carbon from one sink to another by various chemical, physical, geological, and biological processes. Also see Carbon sink. (EIA)

Carbon Dioxide (CO_2): A colorless, odorless, non-poisonous gas that is a normal part of Earth's atmosphere. Carbon dioxide is a product of fossil-fuel combustion as well as other processes. It is considered a greenhouse gas as it traps heat (infrared energy) radiated by the Earth into the atmosphere and thereby contributes to the potential for global warming. The global warming potential (GWP) of other greenhouse gases is measured in relation to that of carbon dioxide, which by international scientific convention is assigned a value of one (1). (See also *Global Warming Potential (GWP) and Greenhouse Gases)* (EIA)

Carbon Dioxide Equivalent: The amount of carbon dioxide by weight emitted into the atmosphere that would produce the same estimated radiative forcing as a given weight of another radiatively active gas. Carbon dioxide equivalents are computed by multiplying the weight of the gas being measured (for example, methane)by its estimated global warming potential (which is 21 for methane)."Carbon equivalent units" are defined as carbon dioxide equivalents multiplied by the carbon content of carbon dioxide (i.e., 12/44). (EIA)

Carbon Intensity: The amount of carbon by weight emitted per unit of energy consumed. A common measure of carbon intensity is weight of carbon per British thermal unit (Btu) of energy. When there is only one fossil fuel under consideration, the carbon intensity and the emissions coefficient are identical. When there are several fuels, carbon intensity is based on their combined emissions coefficients weighted by their energy consumption levels. (*See also Emissions Coefficient and Carbon Output Rate)*. The following graphic is from U.N. Environment Program (UNEP) said in its annual Emissions Gap Report published Nov 26, 2019.



Carbon Output Rate: The amount of carbon by weight per kilowatthour of electricity produced.

Carbon Sequestration (a/k/a Storage): The fixation of atmospheric carbon dioxide in a carbon sink through biological or physical processes.

Carbon Sink: A reservoir that absorbs or takes up released carbon from another part of the carbon cycle. The four sinks, which are regions of the Earth within which carbon behaves in a systematic manner, are the atmosphere, terrestrial biosphere (usually including freshwater systems), oceans, and sediments (including fossil fuels). EIA

Carbon Tax (see also Cap and Trade): A Carbon Tax is a fee intended to make users of fossil fuels pay for climate damage their fuel use imposes by releasing carbon dioxide (could be applied to other pollutants) or to maintain infrastructure such as the tax on gasoline. Proponents of a Tax also argue it provides a motivation to reduce use and to switch to cleaner energy and proceeds from the Tax might be used to subsidize renewable energy (perhaps including nuclear generation) or other public policy goals such as transportation infrastructure. A Carbon Tax could be applied to all fossil fuels – including imported goods. For resource modeling, a Tax is easier to model.

CARP (Cost Allocation and Resource Planning): CARP process established by the Organization of MISO States and Chaired by Commissioner Lauren Azar of Wisconsin. The CARP was intended to alleviate the inherent controversy regarding the pricing of new transmission. The CARP process was analytically intensive, transparent and supported by the MISO and stakeholders to establish a recommended transmission pricing protocol for the Midcontinent ISO.

Carrying Charges: Typically the cost of the time value of money associated with a project (i.e., allowance of funds used during construction - AFUDC). It also may include other short-term costs such as costs associated with storing a physical commodity, holding a financial instrument over a defined period of time, insurance or interest charges on borrowed funds.

Carrying Costs: Costs incurred in order to retain exploration and property rights after acquisition but before production has occurred. Carrying charges include insurance, storage costs, interest charges on borrowed funds, and other related costs. Carrying cost is associated with storing a physical commodity or holding a financial instrument over a defined period of time. For electric, natural gas, and water / sewer utilities, these often are included in *Allowance for Funds Used During Construction (AFUDC).* That is, construction projects often incur carrying costs such as booking interest expenses associated with funding the project until such time as the regulator determines that the project's costs are prudent and should be included in rates. The carrying costs of the capital expenses are a legitimate cost of doing business and compensate investors for providing the funds.

Cartel (see also OPEC): Cartels are groups of independent producers that produce a homogenous product (e.g., oil). Typically, a cartel is an *oligopoly*, whose goal is to increase their collective profits by means of price fixing by regulating (typically limiting) supply or other restraints of trade. U.S. antitrust laws forbid firms in the United States from participating in cartels. In OPEC, for example, Saudi Arabia is considered to be the pivotal supplier that can enforce production quotas that largely dictate the price of world oil. The other largest members of the Cartel are generally accepting of the Saudi production quotas because it bolsters their domestic prices. However, there are several smaller sellers that often cheat on production quotas to maintain their revenues. The pivotal supplier(s) will often discipline OPEC members that do not adhere to the production quotas by increasing production and depressing the worldwide price of oil.

Cascading Blackouts (see also Blackout and Rolling Blackout): An uncontrolled successive loss of system elements triggered by an incident at any locale which typically results in widespread service interruptions and cannot be restrained from spreading ("cascading") beyond an area predetermined by appropriate studies.

Cash Basis Accounting (see also Accrual Basis Accounting): Revenues are recorded when cash is received and expenditures are recorded when cash is disbursed.

Central Air Conditioners (AC): circulate cool air through a system of supply and return ducts and registers. As the cooled air becomes warmer due to circulation though the home or business, it flows back to the central AC through return ducts and registers. Air conditioners help dehumidify the home or business. A central AC is either a split system or a package unit. In a split system, the central AC has an outdoor cabinet that contains the *condenser* (cools refrigerant to cause it to change from a gas to a liquid and removes the thermal energy from the system) *and compressor* (uses electric power to increase the pressure of the refrigerant) and an indoor cabinet contains the *evaporator* (cooling coils heats refrigerant and cools air, refrigerant changes back to gas and adds thermal energy to the system). The indoor cabinet may also contain a furnace or the indoor part of a heat pump. A packaged central AC the evaporator, condenser , and compressor are all located in one cabinet (usually on a roof). Packaged AC units often have heading coils or a natural gas furnace which eliminates the need for a separate furnace indoors. Effective January 2015, air conditioners (standard for split systems) will have a *Seasonal Energy Efficiency Rating* (SEER) of 14 or above. Also beginning in 2015, central AC units installed in the Southwest (CA, AZ, NM, and NV) will also have to meet the new Energy Efficiency Ratio (EER) standard that varies by cooling capacity.

Central Limit Theorem (CLT – see also Normal Distribution). In probability theory, CLT results when the sum *of independent random variables* tends toward a *normal distribution* (i.e., a *bell curve*) even in instances where the variables are not normally distributed. The *arithmetic mean* of a sufficiently large number of iterates of independent random variables, each with a well-defined (finite) expected value and finite variance, will be approximate a normal distribution; regardless of the underlying distribution. The theorem is a key concept in probability theory because it implies that probabilistic and statistical methods that work for normal distributions can be applicable to many problems involving other types of distributions.

Certificated Capacity (Natural Gas): The capability of a pipeline project to move gas volumes on a given day, based on a specific set of flowing parameters (operating pressures, temperature, efficiency, and fluid properties) for the pipeline system as stated in the dockets filed (and subsequently certified) in the volume used in computing the average daily flow rate is the volume associated with the direction of flowing gas on the peak day.

Chained Dollars: A measure used to express real prices. Real prices are those that have been adjusted to remove the effect of changes in the purchasing power of the dollar; they usually reflect buying power relative to a reference year. Prior to 1996, real prices were expressed in constant dollars, a measure based on the weights of goods and services in a single year, usually a recent year. In 1996, the U.S. Department of Commerce introduced the chained-dollar measure. The new measure is based on the average weights of goods and services in successive pairs of years. It is "chained" because the second year in each pair, with its weights, becomes the first year of the next pair. The advantage of using the chained-dollar measure is that it is more closely related to any given period covered and is therefore subject to less distortion over time.

Charge Voltage: The voltage that the battery is charged to when charged to full capacity. Charging schemes generally consist of a constant current charging until the battery voltage reaching the charge voltage, then constant voltage charging, allowing the charge current to taper until it is very small.

China Syndrome: A phrase that has no scientific basis but is intended to describe a fictional result of a nuclear meltdown, where reactor components melt through their containment structures and into the underlying earth -all the way to China. The events at Chernobyl and Fukishima while terrible have proved that the China Syndrome will not occur.

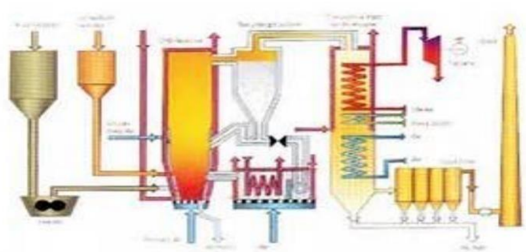
Chronological Dispatch: For purposes of planning and operational power system, modeling maintaining the time information (chronology) of utilization for all resources provides more credible and accurate information than use of typical load shapes or other proxy simplifications. This higher degree of granularity can provide enhanced insights into the most cost-effective utilization of the portfolio (or candidate portfolios) of power plants, Distributed Energy Resources, energy efficiency, demand response, and storage. This level of detail requires hourly and sub-hourly data to better approximate actual operations. Real-time wholesale and retail prices, Advanced Metering Infrastructures, advances in software, and ever increasing computer computational capabilities have made it increasingly feasible to use much more granularity in the data to support more sophisticated planning models that more accurately characterize system operations.

Circuit (Ckt): A conductor or a system of conductors through which electric current flows.

Circuit Breaker: A circuit breaker is a switching device capable of starting, carrying and stopping electrical currents under normal circuit conditions. It also can start and carry currents for a specified time and stop currents under specified abnormal conditions such as a short circuit.

Circuit-Mile: The total length in miles of separate circuits regardless of the number of conductors used per circuit.

Circulating Fluidized Bed (CFB): Is a comparatively clean process compared to traditional coal-fired power plants with the ability to achieve lower emission of pollutants. If this technology proves economically viable, up to 95% of pollutants could be absorbed



before being emitted to the atmosphere. CFB may have rrelatively high combustion efficiency, high unit availability, lower emissions, lower maintenance costs, and increased fuel flexibility.

City Gate (Natural Gas): The location at which the interstate and intrastate pipelines sell / deliver natural gas to local distribution companies.

Classification: (Cost-of-Service term - see also Allocation, Functionalization, and Revenue Requirement): For an electric utility, classification determines costs that are attributable to "demand." "energy use," or "customer related costs." Customer related costs typically do not vary with the amount of usage. In cost-of-service, classification follows functionalization. Classification is also used by the natural gas local distribution companies to separate commodity costs from customer related costs.

Clean Air Act (CAA): Under Clean Air Act section 111(d), state plans must establish standards of performance that reflect the degree of emission limitation achievable through the application of the "best system of emission reduction" (BSER). Several additional regulations have been imposed under the authority of the CAA including, but not limited to, the following relatively new regulations:

Clean Air Interstate Rule (CAIR): CAIR was initially proposed March 2005 and, after several court challenges and reforms, was sustained by the D.C. Court of Appeals as the Cross-State Air Pollution Rule (CSAPR) on July 28, 2015. The Rule addresses the interstate transport of SO_2 and NO_X emissions and to assist counties in non-attainment status of the Parts per Million 2.5 and the 8-hour ozone standards under National Ambient Air Quality Standards (NAAQS).

Clean Power Plan (CPP): Proposed rule for Carbon Dioxide Regulation 111(d)**.** On June 2, 2014, EPA proposed a plan to cut carbon pollution from power plants. On February 9, 2016 the CPP was stayed by the Supreme Court and remanded to the DC Circuit for reconsideration. The CPP defined standards for existing power plants and specific targets for states to reduce emissions of carbon dioxide, the Clean Power Plan aims to provide a nationwide path that will reduce power sector carbon emissions in 2030 by 32% from 2005 levels. Additionally, EPA proposed a federal plan to be implemented in the event that a state does not have an approved plan to comply with the CPP. The proposed federal plan and proposed model rules for the states to potentially adopt have both a *mass-based* (federal or state) and *rate-based* (federal or state) option and are *trade-ready*.

A "Mass-Based" compliance approach allocates a limited set of CO_2 emissions allowances for power plants that must comply with the rule, and a "rate-based" compliance approach allows power plants to receive credits for reduced emissions per unit of energy generated. "Trade-ready" refers to when affected power plants in one state can trade allowances or credits with those in other states implementing the same federal or state approach (i.e., mass- or rate-based plan). The ability to trade Emission Reduction Credits (ERCs), regardless of whether a state choses to use a rate-based or mass-based plan, is a key component of the compliance regime. The intention is that a robust, transparent, and efficient trading mechanism for compliance will benefit the nation as a whole by ensuring a deep and liquid allowance/credit market. Depth and liquidity is important for ensuring the most efficient means of compliance. Efficient trading will ensure that resources will be able to accurately reflect their cost of compliance

There seems to be a broad consensus, especially in regions served by Regional Transmission Organizations, that a mass-based approach would be more efficient. There is also a growing consensus that the combination of existing environmental rules, the expected retirement of aging coal-fired power plants, projections of low cost natural gas, declines in the cost of renewable energy resources, increasing cost-effectiveness of Demand-Side Management, low load-growth, and the potential for innovations in technologies will provide the greatest impetus to restructure the Nation's resource mix relative to the CPP and does not fundamentally change economic dispatch practices.

Clean Dark Spread: This is used as a short-term driver of carbon prices. The "Clean" is an indicator of profitability of coal-fired electricity. Some might use "Quark Spread" for the profitability of nuclear power production.

Climate Change: A term used to refer to all forms of climatic inconsistency, but especially to significant change from one prevailing climatic condition to another. In some cases, "climate change" has been used synonymously with the term "global warming." Scientists, however, tend to use the term in a wider sense that is inclusive of natural changes in climate, including climatic cooling, changing patterns of precipitation, the severity of storms, etc.

CO_2 Non-Attainment Areas: Areas with carbon monoxide design values of 9.5 parts per million or more, generally based on data for 1988-89.

Coal Combustion Residuals or Coal Ash Rule (CCRs): In 1976, the Resource Conservaton and Recovery Act was enacted (42 USC §6901). In 2010, the EPA issued a proposal to regulate coal ash to address the risk associated with the disposal of the wastes generated by coal-fired power plants in *ash ponds - surface impoundments* for liquid waste, and *landfills* for solid waste. In 2015, the CCR Rule became effective. CCRs are residuals from the combustion of coal that are captured by pollution control equipment such as *electrostatic precipitators* or *bag houses.*

Coal and Natural Gas Competition in 2017: From 2008, 46,000 MW of coal-fired generating capacity has been retired. While there were numerous retirements of generating units that are less than 30 years old, the average age of the retired capacity was over 50 years. These retirements constitute about 15% of the 2008 total coal-fired MWh generating capacity and coal has gone from about 45% - 32% of the Nation's generating mix while gas has increased its market share by about 13% over the same period. While many coal plants remain in operation, most are running at levels far below their potential as evidenced by declining capacity factors. Coal-fired power plants that are economically dispatched by Regional Transmission Organizations / ISOs, are frequently *out of the money* and the use of coal has generally diminished over the past several years. Coal use for electric power production fell from 1,042 million tons in 2008 to 740 million tons in 2015. Two forces have been at work: prices for natural gas low enough to make gas-fired power generation competitive with coal; and tightened air emission and other environmental regulations on coal burning. These forces are additive so that when owners of coal-fired plants face gas competition and must invest to comply with environmental regulations, coal units are likely to lose. [See, for example, The Future of Coal Versus Gas Competition, Mark Repsher of PA Consulting Group, Jamie Heller, Charlie Mann and Trygve Gaalaas of Hellerworx, 2017, PJM's Evolving Resource Mix and System Reliability, March 30, 2017, SNL coal-fired retirement database, Electricity Markets, Reliability, and the Evolving U.S. Power System, Analysis Group, Summer 2017 and EIA)].

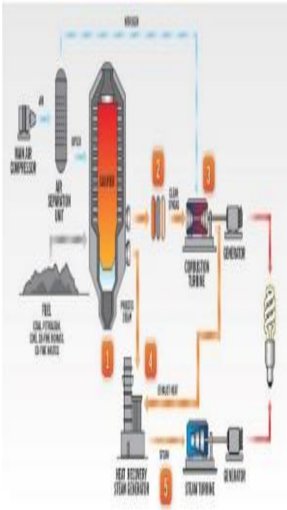
Coal Basins: The U.S. Geological Survey (USGS) National Coal Resource Assessment (NCRA) divides the contiguous states into five regions: Eastern, Gulf Coast, Interior, Rocky Mountain, and Northern Great Plains. These regions constituted 93 percent of U.S. coal production. A very large percentage of the coal mined in the United States comes from a few large-scale mines (mega-mines) in the Powder River Basin of Wyoming and Montana. The Illinois and Appalachian coal basins also produce a significant amount of coal. Reported reserves of about 200 years do not account for future potential reserves or for future development of technology that may make coal classified currently as resources into reserves in the future. *Recoverable coal reserves at producing mines* represent the quantity of coal that can be recovered (i.e. mined) from existing coal reserves at reporting mines. These reserves essentially reflect the working inventory at producing mines. In 2009, the recoverable coal reserves in the United States totaled 17,468 million short tons at producing (active) mines (EIA 2011). The estimated recoverable reserves include the coal in the demonstrated reserve base considered recoverable after excluding coal estimated to be unavailable due to land use restrictions or currently economically unattractive for mining, and after applying assumed mining recovery rates. See the EIA Glossary for criteria. In 2009, the estimated recoverable reserves totaled 260,551 million short tons (EIA 2011). The demonstrated reserve base includes publicly-available data on coal that has been mapped and verified to be technologically minable. For 2009, the demonstrated reserve base was estimated to contain 486,102 million short tons (EIA's AEO 2011).

Coal Bed Degasification: This refers to the removal of methane or coal bed gas from a coal mine before or during mining.

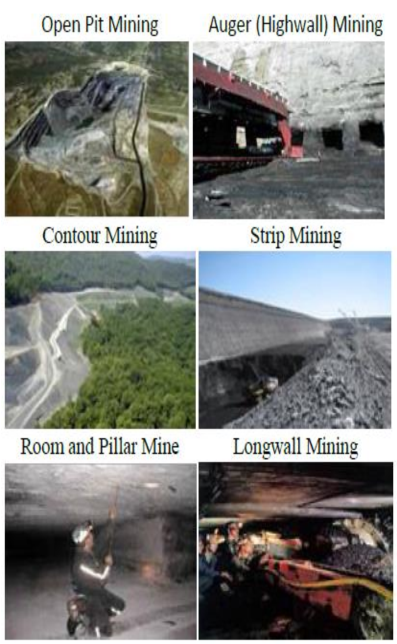
Coal Combustion Residuals Final Rule (CCR): The CCR Final Rule was published in the Federal Register on April 17, 2015 and became effective on October 19, 2015. This rule establishes nationally applicable minimum criteria for the safe disposal of CCR in landfills and surface impoundments. CCRs are designated as a RCRA Subtitle D Waste – non-hazardous. CCRs are generated from the combustion of coal for the purpose of generating steam for electric power or thermal energy. CCRs include: Fly Ash; Bottom Ash; Boiler slag; and FGD solid wastes.

Coal Gasification: The process of converting coal into gas. The basic process involves crushing coal to a powder, which is then heated in the presence of steam and oxygen to produce a gas. The gas is then refined to reduce sulfur and other impurities. The gas can be used as a fuel or processed further and concentrated into chemical or liquid fuel. For Indiana, the use of native coal, if competitive with other fuels and resources, could be of significant economic and environmental value. The recently retired Wabash facility near Terre Haute, IN was the first major generating facility to use this technology. Duke Energy's 618 MW Edwardsport Integrated Gasification Combined Cycle (IGCC) was commercially operational in 2013. Kemper County IGCC, as of 2016 is not completed. Thus far, the cost is in excess of $7 billion.

Coal Gasification Generating Facilities

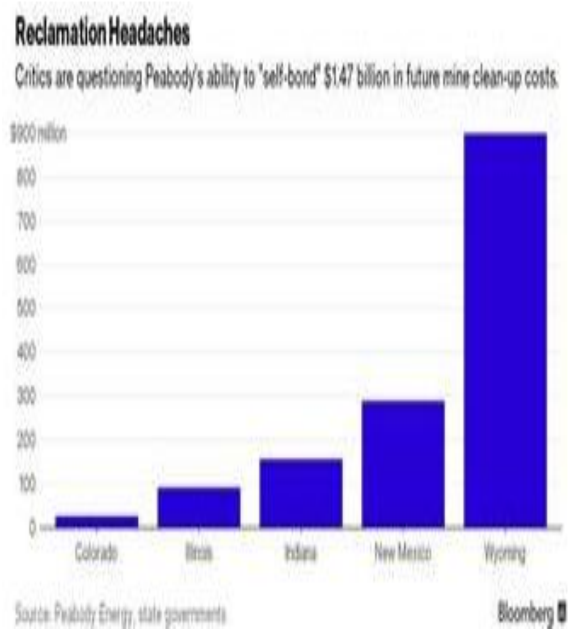


Coal Mining Methods: Surface and underground coal mining are the two basic methods to remove coal. Surface mining is used when the coal is typically less than 200 feet below the surface. *Underground Mining* is used when the coal is buried several hundred feet below the surface or more. Some mines can extend to depths of more than 1,000 feet. *Strip* (area stripping or contour stripping) and *Auger Mining* are the two most common surface methods of extracting coal in the United States. *Open-pit mining* is sometimes used in thick shallow-lying western coal seams. In the western U.S., area stripping is most common. This entails stripping off the overlying material to expose the coal seams. or strips. Parallel cuts continue until the thickness of the overburden becomes too great to be removed economically or until the end of the coal seam property is reached. Once the coal recovery is no longer economic, reclamation laws require soil and rock to be filled-in to the location to similar condition, including revegetation, prior to mining activity. *Contour stripping* is practiced on steep terrain mostly in the *Appalachian coal basin*. The method consists of removing overburden from the coalbed and proceeding around the hillside. After the uncovered bed is removed are made until the depth of the overburden becomes too great for economical recovery of the coal. Contour mining creates a shelf or bench on the side of the hill. On the inside, it is bordered by the highwall, ranging in height from a few feet to more than 100 feet, and on the outer side, by a high ridge of spoil. In the eastern United States, auger mining is used on hillside terrain. It requires a surface cut (removal of overburden and a portion of the coalbed) to allow the auger access to the bed. It is also used to recover part of the coal left from underground mining. In the western United States, auger mining is used in conjunction with strip mining. Coal mining by the auger method entails boring horizontal or near-horizontal holes in an exposed face of the coal, and loading the coal removed by the auger. Single, dual, or triple auger heads can remove up to 90 inches of coal for a distance of over 200 feet. Augering is generally used to supplement recovery at contour or strip mines when the overburden becomes too great to be economically removed. It is also used where the terrain is too steep for overburden removal and where recovery by underground methods would be impractical or unsafe. *Open-Pit Mining*, begins by drilling and blasting waste rock to expose the coal seam. overburden is removed and placed outside the mining area and rarely returned to the pit. *Mountaintop Removal Mining* (MTR), often referred to as mountaintop mining/valley fills, is a form of surface mining that involves extreme topographic change to the summit or summit ridge of a mountain. It is most closely associated with coal mining in the Appalachian Mountains. The process involves the removal of up to 1,000 vertical feet of overburden to expose underlying coal seams. The overburden is often scraped into the adjacent drainage valleys in what is called a valley fill. *Room-and-Pillar* mining has been used in the United States longer than any other underground method. Mining is accomplished by driving entries off the panel entries. As mining advances, rooms are excavated in the coal seam; the strata above the seam are supported by pillars of coal left in place. After a block panel or section has been mined, part of the coal in the pillars can be recovered as a retreat is made toward a main entry. Since about 1950, continuous mining using electric-powered machines to bore, dig, or rip the coal



from the working face has largely replaced conventional mining, which involved undercutting, drilling, placing explosives, and blasting to extract the coal. *Longwall* mining is used most efficiently in uniform coal seams of medium height (42 to 60 inches). As in the room–and-pillar method, longwall mining starts with sets of entries cut into the panel areas. The difference in the technique lies in the distance between these sets of entries and the method used to extract intervening coal. Longwall blocks range from 300 to 600 feet wide and are sometimes a mile long. The longwall machine laterally shears or plows coal from the entire face, transports the fallen coal by an advancing conveyor to a secondary haulage conveyor, reverses direction at the end of a cut, and supports the roof in the area of the face by a self-advancing system of hydraulic jacks. Over 80% of the entire coal face can be removed with this method. After coal is removed, it typically goes on a conveyor belt to a preparation plant that is located at the mining site. The plant cleans and processes coal to remove dirt, rock, ash, sulfur, and other unwanted materials, increasing the heating value of the coal. The coal may also be sorted by quality and size.

Coal Mining Reclamation: **The Surface Mining Control and Reclamation Act** of 1977 (SMCRA - 91 Stat. 445, 30 USC Mineral Lands and Mining, and 30 USC ch 25 §1201 et. seq) is the primary federal law that regulates the environmental effects of coal mining and reclamation of abandoned mines. In *Hodel v. Virginia Surface Mining & Reclamation Association, Inc.*, 452 U.S. 264(1981) the Supreme Court held SMCRA does not violate the Tenth Amendment by impinging on state jurisdiction. SMCRA created two programs: one for regulating active coal mines and a second for reclaiming abandoned mine lands. SMCRA also created the Office of Surface Mining - an agency within the Department of the Interior, to promulgate regulations, to fund state regulatory and reclamation efforts, and ensure consistency among state regulatory programs. The genesis for SMCRA was the prospective and cumulative environmental effects of strip mining since the 1930s (mining began in about 1740 but on a small scale). In the absence of federal environmental regulation, states enacted their own regulations over mining. West Virginia in 1939, Indiana in 1941, Illinois in 1943, and Pennsylvania in 1945. Mining companies would threaten or actually move operations from a state with more restrictive regulations to states with more lax regulation. SMCRA 1) establishes standards of performance, 2) permitting that includes how the land will be used after reclamation, 3) bonding sufficient to cover the cost of reclamation if the company goes out of business or fails to properly reclaim the land, inspection and enforcement, and 4) imposes land restrictions such as not mining in national parks. Unfortunately, despite bonding, this has not proved to be sufficient since many states do not require large mining companies to post a surety bond for the costs of reclamation. Instead, these companies can hold their own assets as “self-bonding”. The 2016 bankruptcies of large mining companies overwhelm the $3.7 billion state regulators have allowed in self-bonding. For example, shortly before it declared bankruptcy Peabody Energy held $1.47 billion in self-bonding liabilities, including $900.5 million in Wyoming alone. See *The $1.47 Billion Problem Threatening Peabody’s Finances.* Bloomberg February 17, 2016. “For decades, Peabody and other coal producers deemed to have strong balance sheets have saved cash under this privilege that excuses them from having to post collateral or obtain surety bonds that cover future mine clean-up costs.” At a time when coal companies are losing market share to natural gas and some coal mining companies have declared bankruptcy (e.g., Peabody April 2016, Alpha Natural Resources – August 2013, Arch Coal Inc- January 2016, Patriot Coal – July 9, 2012, James River Coal – April 8, 2014,), self-bonding is *the sword of Damocles.* Peabody was the world’s largest producer of coal.



Coal Plant Retirements (2002 – 2016): *Staff Report to the Secretary on Electricity Markets and Reliability*, Page 20 and 23, August 3017. *There were approximately 306,000 MW of coal-fired power plants in the United States at the start of 2002 and 270,000 MW at the end of 2016, representing a net retirement of approximately 36,000 MW (about 12 percent) of coal capacity. The remaining fleet of coal-fired generators covers most of the lower 48 states, with the exception of the Northeast, Northwest, and California. More than 90 percent of the coal consumed in the United States is used for power generation. Coal energy production peaked in 2007 and has been declining since. No new coal plants have been built for domestic utility electricity production since 2014 because new coal plants are more expensive to build and operate than natural gas-fired plants. August 2017. More than 90 percent of the coal consumed in the United States is used for power generation. Coal energy production peaked in 2007 and has been declining since. No new coal plants have been built for domestic utility electricity production since 2014 because new coal plants are more expensive to build and operate than natural gas-fired plants. The age of coal plants is an important factor. The vast majority of coal-fired capacity was built before 1990, with the average of the fleet built in the mid to late 1970s. According to the Congressional Research Service, the service life of coal-fired generators reportedly 'averages between 35 and 50 years, and varies according to boiler type, maintenance practices, and the type of coal burned, among other factors.' Between 2002 and 2016, 531 coal generating units representing approximately 59,000 MW of generation capacity retired from the U.S. generation fleet. EIA reported that coal-fired power plants made up more than 80 percent of the 18,000 MW of electric generating capacity that retired in 2015, and that the retiring units "tended to be older and smaller in capacity than the coal generation fleet that continues to operate.' An analysis of coal plant and other data indicates several important trends and attributes:*

About 70 percent of the plants that retired between 2010 and 2016 had a capacity factor of less than 50 percent in the year prior to retirement, and about half of the future planned retirements operated below a 50 percent capacity factor in 2016.43

While none of the units that retired between 2010 and 2016 had significant SO2 control equipment installed, more than half of the future announced retirements have SO2 control.

The average size of planned retirements (380 MW) exceeds the average size of recent retirements (218 MW), indicating that future retirements will be generally larger than previous ones.

Retired plants are older than the remaining fleet. The coal units that retired in 2015 were mainly built between 1950 and 1970, and the average age of those retired units was 54 years.

The remaining coal fleet is relatively younger, with an average age of 38 years in 2016.45 In summary, until quite recently, the coal plants that have retired were smaller, older, had higher heat rates, and therefore were dispatched less often and ran at lower capacity factors. Most of the earliest coal retirements were merchant-owned units in the Northeast and Midwest that were more exposed to competition from other generators and fuel types, while VIEU-owned plants in the Southeast and elsewhere experienced a longer period of protection from low market prices.

Coal Quality: The character or nature of the amount of impurities (ash and trace elements) in coal. Coal quality parameters of greatest interest include ash, moisture, sulfur, and energy value (a/k/a heat content).

Since the mid-1970s, the U.S. Geological Survey (USGS) has maintained a coal quality database of national scope named USCHEM. One of the problems that accompany the mining and use of coal is acid mine drainage, which results when coal beds and surrounding strata containing medium to high amounts of sulfur, in the form of compounds known as sulfides, are disrupted by mining, thereby exposing the sulfides to air and water. Atmospheric sulfur oxides (SOx) and subsequent acid deposition (such as acid rain) result from the burning of moderate- to high-sulfur coal. The quality of surface and groundwater may be affected adversely by the disposal of the ash and sludge that result from the burning of coal and cleaning of flue gases. These are some of the serious problems requiring either improved or new remedies. Other environmental problems are associated with emissions of carbon dioxide (CO_2) and nitrogen oxides (NOx), two of the so-called "greenhouse gases." These emissions are often attributed to coal use only; however, they also result from the burning of any fossil or biomass fuel, such as wood, natural gas, gasoline, and heating oil. The greenhouse gas problem requires a broader solution than just reducing the use of coal. A Federal law, the 1990 Clean Air Act, required the U.S. Environmental Protection Agency (USEPA) to conduct studies of 15 trace elements released by the burning of coal to determine if they present health hazards. These 15 elements (antimony, arsenic, beryllium, cadmium, chlorine, chromium, cobalt, lead, manganese, mercury, nickel, potassium, selenium, thorium, and uranium), along with many other potentially hazardous substances released into the air by other industries, are termed "hazardous air pollutants" (HAPs).

Coal Types and Characteristics: Coal is an organic sedimentary rock that forms from the decay of plant matter in swampy areas which is converted into peat (a precursor to coal), which in turn is converted into lignite (lowest rank of coal- about 4,000-8000 Btu per pound, 25%-35% carbon content, a very high water content, and sometimes referred to as high Btu dirt), then sub-bituminous coal (ranging from lignite to bituminous is the primary fuel for electric utility generators, bituminous coal (a dense sedimentary rock is also used as a fuel to generate electricity – it is also used to manufacture coke. The heat content ranges from about 10,500 Btu to 15,000 Btu per pound. Its carbon content is generally from 45-85%), steam coal is a grade of bituminous and anthracite, and lastly anthracite. Anthracite is the highest rank coal with about 85% - 95% carbon and in excess of 15,000 Btu per pound. Anthracite is typically harder and glossy black. *Hilt's Law* is a geological term that states that, in a small area, the deeper the coal, the higher its rank (grade). The law holds true if the thermal gradient is entirely vertical, but metamorphism may cause lateral changes of rank, irrespective of depth. Coal is an organic sedimentary rock that forms from the accumulation and preservation of plant materials, usually in a swamp environment. Carbon is the primary component but also contains hydrogen, oxygen, nitrogen, sulphur, and several other impurities such as arsenic. Appalachian coal is bituminous and tends to have a high energy content with low sulphur. Illinois Basin coal is bituminous with high energy content but high Sulphur content. Powder River Basin coal has a lower energy content and a lower sulphur content.

Coal, Natural Gas, and Electric Operations Employment: *Falling demand for coal due to coal plant retirements and capacity factor reductions, a regional shift in coal production, and automation in mining have led to a reduction in coal production jobs. Between 2011 and September 2016, increased mechanization and a shift to western coal resulted in a loss of 36,000 coal mining jobs, of which nearly 90 percent were in Appalachia.* [As shown in the following table- Direct Employment and Income in Industries Related to Electric Power Supply for 2016] *more than 80 percent of the coal jobs in the United States support electricity production. The oil and gas extraction sector is not subdivided and includes many non-power uses. About 35 percent of the natural gas and roughly one percent of petroleum jobs in the United States support electricity production*. *Staff Report to the Secretary on Electricity Markets and Reliability*, Page 23, *August 2017.*

Industry Sector/Subsector	Jobs	Percent Related to Electricity Industry	Average Annual Income
Electric power generation	191,000	100%	$113,000
Electric power transmission and distribution	292,000	100%	$99,000
Electric power total	483,000	100%	$104,000
Coal mining	55,000	~80%	$82,000
Oil and gas extraction	377,000	~35% of gas, ~1% of oil	$118,000
Mining and extraction total	432,000	Unknown	$113,000

Coalbed Methane (CBM) (Natural Gas): Methane is generated during coal formation and is contained in the coal microstructure. Typical recovery entails pumping water out of the coal to allow the gas to escape. Methane is the principal component of natural gas. Coal bed methane can be added to natural gas pipelines without any special treatment.

Code of Conduct: For electric and natural gas utilities, Codes of Conduct are rules intended to promote fair competition by establishing measures to prevent cross-subsidization, information sharing, and preferential treatment between the regulated and unregulated operations of electric utilities and their affiliates. The Codes of Conduct, among other things, are intended to prevent a utility from sharing information with an affiliate that might provide an unfair advantage. As of May 2008, FERC refers to Codes of Conduct as Affiliate Restrictions. Historically, when a market-regulated applicant requested authority to make sales of power or ancillary services at market-based rates, the Commission also required the applicant, on a case-by-case basis, to abide by a “code of conduct” to protect captive customers and prevent affiliate abuse. Affiliate Restrictions require the public utility’s operating personnel to function independently of the market-regulated power sales affiliate and, as revised by Order No.697-A, imposes a posting requirement if a franchised public utility with captive customers shares non-public market information with a market-regulated power sales affiliate if the sharing could be used to the detriment of captive customers. The Affiliate Restrictions also expressly prohibit power sales between a franchised public utility with captive customers and a market-regulated power sales affiliate without first receiving Commission authorization. The earliest references to code of conduct requirements are in *Heartland Energy Services, Inc., et al.,* 68 FERC ¶ 61,223 (1994) and *LG&E Power Marketing Inc., et al.,*68 FERC ¶ 61,247 (1994). [see also Affiliate Rules and Standards of Conduct].

Coefficient of Variation (CV or COV): CV is the ratio of the *standard deviation* to the *mean* for evaluating a single variable. In modeling, CV is calculated as the ratio of the root mean squared error (RMSE) to the mean of the dependent variable. For both, the CV is typically stated as the ratio multiplied by 100. The CV for a single variable describes the dispersion of the variable in a way that does not depend on the variable's measurement unit. The higher the CV, the greater the dispersion in the variable. As used in modeling, the CV describes the model fit in terms of the relative sizes of the squared residuals and outcome values. The lower the CV, the smaller the residuals relative to the predicted value. This is suggestive of a good model fit.

CV measures the spread of a set of data as a proportion of its mean. It is often expressed as a percentage. It is the ratio of the sample standard deviation to the sample mean:

CV = (Standard Deviation / Mean) * 100.

Where “SD” is the Standard Deviation and $\bar{x}$ is the sample mean.

Co-Firing: The process of burning two fuels in conjunction. Examples include co-firing coal with biomass to increase renewable fuel content and co-firing biogas with natural gas to improve combustion equipment performance.

Cogeneration: Production of electricity from steam, heat, or other forms of energy produced as a by-product of another process.(NERC)

Coincidental Demand: The sum of two or more demands that occur in the same time interval. Typically, used in planning resources such as generation, transmission, and demand response. For example, in regions served by RTOs / ISOs, the relevant peak is the RTOs / ISOs peak demand rather than the peak demand of any utility or other entity. So, the contribution by any entity to the RTOs / ISOs peak is that entity’s “Coincidence Factor.” See also “Non-Coincident” and “Diversity.” In regions not served by an RTOs / ISOs, the relevant peak is the contribution of each customer to their utility’s peak demand.

Coincidental Peak Load (CP): The sum of two or more peak loads that occur in the same time interval.

Collar (Finance – Mergers): A collar is a type of hedge. It is the ceiling and floor of the price fluctuation of an underlying asset. A collar is usually set up with options, swaps, or by other agreements. The collar strategy is to buy puts and selling calls is to mitigate the risk of a concentrated position in (sometimes) restricted stock. an investor holds a stock that has recently experienced significant gains. If the stock falls, the investor can exercise the put, ensuring a profit. If it continues to rise, the call places a cap on the profit. On a stock exchange, a collar may be used as a hedge against panic selling if the market losses some significant amount of its value. In this instance, it is also called *a circuit breaker*.

Collective Action Problem: A situation where individuals (or communities, states, or nations) recognize they share a common objective, recognize that no individual can or will undertake the costs and efforts to solve the problem alone, and are deterred by the attendant cost of joint action which makes the effort implausible. Even if some agree to undertake a collective action, there is a possibility *free riders* will elect not to honor their commitments and allow others to shoulder all of the costs.

Combined Cooling, Heat, and Power (CCHP): Simultaneous generation of electricity, heating, and cooling from the combustion of a fuel or a solar heat collector. This is a derivative of Combined Heat and Power (CHP) using an absorption chiller. Also referred to as *trigeneration.*

Combined Cycle (CC or Conventional Natural Gas Combined Cycle or Combined Cycle Gas Turbine-CCGT): A combustion turbine installation using waste heat boilers to capture exhaust energy for steam generation. First a combustion turbine fueled by the gas and then a steam turbine fueled by steam created from water heated with the waste heat from the combustion turbine

Combined Heat and Power (CHP) Plant: A plant designed to produce both heat and electricity from a single heat source. CHP better describes the facilities because some of the plants included do not produce heat and power in a sequential fashion and, as a result, do not meet the legal definition of cogeneration specified in the Public Utility Regulatory Policies Act (PURPA).

Combined Hydroelectric Plant: A hydroelectric plant that uses both pumped water and natural stream-flow for the production of power.

Combined Pumped-Storage Plant: A pumped-storage hydro-electric power plant that uses both pumped water and natural stream-flow to produce electricity.

Combustion Turbine (CT): An electric generating unit in which the prime mover is a gas turbine engine. (Typically Peaking Units are combustion turbines).

Commercial Operation Date: The date on which the Generating Facility commences Commercial Operation as agreed to by the Parties (see also In-Service Date Initial Synchronization Date).

Commercial Paper: Commercial paper is an unsecured (no collateral), short-term debt instrument issued by a corporation, typically for the financing of accounts receivable, inventories and meeting short-term liabilities. Maturities on commercial paper rarely range any longer than 270 days. Commercial paper is usually issued at a discount from face value and reflects prevailing market interest rates. A major benefit of commercial paper is that it does not need to be registered with the Securities and Exchange Commission (SEC) as long as it matures before nine months, or 270 days, making it a very cost-effective means of financing.

Commodity: Anything that is bought and sold in a highly competitive market (e.g., Commodity Futures Market). Commodities like natural gas and electricity typically have many buyers and sellers, are very liquid, and subject to fluctuation in price according to supply and demand.

Communications Technologies for Electric Utilities: The objectives for an intelligent grid is that it be capable of *greater situational awareness,* enhance *system control, self-healing*, *optimizing the flow of electricity, integrating renewable* and *Distributed Energy Resources (DERs)*, *utilizing Demand Response, implementing sophisticated rates* based on more discrete price signals, obtaining a wealth of data for *load research, load forecasting, DSM EM&V, integrated resource planning of T&D as well as all resources,.* and improving overall efficiency of delivery. A modern grid has intelligent electronic devices (IEDs) throughout the transmission and distribution infrastructure. The AMI Integrated Communications Infrastructure (including Access BPL and its alternatives) supports interaction between the utility, the consumer portal and any controllable electrical loads on the Home Area Network. (The Smart Grid Information Clearinghouse also has information on Integrated Communications) It must employ “open” (non-proprietary) bi-directional, encrypted communications and is the foundation of all modern grid functions. Supporting media must accurately and securely transmit information at the required speed with the required throughput. Technologies include *wireline and wireless*: Some of the wireline communications technologies are *Broad Band over Power Lines* (BPL) *In Premises BPL* (home plug-in) *In Premises BPL* (Home Grid Forum) *Power Line Carrier* (PLC), *Fiber Optics, Copper UTP* Wireless technologies include: *WiFi (see open standards to IEEE 802.11b and 802 11g), WiMAX, Multi Address System Radio* see IEEE 802 16d (MASR), *ZigBee* (See IEEE standard 802 16.4). *OSHAN, 3G Cellular, TDMA, VSAT, Paging Networks, FHSS Spread Spectrum Radio Internet Protocol* (IP) *Internet Protocol 2 Fiber to the Home* (FTTH), *Hybrid Fiber and Coax* (HFC). The Information Technology Infrastructure Library (ITIL) may also be a useful resource for understanding the pros and cons of different communication systems.

Community Choice Aggregators (CCAs – see also Aggregators of Retail Customers, Energy Service Companies, Energy Service Providers): CCAs attract customers by offering lower rates as a result for energy efficiency, demand response, distributed solar and wind facilities – including *community solar* and *wind* providing greater local control over energy supplies. Over time, the CCAs would be expected to provide customers with battery storage and other newer technologies. However, most customers of a CCA would remain customers of a traditional utility for transmission and distribution services unless CCAs are allowed to enter the transmission and distribution market.

Community Solar (CS): A community solar project is sometimes referred to as a *solar garden* or *shared renewable energy plant*—is a solar power plant whose electricity is shared by more than one household. The concept could be expanded to include commercial customers.

Competitive Price: Is, by common definition, the *market-clearing price* where supply equals demand. Generators need to recover the additional costs (marginal cost) of producing an additional unit of electricity sold in the market. However, when supplies grow increasingly scarce, leading to a tight balance between demand and supply, generating costs can rise dramatically because they include the costs of running generating units at higher than normal rates, thereby increasing the likelihood of breakdowns. In extreme circumstances such as a blackout, there is no competitive or market-clearing price.

Competitive Transition Charge (see also Stranded Costs)**:** A non-bypassable charge levied on each customer of the distribution utility, including those who are served under contracts with nonutility suppliers, for recovery of the utility's stranded costs that develop because of competition.

Compliance Monitor: The entity that monitors, reviews, and ensures compliance of responsible entities with reliability standards

Compound Annual Growth Rate (CAGR) Compound annual growth rate) is the mean annual growth rate of an investment over a specified period of time longer than one year. To calculate compound annual growth rate, divide the value of an investment at the end of the period in question by its value at the beginning of that period, raise the result to the power of one divided by the period length, and subtract one from the subsequent result. This can be written as follows:

$$\text{CAGR} = \left(\frac{\text{Ending Value}}{\text{Beginning Value}}\right)^{\left(\frac{1}{\#\text{ of years}}\right)} - 1$$

Compression (Natural Gas): During transportation and storage, natural gas is compressed at compression stations.

Compressor Station: A facility that is used to compress natural gas in order to create additional pressure to increase the amount of gas a pipeline can hold, help move it through a pipeline, or to move it into or from storage.

Concentrating Solar Power (CSP): CSP technologies consist of two primary parts. The first part is mirrors to focus (concentrate) sunlight to produce heat (thermal energy) that drives conventional thermoelectric generation systems. The second major component converts the heat energy into electricity, As of 2016, there is about 1,800 MW of CSP in the United States. The unique feature of CSP is the ability to store heated material in an inexpensive and efficient thermal energy storage system. The stored thermal energy can be tapped between sunset and sunrise or during cloudy weather to provide renewable electricity on demand. In addition to providing electricity, CSP technologies may be increasingly able to provide process heat, solar fuels (e.g., for powering cars or hydrogen fuel cells that might power public transportation), and desalination. Some CSP systems are sun-tracking **Parabolic Trough Systems** (a receiver tube runs through the trough) where the *transfer fluid* – such as synthetic oil – reaches temperatures in excess of 750 F and passes through a heat exchanger to heat water and produce steam that drives a conventional steam turbine. **Compact Linear Fresnel Reflectors** uses the principles of curved-mirror trough systems, but with long parallel rows of lower-cost flat mirrors. These modular reflectors focus the sun's energy onto elevated receivers, which consist of a system of tubes through which water flows. The concentrated sunlight boils the water, generating high-pressure steam for direct use in power generation and industrial steam applications. **Power Towers** use a central receiver system, which allows for higher operating temperatures and thus greater efficiencies. Computer-controlled flat mirrors (called *heliostats*) track the sun along two axes and focus solar energy on a receiver at the top of a high tower. The focused energy is used to heat a transfer fluid (over 1,000° F) to produce steam and run a central power generator. When using molten salt as a transfer fluid and thermal energy storage medium, energy storage can be efficiently incorporated with these projects, allowing for 24 hour power generation. **Dish-Engine** require mirrors to be distributed over a parabolic dish surface to concentrate sunlight on a receiver fixed at the focal point. In contrast to other CSP technologies that employ steam to create electricity via a turbine, a dish-engine system uses a working fluid such as hydrogen that is heated up to 1,200° F in the receiver to drive an engine such as the Stirling engine. Each dish rotates along two axes to track the sun.

Conditional Probability (Statistical) (see also Joint Probability and Bayes' Theorem): The probability of A occurring given that B occurs is denoted as p(A|B). For example, if a red card is drawn, what is the probability the card is an ace? This can be expressed as P(ace | red))=2/26=1/13. The conditional probability is, then, out of 26 red cards in the deck there are two aces so that is expressed as 2/26 = 1/13.

Conductor: Metal wires, cables, and bus-bar used for carrying electric current. Conductors may be solid or stranded, that is, built up by a assembly of smaller solid conductors.

Conductor Gallop: Is the high-amplitude, low-frequency oscillation of over-head power lines due to wind. The movement of the wires occur most commonly in the vertical plane, although horizontal or rotational motion is also possible. The natural frequency mode tends to be around 1 Hz, leading the often graceful periodic motion to also be known as **conductor dancing**. The oscillations can exhibit amplitudes in excess of a meter, and the displacement is sometimes sufficient for the phase conductors to infringe on the operating clearances (also coming too close to other objects), and causing flashover. The forceful motion also adds significantly to the loading stress on insulators and towers, raising the risk of failure. The mechanisms that initiate gallop are not always clear, though it is thought to be often caused by asymmetric conductor due to ice build-up on one side of a wire. Gallop can be a significant problem for transmission system operators, particularly where lines cross open, windswept country and are at risk to ice loading. If gallop is likely to be a concern, designers can employ smooth-faced conductors, whose improved icing and aerodynamic characteristics reduce the motion.

CONE – Cost of New Entry: This is the potential cost of building a new generating facility which can, in turn, be used as a proxy for estimating the value of demand response or transmission facilities.

CONE is an estimate of the cost per kW of (installed) capacity per month or year for the most economical form of new construction, excluding variable energy costs. Specifically, CONE represents the first-year total net revenue (net of variable operating costs) a new generation resource would need in order to recover its capital investment and fixed costs, given reasonable expectations about future cost recovery over its economic life. *Gross CONE* includes all fixed costs related to the construction and availability of a facility, including those related to capital, financing and fixed Operations, Maintenance, & Ancillary Services but typically not fuel delivery fixed costs. Gross CONE can vary by location. *Net CONE* equals gross CONE minus the expected margin on sales of energy and ancillary services. Net CONE is defined as the operating margins that a new resource would need to earn in the capacity market, after netting margins earned in markets for energy and ancillary services (E&AS). Net CONE and CONE are typically estimated by the ISO/RTO and often on a locational basis. New Generation should be economic if the price of new capacity is greater than or equal to Net Cone. If new capacity is not needed to satisfy Resource Adequacy requirements, the *market clearing price* will likely be less than Net Cone but sufficient to support existing resources.

Confidence Interval (CI) (Statistical) (see also T-Value, P-Value, and Degrees of Freedom): In statistics, a ***confidence interval*** is an interval estimate of a population parameter. Instead of estimating the parameter by a single value, an interval likely to include the parameter is given. Thus, confidence intervals are used to indicate the reliability of an estimate. How likely the interval is to contain the parameter is determined by the ***confidence level*** or confidence coefficient.

Increasing the desired confidence level will widen the confidence interval. A confidence interval is always qualified by a particular ***confidence level*** (say, γ), usually expressed as a percentage; thus one speaks of a "95% confidence interval". The end points of the confidence interval are referred to as ***confidence limits***. For a given estimation procedure in a given situation, the higher the confidence level, the wider the confidence interval will be.

Configuration Maps: Geographic information containing transmission line, substation, and terminal information. It shows the normal operating voltages and includes information about other operational and political boundaries.

Confirmed Interchange: Ensures that each arranged interchanged has been checked to ensure that it does not adversely affect reliability.

Congestion: A condition that restricts the ability to add or substitute one source of electric power for another on a transmission grid (more simply: congestion occurs when insufficient transfer capacity is available to implement all of the preferred schedules simultaneously). In regions served by RTO/ISO, this congestion is “cleared” by the use of economic price signals referred to as Locational Marginal Cost Pricing (LMP). Prior to RTO / ISOs and in areas not served by RTO / ISOs, transmission congestion is cleared by the use of “Transmission Line Loading Relief” (TLRs). TLRs, in extreme instances, curtail even firm transactions to prevent a blackout condition. Natural gas pipelines may also experience congestion.

Congestion Costs (see also Locational Marginal Cost Pricing and Shadow Pricing): The price that represents the inability to use the least expensive generation to meet the electricity demand due to transmission limitations. Congestion Cost is one of the three components of *Locational Marginal Pricing*.

Congestion Management Report: A report that the Interchange Distribution Calculator issues when a Reliability Coordinator initiates the Transmission Loading Relief procedure. This report identifies the transactions and native and network load curtailments that must be initiated to achieve the loading relief requested by the initiating Reliability Coordinator.(NERC)

Congestion Rent: Congestion rent equals the shadow price per MWh times the MWh flowing through a transmission element, summed over all the hours when the element is operating at its maximum (binding) limit.

Congestion Revenue Rights (CRR - see also Financial Transmission Rights -FTRs): A term used by some RTOs such as the California ISO and ERCOT to CRRs may be used as either a financial hedge or a financial investment. When used as a hedge, a CRR locks in the price of congestion at the purchase price of the CRR. The intention is to support a liquid energy market by providing tradable financial instruments for the hedging of transmission congestion charges, primarily for the purpose of offsetting integrated forward market congestion costs that occur in the day-ahead market. This can occur in *point to point* with a designated point of injection (*source*) and a point of withdrawal (*sink*).

Connected Load: The sum of the continuous ratings or the capacities for a system, part of a system, or a customer's electric power consuming apparatus.

Connection: The physical connection (e.g., transmission lines, transformers, switch gear, etc.) between two electric systems permitting the transfer of electric energy in one or both directions.

Consequential Load Loss: All Load that is no longer served by the Transmission system as a result of Transmission Facilities being removed from service by a Protection System operation designed to isolate the fault

Conservation and Other DSM: This Demand-Side Management category represents the amount of consumer load reduction at the time of system peak due to utility programs that reduce consumer load during many hours of the year. Examples include utility rebate and shared savings activities for the installation of energy efficient appliances, lighting and electrical machinery, and weatherization materials. In addition, this category includes all other Demand-Side Management activities, such as thermal storage, time-of-use rates, fuel substitution, measurement and evaluation, and any other utility-administered Demand-Side Management activity designed to reduce demand and/or electricity use.

Conservation Voltage Reduction (CVR – see also Volt / Var Operations)**:** CVR is typically part of a Distribution Management System (DMS), usually in conjunction with *capacity banks* and / or *voltage regulators*, and / or a *voltage tap changer*, is a voltage reduction scheme that flattens and lowers the distribution voltage profile to reduce overall energy consumption. CVR works best on circuits with large amounts of resistive loads. Source: Grid Modernization Laboratory Consortium, U.S. Department of Energy.

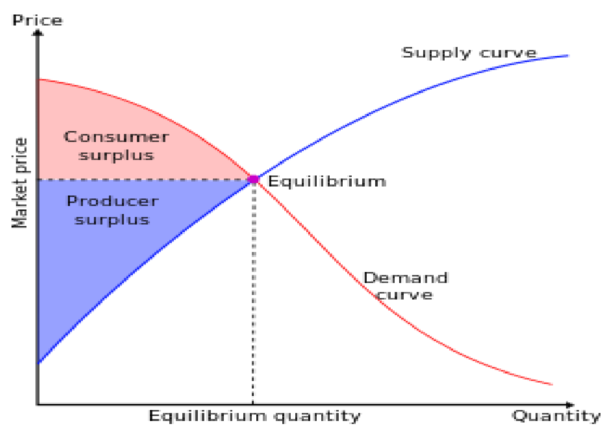
Conservative System Operations: Reliability Coordinators (RC) may issue conservative system operations if certain events, conditions, or circumstances occur that may put the Bulk Electric System (BES) at an increased level of risk, compared to normal operating conditions. In these situations, the RCs – must implement additional actions to ensure the BES remains sufficiently reliable to address threats (e.g., fuel delivery concerns, fires, weather events, earthquakes, cyber threats, physical threats, geomagnetic disturbances - GMD). Transfer Limits can be reduced, contracts may be suspended or curtailed, and Transmission Loading Relief (TLR) may be issued. The RC may also procure additional reserves to make more resources available to respond to any unexpected events.

Constrained Facility: A transmission facility (line, transformer, breaker, etc.) that is approaching, is at, or is beyond its System Operating Limit or Interconnection Reliability Operating Limit.

Construction Work In Progress (CWIP): The balance shown on a utility's balance sheet for construction work not yet completed but in process. This balance line item may or may not be included in the rate base.

Consumer Price Index (CPI see also Producer Price Index or PPI, Gross Domestic Product or GDP, and Implicit Price Deflator or IPD): GDP measures changes in the price level of a market basket of consumer goods and services. The CPI is a statistical estimate constructed by the U.S. Bureau of Labor Statistics using the prices of a sample of representative items whose prices are collected periodically (the market basket changes periodically to reflect changes such as technological changes like computers). Sub-indices and sub-sub-indices are computed for different categories and sub-categories of goods and services, being combined to produce the overall index with weights reflecting their shares in the total of the consumer expenditures covered by the index. It is one of several price indices. The annual percentage change in a CPI is used as a measure of the rate of inflation. A CPI can be used to index (i.e., adjust for the effect of inflation) the real value of wages, salaries, pensions, and for deflating monetary magnitudes to show changes in *real values*.

Consumer Surplus (see also producer surplus, demand curves, supply curves, welfare economics, and subsidies and shifts in supply and demand curves): Consumer surplus occurs when consumers pay less than the consumers were willing to pay. That is, customers realize savings (benefits or welfare) because the amount paid is less than the amount consumers were prepared to pay. Correspondingly, the producer surplus is the amount of revenue realized by the producer above the cost they were willing to sell the product for which approximates profit. The combination of consumer and producer surplus is *total welfare* (or Marshallian Surplus).



$$CS = \frac{1}{2} Q_{mkt} \left(P_{max} - P_{mkt}\right),$$

Where Pmkt is the equilibrium price (where supply equals demand), Qmkt is the total quantity purchased at the equilibrium price and Pmax is the price at which the quantity purchased would fall to 0 (that is, where the demand curve intercepts the price axis). The intersection of supply and demand is equilibrium. At any instant in time, a utility's load shape (e.g., 24 hours) is a supply and demand curve.

Contamination (Nuclear): Radioactive material that is present within other material and cannot be easily separated and its presence is unwanted. Contamination can be mitigated by disposal, painting over the contamination or attempting to clean the material. For example, at Fukushima top soil is being removed to dispose of contaminated soil. (see Radiation)

Contingency: The unexpected failure or outage of a system component, such as a generator, transmission line, circuit breaker, switch, or other electrical element. A contingency also may include multiple components, which are related by situations leading to simultaneous component outages.

NERC Contingencies:

ALR1-4 BPS Transmission Related Events Resulting in Loss of Load. This metric is designed to track Bulk Power System (BPS) transmission related credible events which result in loss of load. The metric allows planners and operators to validate their design and operating criteria by identifying the number of instances when there is unacceptable performance of the system.

ALR2-4 Average Percent Non-Recovery of Disturbance Control Standard (DCS) Events. The Disturbance Control Standard Failures metric measures the Balancing Authority or Reserve Sharing Groups' ability to utilize contingency reserve to balance resources and demand and return the Interconnection frequency within defined limits following a Reportable Disturbance.

ALR2-5 Disturbance Control Events Greater than Most of Severe Single Contingency (MSSC). This metric is designed to identify the number of disturbance events that exceed the Most Severe Single Contingency (MSSC) and is specific to each BA. Balancing Authority or Reserve Sharing Groups report disturbances greater than the MSSC on a quarterly basis. The results will help validate current contingency reserve requirements. Investigations of these events document how often these contingencies occur. The MSSC is determined based on the specific configuration of each system and that while there are general guidelines; they vary in significance and impact on the Bulk Power System.

Contingency Event Recovery Period: A period that begins at the time that the resource output begins to decline within the first one-minute interval of a Reportable Balancing Contingency Event, and extends for fifteen minutes thereafter (NERC)

Contingency Reserves (see also operating reserve, spinning reserve, and non-spinning reserves): Contingency reserves are the generating capacity available to the system operator within a short period (e.g., 10 minutes) to meet demand in the event of the loss of a generator (or transmission facility or other event) to prevent a disruption to the power system. Most power systems are designed for a single or double contingency. The operating reserve is made up of the spinning reserve as well as the non-spinning or supplemental reserve: The ***spinning reserve*** is the extra generating capacity that is available by increasing the power output of generators that are already connected to the power system and ready to take load. The ***non-spinning reserve*** or ***supplemental reserve*** is the extra generating capacity that is not currently connected to the system but can be brought online after a short delay. In isolated power systems, this typically equates to the power available from fast-start generators. However, in interconnected power systems, this may include the power available on short notice by importing power from other systems or retracting power that is currently being exported to other systems.

Contingency Reserve Restoration Period: A period not exceeding 90 minutes following the end of the Contingency Event Recovery Period. (NERC)

Continuous Oil & Gas Accumulations (see also Economically Recoverable Resources, Proved Reserves, Technically Recoverable, Unconventional Oil Accumulation): Commonly are regional in extent, have diffuse boundaries, and are not buoyant on a column of water. Continuous accumulations have very low matrix permeabilities, do not have obvious seals and traps, are in close proximity to source rocks, are abnormally pressured, and have relatively low recovery factors. Included in the category of continuous accumulations are hydrocarbons that occur in tight sand reservoirs, shale reservoirs, basin-centered reservoirs, fractured reservoirs, and coal beds.

Continuous Probability Distribution (see also Probability Density Function or PDF): If a *random variable* is a *continuous variable*, its probability distribution is called a continuous probability distribution. A continuous probability distribution differs from a discrete probability distribution in several ways.

The probability that a continuous random variable will assume a particular value is zero.

As a result, a continuous probability distribution cannot be expressed in tabular form.

Instead, an equation or formula is used to describe a continuous probability distribution.

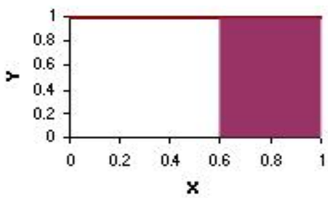
The equation used to describe a continuous probability distribution is called a *probability density function* (pdf). All probability density functions satisfy the following conditions:

The random variable Y is a function of X; that is, y = f(x).

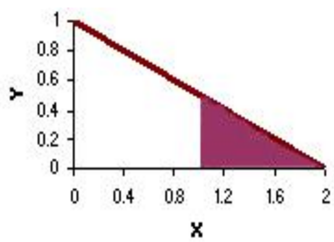
The value of y is greater than or equal to zero for all values of x.

The total area under the curve of the function is equal to one.

The charts below show two continuous probability distributions. The first chart shows a probability density function described by the equation y = 1 over the range of 0 to 1 and y = 0 elsewhere.



The next chart shows a probability density function described by the equation y = 1 - 0.5x over the range of 0 to 2 and y = 0 elsewhere. The area under the curve is equal to 1 for both charts.



Y = 1 - 0.5x

The probability that a continuous random variable falls in the interval between *a* and *b* is equal to the area under the pdf curve between *a* and *b*. For example, in the first chart above, the shaded area shows the probability that the random variable X will fall between 0.6 and 1.0. That probability is 0.40. And in the second chart, the shaded area shows the probability of falling between 1.0 and 2.0. That probability is 0.25.

Continuous Ranked Probability Score (CRPS - statistics): Appropriate verification tools are essential for understanding the abilities and weaknesses of probabilistic forecast systems. Verification is often focused on specific events. The CRPS is related to the rank probability score, but compares a full distribution with the observation, where both are represented as *cumulative distribution functions* (CDFs). Simple accuracy metrics such as Mean Absolute Error (MAE) or Mean Absolute Percentage Error (MAPE) are not directly applicable to probabilistic forecasts. The CRP Score generalizes the MAE to the case of probabilistic forecasts.

Continuous Variable (statistical – see also Discrete Variable): A specific variable can be many – even infinite – values. *A probability density function* is used to describe a continuous variable. In calculus, "optimization" problems involve continuous variables. A continuous function in mathematics is a function for which sufficiently small changes in the input result in arbitrarily small changes in the output. Otherwise, a function is said to be a *discontinuous* function.

Contract for Differences (CFDs): Contracts for difference is a contract between two parties speculating on the price movement of an asset (money, property, and commodity). Generally, if the asset rises in price, the buyer receives cash from the seller, and vice versa. The State of Maryland, because of a lack of faith in the ability of the PJM Capacity Market (RPM) to construct sufficient generating capacity, offered CFDs for companies to build electric generators in Maryland. If the PJM's capacity market had prices lower than the CFD, Maryland's construct would pay the difference (subsidize) to the generators. The FERC and the federal court's held this would distort the PJM's capacity market and was an illegal infringement on the FERC's jurisdiction.

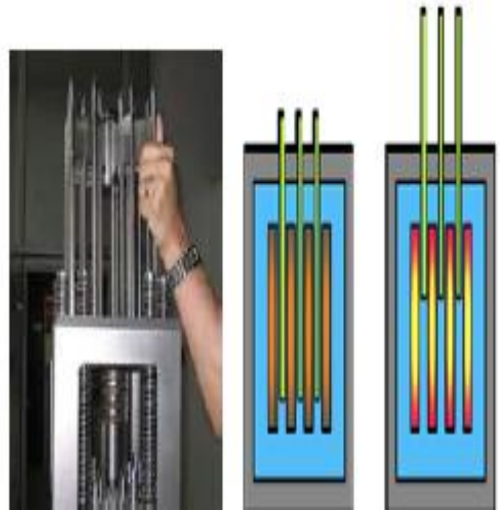
Contract Path: A specific contiguous electrical path from a Point of Receipt to a Point of Delivery for which transfer rights have been contracted. Traditional industry practice was to specify that power flows along a fictional *contract path* consisting of the transmission-owning utilities between the ultimate points of delivery and receipt. Transmission charges across two or more utilities were added together, or *pancaked.*

Control Area: An electric system or systems, bounded by interconnection metering and telemetry, capable of controlling generation to maintain its interchange schedule with other Control Areas and contributing to frequency regulation of the Interconnection.

Control Group: A comparison group to those participants that were exposed to the elements of the pilot experiment.

Control Performance Standard (CPS1 – NERC requirement); This is a statistical measure of a *Balancing Authority's* (BA's) *Area Control Error* (ACE) variability in combination with the interconnection frequency error from scheduled frequency. It measures the covariance between the ACE of a BA and the frequency deviation of the interconnection, which is equal to the sum of the ACEs of all of the BAs. CPS1 assigns each BA a share of the responsibility for controlling the interconnection's steady-state frequency. The CPS1 score is reported to NERC on a monthly basis and averaged over a 12-month moving window. A violation of CPS1 occurs whenever a BA's CPS1 score for the 12-month moving window falls below 100 percent,

Control Rods (Nuclear): Control rods are used in nuclear reactors to maintain the desired state of fission reactions within a nuclear reactor. Control rods constitute a real-time control of the fission process, which is crucial for both keeping the fission chain reaction active and preventing it from accelerating beyond control.control the fission rate of uranium and plutonium. Fission occurs when a U-235 atom is struck by an incident neutron, causing the atom to fission into two smaller atoms (Krypton K-92 and Barium B-141) and also release an average of 2.5 new neutrons. These new neutrons can then collide into more U-235 atoms, which undergo the same fission process, creating a chain reaction that releases substantial energy with each fission event. Therefore, the key to sustaining the fission chain reaction is the amount of neutrons that propagate to the next generation of fissions. Control rods are composed of chemical elements such as boron, silver, indium and cadmium that are capable of absorbing many neutrons without themselves fissioning.

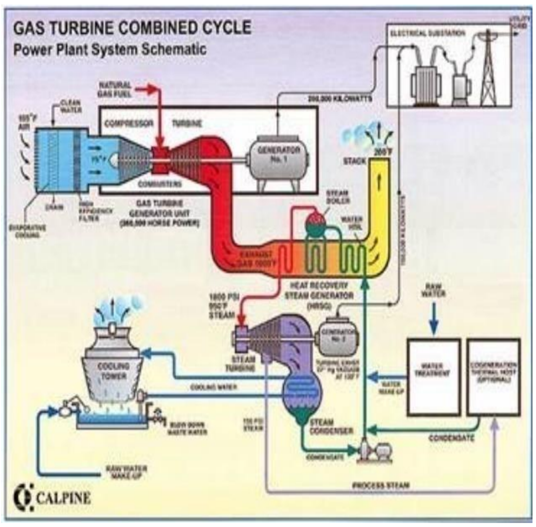


Control Zones: One more transmission zones or multiple contiguous zones determined by the RTO.

Controllable Load: Customer-owned device that can be remotely controlled to adjust usage.

Conventional Gas Resources (Natural Gas): Generally defined as those associated with higher permeability fields and reservoirs. Typically, such a reservoir is characterized by a water zone below the oil and gas. These resources are discrete accumulations, typified by a well-defined field outline.

Conventional Natural Gas Combined Cycle (NGCC – see also Combined Cycle and Combined Cycle Gas Turbine): The combined cycle power plant consists of a gas turbine generator and waste heat is used to make steam to generate additional electricity through a steam turbine. That is, a NGCC unit combines existing gas and steam technologies into one unit, yielding significant improvements in thermal efficiency over conventional steam plant (the Energy Information Administration, in 2015 reported the average heat rate for a coal-fired power plant was 10,059 while a natural gas combined cycle generating unit was 7,655). A NGCC produces high power outputs at high efficiencies (up to 55%) and with low emissions compared to coal-fired power plants or natural gas peaking facilities and NGCC units are substantially less expensive than a coal-fired or nuclear generating facility. In a conventional power plant, the efficiency is about *33%* electricity only and remaining 67% as waste. By using combined cycle power plant we are getting *68%* electricity. The combined-cycle system includes *single-shaft* and *multi-shaft configurations*. The single-shaft system consists of one gas turbine, one steam turbine, one generator and one *Heat Recovery Steam Generator* (HRSG), with the gas turbine and steam turbine coupled to the single generator on a single shaft. Multi-shaft systems have one or more gas turbine-generators and HRSGs that supply steam through a common header to a separate single steam turbine-generator. In terms of overall investment a multi-shaft system is about 5% higher in costs. The steam turbine cycle produces about one third of the power and gas turbine cycle produces two thirds of the power output of the NGCC. By combining both gas and steam cycles, high input temperatures and low output temperatures can be achieved.



Converter: An electrical device, comprising a rectifier and inverter, used to alter the voltage and frequency of incoming alternating current in an electrical system. The term may also refer to inverters, rectifiers or frequency converters. (see also Converter station, Inverter, Rectifier, Frequency converter).

Converting BTU per Hour to Watts: Power *P* in BTUs per hour (BTU/hr) is equal to 3.412141633 times the power *P* in watts (W):

$P_{(BTU/hr)} = 3.412141633 \times P_{(W)}$ So 1W = 3.412141633 BTU/hr. **Example**: Convert 5000W to BTUs per hour: $P_{(BTU/hr)}$ = 3.412141633 · 5000W = 17060.71 BTU/hr

Watts to BTU/hr conversion table

Power (watt)	Power (BTU/hr)
1 W	3.412142 BTU/hr
10 W	34.121416 BTU/hr
100 W	341.214163 BTU/hr
1000 W	3412.141633 BTU/hr
10000 W	34121.416330 BTU/hr

Converting mcf to MMBtu: According to the Energy Information Administration, in 2015, the average heat content of natural gas for the residential, commercial, and industrial sectors was about 1,032 Btu per cf (cubic foot). One Ccf (100 cubic feet of gas) = 103,200 Btu or 1.032 therms; one Mcf (one thousand cubic feet of gas) = 1.032 MMBtu (one million cubic feet of gas) = or 10.32 therms (one therm equals 100,000 Btu or 10 MMBtu). Therefore, dollars per Ccf divided by 1.032 = dollars per therm. Similarly, dollars per therm multiplied by 1.032 = dollars per Ccf. Dollars per Mcf divided by 1.032 = dollars per MMBtu and dollars per Mcf divided by 10.32 = dollars per therm. Dollars per MMBtu multiplied by 1.032 = dollars per Mcf and dollars per therm multiplied by 10.32 = dollars per Mcf.

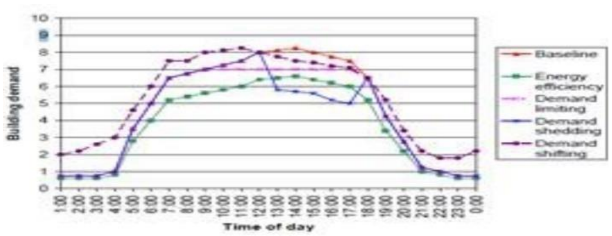
Convex Hull Pricing (Extended LMP or ELMP): Pricing calculates nodal price based on marginal costs from offers associated with an incremental increase in energy that is large enough to take into account unit commitment costs that are not calculated in traditional LMP. Start-up costs are an example of costs that would be included in ELMP. Start-up costs are the incremental costs associated with getting a unit that is shut down up and running, and do not reoccur each hour that the unit continues to run. ELMP is intended to minimize the unaccounted for costs of dispatch and, as a result, the amount of uplift required to cover all of the costs of a generator.

Convex Optimization: Convex Optimization is a specialized area of mathematics that includes least-squares and linear programming. Convex optimization enables analysts to make the best choice when confronted with conflicting requirements. C*onvex Optimization* means that when an optimal solution is found, it is guaranteed to be a best solution or choice.

Cool Coloring: A cool-colored material strongly reflects the invisible "near-infrared" radiation that makes up nearly half of sunlight. Replacing a standard (warm) color with a matching cool color can boost solar reflectance by as much as 0.4 without affecting appearance. (We note that a light color, such as white, is also cool, but the term "cool color" is most commonly used to describe a surface that reflects more strongly in the near-infrared spectrum than in the visible spectrum.)

Cool Storage (a form of Thermal Energy Storage): Is a type of Demand Response that typically involves chilling a reservoir of water or ice during the off-peak hours to supplement the

Heating, Ventilation, and Air-conditioning (HVAC) systems for cooling during the day. That is, water or ice is used the following day during peak electrical rate periods to meet the buildings' cooling load. Cool storage can also be used to facilitate pre-cooling as a means of reducing the customer's peak load at the time of the utility's or RTO's / ISO's peak (*peak clipping)* and, at a minimum *shifts demand* to lower cost periods. For example, in summer, the building mass can be cooled during non-peak hours to reduce the cooling load in the peak hours. As a result, the cooling load is shifted in time and the peak demand is reduced. Cool storage systems can be installed in many new commercial buildings as well as in existing supermarkets, office buildings, schools / universities, hospitals, microgrids etc. Cool storage is a form of DR that is best suited for commercial buildings and works best with dynamic pricing such as real-time or critical peak pricing rates. Generally, facilities managers, owners, control contractors and others understand the potential, commercial buildings are largely an untapped market. Most notably, HVAC systems comprise a substantial portion of the electric load in commercial buildings. Because of the building's mass, the "*thermal flywheel*" effect (thermal storage) allows HVAC systems to be temporarily unloaded without immediate impact on the



building occupants. Since HVAC systems for major buildings are at least partially automated with *energy management and control systems* (EMCS), ECMS helps avoid demand spikes caused by an immediate increase of cooling load (avoiding or minimizing the *rebound effect*).

Coolant (Nuclear): The fission process raises the temperature of the fuel rods used in the nuclear reactor. Coolant transfers the heat from the fuel rods to an intermediate heat exchanger or turbine depending on the design of the power plant. Modern U.S. reactors use water as the coolant. Other reactors use heavy water (deuterium), liquid sodium, or helium.

Cooling Degree-Days: A measure of how warm a location is over a period of time relative to a base temperature, most commonly specified as 65 degrees Fahrenheit. The measure is computed for each day by subtracting the base temperature (65 degrees) from the average of the day's high and low temperatures, with negative values set equal to zero. Each day's cooling degree-days are summed to create a cooling degree-day measure for a specified reference period. Cooling degree-days are used in energy analysis as an indicator of air conditioning energy requirements or use.

Cooling Water Intake Rules - Effluent Limitation Guidelines (ELG): Established under Section 316(b) of the Clean Water Act (CWA) seeks to address impingement (where aquatic life is trapped against thermal power plants' intake screens and injured or killed as a result) and entrainment (where organisms are drawn into the once-through cooling system and killed by pressure and high temperatures). The Effluent Limitation Guidelines for Power Plants was finalized by the EPA on September 30, 2015 and published in the Federal Register November 3, 2015. It became effective on January 4, 2016. ELG is applicable to coal-fired steam electric power plants (primarily coal-fired power plants greater than 50 MW). ELG establishes *new source performance standards* (NSPS) for direct discharges into waters of the United States. Specifically, it limits comingling of waste water streams from FGD Wastewater, Gasification Wastewater, Combustion Residual Landfill and Impoundment Leachate, Fly Ash Transport Water, and Bottom Ash Transport Water.

Co-Optimization: Co-optimization models are computer-aided decision-support tools that search among possible combinations of resources such as generation and transmission investments to identify integrated solutions that are "best" in terms of cost or other objectives while satisfying all physical, economic, environmental, and policy constraints. That is, co-optimization facilitates integrated and simultaneous assessment of all planning alternatives, including supply-side options (bulk and distributed generation and storage), demand management, and transmission, so as to identify the most economically and environmentally efficient combinations. With advances in computer capabilities, eventually, it may be possible to engage in multiple optimization of resource alternatives.

Coordinated Transaction Scheduling (CTS): Interchange transactions between neighboring RTOs / ISOs that are designed to improve efficiencies across seams using forward pricing to achieve price convergence and efficiency in flow direction.

Copper Sheeting: A planning technique used to ascertain the transfer of power over large distances by assuming there were no physical or other impediments (such as pancaked transmission rates or other inefficiencies). This idealistic construct, while not realistic and of no practical value, has the value of establishing a reasonable bound on the solution without having to solve the far more computationally complex non-linear electricity flow problem.

Core Damage Frequency (Nuclear): An expression of the likelihood that, given the way a reactor is designed and operated, an accident could cause the fuel in the reactor to be damaged.

Corona Effects: In a high voltage environment, the phenomenon of ionization of surrounding air around the conductor may cause a luminous violet glow, a hissing noise, and creation of ozone gas. This is known as the corona effect. Air acts as a dielectric medium (an imperfect insulator) between the transmission lines (conductors). The corona effect can increase energy losses, increase lead corrosion (which causes a weakening of the lines), and could interfere with communications equipment in relatively close proximity. Corona and grading rings are used to modify the strength and gradient of electric fields around high voltage equipment.

Correlation (Statistical): In its most general sense, correlation denotes the inter-dependence between quantitative or qualitative data. It would include the association of dichotomized attributes and the contingency of multiple classified attributes. The concept is quite general and may be extended to more than two variates. The word is most frequently used in a somewhat narrower sense to denote the relationship between measurable variates or ranks. While correlation is a necessary condition for causation, it is important to note this correlation does not equate to cause and effect. By way of illustrating the distinction, there may be a correlation between the Chicago Cubs winning the World Series and a major storm hitting the Gulf Coast but that does not mean that the Cubs success caused the storm.

Correlation Coefficient (Statistics): Is a number between -1 and 1 which measures the degree to which two variables are linearly related. If there is perfect linear relationship with positive slope between the two variables, we have a correlation coefficient of 1; if there is positive correlation, whenever one variable has a high (low) value, so does the other. If there is a perfect linear relationship with negative slope between the two variables, we have a correlation coefficient of -1; if there is negative correlation, whenever one variable has a high (low) value, the other has a low (high) value. A correlation coefficient of 0 means that there is no linear relationship between the variables.

Cost Effectiveness Tests for DSM: Recognizing there is no single or correct cost-effectiveness test, most commonly multiple cost effectiveness tests are used because they provide different information that may be valuable to policymakers. The most common measurement of energy efficiency cost-effectiveness is the **Total Resource Cost test** (TRC), followed by the **Societal Cost Test** (SCT). A positive TRC result indicates that the program will produce a net reduction in energy costs in the utility service territory over the lifetime of the program. The distributional tests (Participant Cost Test - PCT, Utility Cost Test – UTC sometimes referred to as the Program Administrator Cost Test, and Resource Impact Measure - RIM) are then used to indicate how different stakeholders are affected. Reliance on the RIM test has been limited because it is regarded as being unduly restrictive. These tests can be applied to DSM measures, programs, or entire portfolios but it should be recognized that the less granular – moving from measures to portfolios – may result in individual measures or even programs being approved that might not pass one or more cost-effectiveness tests.

The **Net-to-gross ratio** (NTG) The NTG adjusts the impacts of the programs so that they only reflect those energy efficiency gains that are the result of the energy efficiency program. Therefore, the NTG deducts energy savings that would have been achieved without the efficiency program (e.g., “free-riders”) and increases savings for any “spillover” effect that occurs as an indirect result of the program. Since the NTG attempts to measure what customers would have done in the absence of the energy efficiency program, it can be difficult to determine precisely. The NTG can be a significant driver in the results of TRC, PACT, RIM, and SCT.

Cost-effectiveness tests incorporate **avoided costs**. There are two main categories of avoided costs: energy-related and capacity-related. Energy-related avoided costs refer to market prices of energy, fuel costs, and other variable costs. Capacity-related avoided costs refer to infrastructure investments such as power plants, transmission and distribution lines, and pipelines. Within each of these categories, policy-makers must decide which specific benefits are sufficiently known and quantifiable to be included in the cost-effectiveness evaluation.

A significant driver of cost effectiveness is the calculation of net present value (NPV) of the annual costs and benefits and discount rates. Since costs typically occur upfront and savings occur over time, the lower the discount rate the more likely the cost-effectiveness result is to be positive. As each cost-effectiveness test portrays a specific stakeholder's view, each cost-effectiveness test should use the discount rate associated with its perspective. For a household, the consumer lending rate is used, since this is the debt cost that a private individual would pay to finance an energy efficiency investment. For a business firm, the discount rate is the firm's weighted average cost of capital, perhaps in the 8 to 12 percent range. However, commercial and industrial customers often demand payback periods of two years or less, implying a discount rate well in excess of 20 percent. The PACT, RIM, and TRC should reflect the utility weighted average cost of capital. The social discount rate (typically the lowest rate) should be used for the SCT to reflect the benefit to society over the long term.

Participant Cost Test *(PCT)*: From the perspective of the customer installing the measure. Costs may include incremental equipment and installation costs; benefits include incentive payments, bill savings, and applicable tax credits or incentives.

Lost Revenue + Tax Savings / Participant Costs

Utility/Program Administrator Cost Test. From the perspective of utility, government agency or third-party implementing the program. Costs may include program incentive, installation, and overhead costs; benefits may include avoided energy and capacity costs - including generation, transmission and distribution - by the utility.

Avoided Costs / Utility Costs

Ratepayer Impact Measure Test *(RIM).* From the perspective of utility ratepayers not participating in available energy efficiency programs. This text includes the costs and benefits that will affect utility rates, including program and administration costs, as well as "lost revenues" to the utility; benefits include avoided energy and capacity costs, and additional resource savings.

Avoided Cost / Utility Costs and Lost Revenues

Total Resource Cost Test *(TRC).* From the perspective of all utility customers in the service area. Costs may include the full incremental cost of the measure, program installation and overhead costs; benefits may include avoided energy and capacity costs, and additional resource savings.

Avoided Cost + Tax Savings / Utility Costs + Participant Costs Net of Incentives

Societal Cost Test. From the social perspective. In addition to benefits considered in total resource cost test, may also include non-monetized benefits such as environmental and health benefits.

Avoided Costs + Tax Savings + Environmental + Other / Utility Costs + Participant Costs Net of Incentives

Cost of Capital: The rate of return a utility must offer to obtain additional funds. The cost of capital varies with the leverage ratio, the effective income tax rate, conditions in the bond and stock markets, growth rate of the utility, its dividend strategy, stability of net income, the amount of new capital required, and other factors dealing with business and financial risks. It is a composite of the cost for debt interest, preferred stock dividends, and common stockholders' earnings that provide the facilities used in supplying utility service.

Cost of Debt: The interest rate paid on new increments of debt capital multiplied by 1 minus the tax rate.

Cost of Preferred Stock: The preferred stock dividends divided by the net price of the preferred stock.

Cost of Retained Earnings: The residual of an entity's earnings over expenditures, including taxes and dividends that are reinvested in its business. The cost of these funds is always lower than the cost of new equity capital, due to taxes and transactions costs. Therefore, the cost of retained earnings is the yield that retained earnings accrue upon reinvestment.

Cost of Service (COS**)**: Establishing the rates a utility charges its residential, commercial, and industrial customers (also referred to as customer classes) based on what is determined by the relevant state, local or federal commission to be "just and reasonable" costs associated with investment in infrastructure (e.g., generating facilities, transmission lines, distribution circuits) and operations (e.g., the cost of fuel or power). A utility is authorized to recover these prudently incurred costs and earn a reasonable profit but not guaranteed.

Cost-of-Service Regulation: A traditional electric utility regulation under which a utility is allowed to set rates based on the cost of providing service to customers and the right to earn a limited profit.

Cranking Path: A portion of the electric system that can be isolated and then energized to deliver electric power from a generation source to enable the startup of one or more other generating units. (NERC)

Critical Energy Infrastructure Information *(CEII)*: CEII is information concerning proposed or existing critical infrastructure (physical or virtual) that:

1. Relates to the production, generation, transmission or distribution of energy;
2. Could be useful to a person planning an attack on critical infrastructure;
3. Is exempt from mandatory disclosure under the Freedom of Information Act; and
4. Gives strategic information beyond the location of the critical infrastructure.

Cross-Price Elasticity of Demand (see also Price Elasticity, Ramsey Pricing, Inverse Elasticity): Cross-Price Elasticity measures the responsiveness of the quantity demanded for a good (e.g., electricity) to a change in the price of another good (e.g., natural gas); all other things being equal – *ceteris paribus*. Cross Price Elasticity is measured as the percentage change in quantity demanded for the first good that occurs in response to a percentage change in price of the second good. For example, if, in response to a 10% increase in the price of gasoline, the demand for new cars that are not fuel efficient decreased by 20%.

Cross-Subsidization: A practice of charging one type (class) of customers a higher price and thereby enabling the utility to charge similar customers a lower price. A utility that faces competitive pressures in one market, for instance, may subsidize those customers by charging higher prices to their other customers that don't face competition.

Cubic Foot (Natural Gas): The most common unit of measurement of gas volume. It is the amount of gas required to fill a volume of one cubic foot under stated conditions of temperature, pressure, and water vapor. One cubic foot equals approximately 1,027 Btus. Mcf, for instance, is 1000 cubic feet. MMcf = million cubic feet, MMBtu = million British thermal units, Bcf = Billion cubic feet. In 2004, the United States used about 23 Tcf = trillion cubic feet of natural gas.

Current (Electric): A flow of electrons in an electrical conductor. The strength or rate of movement of the electricity is measured in amperes.

Current Transformer (CT)**:** A device used in metering that allows inexpensive meters to measure large amounts of electricity. A CT reduces the current flowing to the meter by a specific ratio so the meter is not exposed to the larger amount of current actually moving in the electrical system**.**

Curtailability: The right of a transmission provider to interrupt all or part of a transmission service due to constraints that reduce the capability of the transmission network to provide that transmission service. Transmission service is to be curtailed only in cases where system reliability is threatened or emergency conditions exist. This term could also be applied to customers that have curtailable contracts that allow the utility or load serving entity to interrupt the customer's use of electricity.

Curtailment (electricity): A reduction in the scheduled capacity or energy delivery when line capacity is not sufficient to carry the scheduled flow. Cutting scheduled deliveries to the grid from a power plant due to system physical conditions or cutting supply to a customer due to system physical conditions.

Curtailment Plan (Natural Gas)*:* A contingency plan developed by local gas distribution companies in conjunction with state regulatory agencies to reduce deliveries to firm gas customers in the event of severe disruption to gas supplies or other emergency.

Curtailment Priority (Natural Gas): The priority specified in a curtailment plan for each type of firm customer. The highest priority customer is the last to lose firm service in the event of severe disruption to gas supplies or other emergency.

Curtailment Service Provider (CSP)**:** An entity that aggregates customers willing to participate in demand response (DR) programs or markets.

Cushion (Base) Gas: The total volume of gas which will maintain storage reservoir pressure sufficient to deliver gas back into transmission systems. The volume of cushion gas is generally constant and its value is treated as part of a utility's rate base.

Customer Average Interruption Duration Index (CAIDI): Often with and without including Major Events. CAIDI is calculated similar to SAIDI except that the denominator is the number of customers interrupted versus the total number of utility customers.

CAIDI = Σ(ri * Ni) / Σ(Ni)

Also see the following distribution system reliability indicies:

- *Average Service Availability Index* (ASAI) which is the amount of time electricity is available to customers;
- System Average Interruption Duration Index (SAIDI),
- Customer Average Interruption Frequency Index (CAIFI),
- *Worst CKAIDI* (Circuits with the worst circuit-level Average Interruption Duration Index),
- *Worst CKAIFI* (Circuits with the worst circuit–level Average Interruption Frequency Index),
- *CELID-X* — customers experiencing longest interruption durations;
- *CELID-8* is the percentage of customers who experienced outages exceeding 8 hours,
- *CEMI-X* — customers experiencing multiple interruptions; a measure of the percentage of customers who experienced X interruptions,
- *CEMMI-X* — customers experiencing multiple momentary interruptions; a measure of the percentage of customers who experienced X momentary interruptions, and
- Momentary Average Interruption Frequency Index (MAIFI). See also Major Event Days.

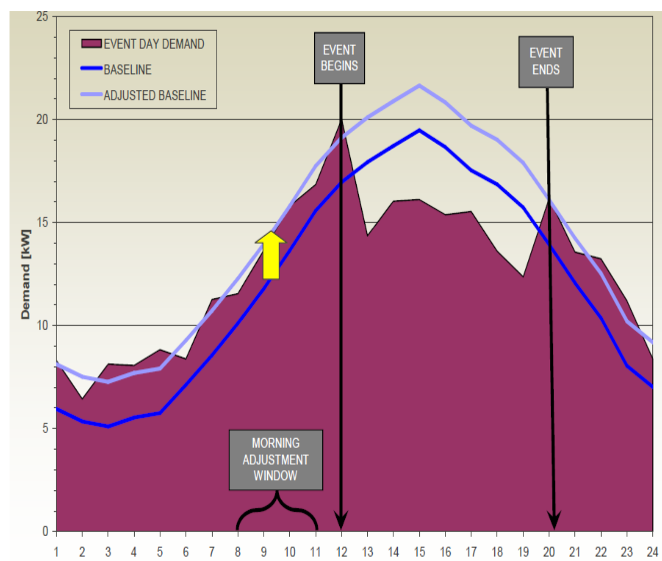
Customer Average Interruption Frequency Index (CAIFI): Similar to SAIFI, the CAIFI measures the average number of interruptions per customer interrupted per year. That is, the number of interruptions divided by the number of customers affected.

CAIFI = Σ(No) / Σ(Ni)

Where: No = Number of interruptions and Ni = Total number of customers interrupted.

A CAIFI of .005 means the average number of interruptions for a customer who was interrupted is 0.005 times.

Customer Base Line (DSM Evaluation, Measurement, and Verification – EM&V)**:** A baseline calculation of a customer's use is counter-factual in that it is an estimate of what a customer's demand and energy use would have been without demand response. This is intended to prevent *false positives and false negatives.* A false positive occurs when a customer receives credit for reducing load when, in fact, the customer did not. A false negative arises when a customer reduces use but does the load reduction was not recognized. A baseline estimate, while analytically challenging is necessary to fairly compensate customers for participation in DSM based on the actual or projected *avoided costs* of the utility (including RTOs / ISOs). The most common type is averaging interval meter data from *representative* (probably excluding weekends, holidays, weather events) *non- DR* days immediately preceding a demand response event. The *adjusted baseline* is intended to be a more accurate estimate of the customer's expected use at the time DR was invoked than the *initial baseline*.



It is more credible to estimate Base Line consumption for a relatively homogenous customers. However, even with in a relatively homogenous class of customers such as residential, stratification (see *Neyman Allocation)* by different home sizes, levels of usage, array of end-uses, and other characteristics would increase the credibility. Similarly, heterogeneous groups of customers can be made more homogenous by use of

North American Industry Classification System - NAICS (formerly Standard Industrial Classification Codes or SIC Codes), stratification by amount of usage, end-uses, whether the customer's use is sensitive to weather, variability of load, and other characteristics. It is particularly difficult to construct a Base Line for highly variable loads and may require baseline calculations that are uniquely tailored to the specific customer or some other technique.

Customer Base Line FERC DSM M&V: NAESB developed a standard *Measurement & Verification* framework which required (1) Maximum Base Load; (2) Meter Before / Meter After; (3) Baseline Type-I (Interval Meter); (4) Baseline Type-II (Non-Interval Meter); and (5) Metering Generator Output. NAESB also included key product definitions and categorizations such as: Wholesale Electric Demand Response Energy, Capacity, day-ahead and spinning Reserve, and Regulation Products – frequency control. FERC adopted by reference Phase I wholesale DR M&V standards in April 2010 (Order 676-F) and Phase II wholesale DR and energy efficiency M&V standards in February 2013 (Order 676-G). See also *Relative Root Mean Square Error* (rRMSE).

Customer Charge: Electric and natural gas utilities have certain costs that do not vary with the amount of electricity (or natural gas) used by customers. Given that usage does not affect these costs is usually the philosophy behind customer charge. Typically, customer charges include costs such as metering, meter reading, and billing. Increasingly, however, utilities may seek to recover the cost of some distribution facilities as part of a customer charge since, within classes of customers such as residential, the costs may not vary significantly with the amount of use. This determination might be a result of a *minimum system cost-of-service analysis.* Regardless of the cost components that are included in a customer charge, the utility assesses a customer charge in addition to the charges for the electricity–kWh and maybe kW (or natural gas) used by the customer. Particularly as customers install solar or other resources to reduce their dependence on their utility – using the utility system as a backup - utilities have been concerned that a traditional customer charge may not accurately reflect the cost of the distribution system. To the extent that customers rely on the utility system for back-up power for their own resources, but not have to pay for a *standby service,* these partial service customers would be subsidized by other customers. In short, the concern expressed by utilities is that they may not be able to fully recover the cost of the distribution system. The utilities' concern is exacerbated by the trend of lower growth (or negative) of electric and natural gas sales. From the customers' perspective, a high customer charge causes customers with lower usage to pay more. For many, this is of particular concern if lower use customers are also more likely to be lower income and unable to pay for essential services and have little ability to reduce their usage (e.g., adding a solar unit).

Customer Choice: The right of customers to purchase energy from a supplier other than their traditional supplier or from more than one seller in the retail market.

Customer Class: A group of end users with similar characteristics; used to segment customers for the purpose of setting rates.

Customer Information System (CIS)**:** CIS for electric utilities (could be used by gas, water / wastewater utilities) provides an analysis of customer usage characteristics and other information for billing, load forecasting, DSM evaluation, customer engagement, and related analytics for marketing, predicting penetration of newer technologies, improve system operations. CIS is enhanced by integration of Advanced Metering Infrastructure (AMI) and Smart Grid.

Cyber Security: Cyber security is a serious and ongoing challenge for the energy sector, and the electricity transmission and delivery system in particular. As the U.S. moves forward with the modernization of its transmission systems, it is critical that infrastructure protection be built into these decision-making processes. In 2006, NERC adopted the Critical Infrastructure Protection (CIP) standards. The standards establish the minimum requirements to ensure the security of electronic information exchange to support the reliability of the bulk power system. Since then, a number of updates have been issued, with version 5 approved by the FERC in November 2013.

Cycling: Electric – Cycling refers to varying output (*ramping up or down*) levels - including on/off, load following, and minimum load operation, in response to changes in system load requirements and the integration of renewable energy into the electric system. It should be noted that, over time, cycling affects the operations, maintenance, and reliability (e.g., the *Forced Outage Rate*). That is, every time a power plant is turned off and on, the boiler, steam lines, turbine, and auxiliary components go through unavoidably thermal and pressure stresses which cause damage; particularly for high temperature components by the phenomenon called *creep-fatigue interaction*.

Natural Gas – The practice of producing natural gas for the extraction of natural gas liquids, returning the dry residue to the producing reservoir to maintain reservoir pressure and increase the ultimate recovery of natural gas liquids. The reinjected gas is produced for disposition after cycling operations are completed.

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Dark Spread (see also Spark Spread): Dark Spread is the positive (or negative) difference between the market price of electricity and the cost of coal-fired generation. The spread can be measured by the difference between the spot or forward prices or LMP-Variable Product Cost (including fuel, Variable Operations & Maintenance, and emissions). **Dark spread calculation**:

$$\text{dark spread (\$/MWh)} = \overbrace{\text{power price (\$/MWh)}}^{\text{power price}} - \overbrace{[\text{coal cost (\$/ton)} + \text{transport cost (\$/ton)}]^{*}\ \frac{\text{heat rate (MMBtu/MWh)}}{\text{heat content (MMBtu/ton)}}}^{\text{fuel costs}}$$

Day-Ahead and Hour-Ahead Markets: Forward markets where electricity quantities and market clearing prices are calculated individually for each hour of the day on the basis of participant bids for energy sales and purchases.

Day Ahead Capacity Obligation: An LSE's daily assignment in megawatts of the Zonal Unforced Capacity Obligation. Calculated as the LSE's Obligation Peak Load in the zone/area the Final Zonal RPM Scaling Factor the Forecast Pool Requirement for an LSE in a zone/area.

Day Ahead Demand: The fixed and/or price-sensitive demand bids cleared in the Day-Ahead Energy Market – used as a financial hedge.

Day Ahead Energy Market: A day-ahead hourly forward market in which market participants may submit offers to sell and bids to buy energy. The results of the Day-Ahead Energy Market are posted daily by 1:30 p.m. and are financially binding. The Day-Ahead Energy Market is based on the concept of Locational Marginal Pricing (LMP) and is cleared using least price security-constrained unit commitment and dispatch programs.

Day-Ahead Schedule: A schedule prepared by a scheduling coordinator or the independent system operator before the beginning of a trading day. This schedule indicates the levels of generation and demand scheduled for each settlement period that trading day.

DC Fast Charging (DCFC): This electric vehicle charging port converts AC electricity to direct current (DC) and delivers charge to the vehicle at high power, typically 50 kilowatts (kW) or greater. DCFC is intended to add a substantial charge to an EV in a short amount of time (e.g., more than 80 miles of range in about 30 minutes of charging, depending on battery size and power level). In contrast, **Level 1** is a 120-volt, alternating current (AC) power and is available from conventional electric outlets that a driver may plug into via a charging cord set that typically is included with an EV. Level 1 charging adds about 4 miles of electric range per hour of charging. **Level 2** is at 240-volts of AC power. Level 2 charging stations typically are mounted on a wall or on a pedestal. Level 2 charging at home typically requires the installation of a 240-volt circuit. Level 2 charging adds about 10 to 20 miles of electric range per hour of charging.

D Curve: The set of curves defining the real and reactive power capacities of a generator; also known as the generator capability curve, or generator capability set. The curves are shaped like a capital letter D, hence the name D-curve.

Deactivation: The "mothballing" of a facility, such that with reconditioning it could be brought back into service in a relatively short time.

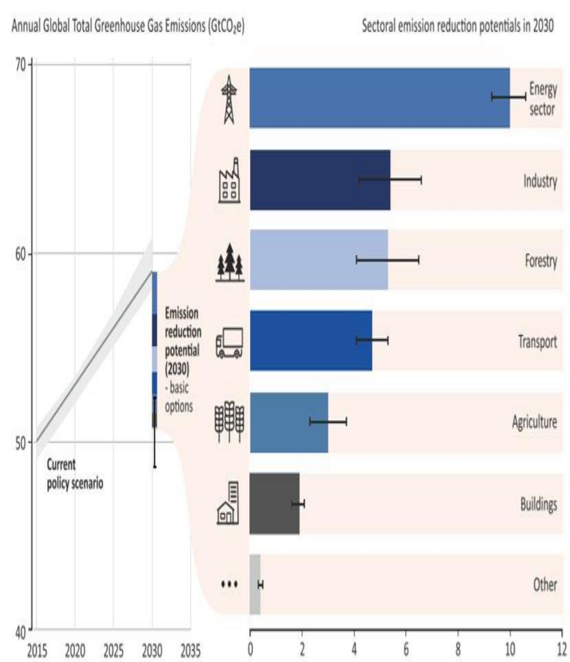
Debenture: A bond backed by the general credit of the company but without a specific pledge of property by mortgage or by other collateral.

Debt Capital, Debt Service, and Debt Service Coverage: A utility's long-term liability represented by borrowed funds. Debt Service: Expenditures for interest and principal on debt instruments. Debt-Service Coverage: The ratio of net revenues to debt service requirements.

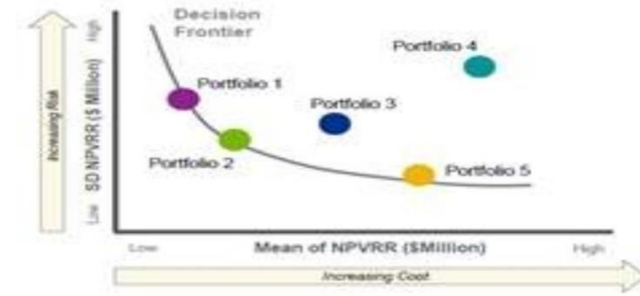
Debt/Equity Ratio: A comparison of the amount of debt to the amount of equity invested in a utility. When the debt is much greater than equity it is referred to as a "highly leveraged" situation.

Decay Heat (Nuclear): Unlike conventional fueled power plants, nuclear reactors continue to generate up to 7% of their power level immediately after shut down due to energy produced by fission byproducts within the reactor. This heat level rapidly reduces to less than 1% 24 hours after shutdown. This energy requires the continuous circulation of coolant to prevent possible damage to fuel cladding and is the basis for emergency core cooling systems and their support equipment. Spent nuclear fuel remains in pools of water for up to 5 years to allow this heat source to dissipate.

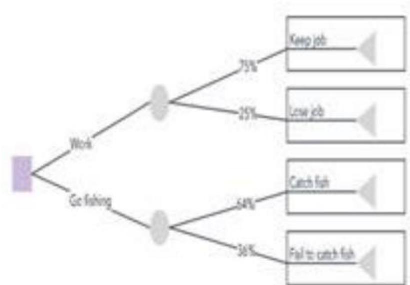
Decarbonization: A reduction of carbon dioxide (CO_2) and / or methane (CH_4) as greenhouse gas (GHG) emissions. GHG emissions are measured in units of technical energy, e.g., per To Total Primary Energy Supply (TPES) and often expressed as kilogram CO_2 equivalent per year. Different GHGs are converted into CO_2 equivalents according to their respective global warming potentials**.**



Decision Frontier: In an Integrated Resource Planning context, the efficiency frontier 'envelops' the inefficient portfolios and shows the relative performance of each portfolio. Any unit on the frontier is considered 100% efficient and any unit below it is relatively less efficient with a rating of less than 100%. This does not imply that the units on the frontier cannot improve their performance but there is no way to quantify the differences.



Decision Trees (see also Risk Analysis and Tornado Charts)**:** This is one form of a predictive model that visually describes potential decisions and their possible consequences. The development of the decision tree to be used in decision analysis or operations research requires heuristic judgement since the future is unknown. A decision tree goes from observations about an item (represented in the branches) to conclusions about the item's target value (represented in the leaves) that are typically represented by squares for decision nodes, circles to assign chance, and end nodes to describe outcomes. Again, Decision Trees are one of many tools that can be used to visually and explicitly represent decisions and decision making (the chart below is from Lucidchart).



Decommissioning: Retirement of a nuclear facility, including decontamination and/or dismantlement. Decommissioning or DECON – A Nuclear Regulatory Commission term for Decommissioning under 10 CFR 50.75 (c), the licensee must provide reasonable assurance that funds will be available for decommissioning costs. This does not include the disposal of spent fuel, ISFSI (Independent Spent Fuel Storage Installation) and removal of clean structures required to return the site to *Greenfield* conditions. This entails removal from the plant site of fuel assemblies, source material, radioactive fission and corrosion products, and all other radioactive and contaminated materials.

Decoupling (see also Straight-Fixed Variable Cost and Performance-Based Regulation): For electric and gas utilities, "decoupling" separates fixed cost recovery from the amount of electricity or gas the utility sells. By appropriately separating fixed and variable costs, utilities will be protected if their sales decline because of customer efforts to reduce energy use and / or to reduce demand – this would include customer owned resources such as solar. To better ensure the costs are appropriately allocated, there is usually a periodic (e.g., annual) regulatory review. If, for example, a utility's customers' significantly reduce their usage due to energy efficiency, the utility may need to increase their rates to maintain the target revenue approved by the regulatory commission. However, from the customers' perspective, their efforts to reduce their reliance on the utility will be reflected in lower bills despite the rate increase.

Decrement Bids (DECs)**:** see also INCs. An hourly bid, expressed in MWh, to purchase energy in the RTOs Day-Ahead Energy Market if the Day-Ahead LMP is less than or equal to the specified bid price. This bid must specify hourly quantity, bid price and location (Transmission Zone, Hub, Aggregate, Interface or single bus). In PJM, for example, As Dr. Bill Hogan said, these virtual transactions include incremental offers that are like generation offers, DECs that are like demand bids, and up-to-congestion bids (UTCs) that are like transmission price spread bids. Virtual transactions offer potential benefits to improve the efficiency of electricity markets, mitigate market power, enhance price formation, hedge real-time market risks, and price those risk hedging benefits.

Decrement Pricing: In response to relatively low natural gas prices, coal-fired generation is run less often. In an effort to burn-down the coal stockpiles, and to enable coal-fired generating units to run at higher capacity factors, some utilities have intentionally offered in their coal units at lower prices than they paid for e the coal.

Default Service Provider (see also Provider of Last Resort and Load Serving Entity): Used in *retail access* (retail competition or *restructured* states) to provide back-up electric service and access to the distribution system. Often it is the incumbent utility prior to restructuring. For Default Service Providers, offering POLR service may be relatively high-priced due to the costs associated with planning and the risk of serving an uncertain number of customers with uncertain electricity loads. This may be regarded as a safety net for customers whose chosen REP is unable to continue service. This service is usually intended to be temporary.

Deferred Charge: Expenditure not recognized as an expense of the period when made but carried forward as an asset to be written off in future periods, such as for advance rent payments or insurance premiums.

Deferred Cost: An expenditure that is not recognized as an expense of the period when made but carried forward as an asset to be written off in future periods.

Definitive Estimate: While still an estimate, the accuracy of a definitive estimate is regarded in Project Management as having a much higher standard of accuracy. This might be the Final Estimate and will be issued when most of the information about the project is known.

Degasification System: The methods employed for removing methane from a coal seam that could not otherwise be removed by standard ventilation fans and thus would pose a substantial hazard to coal miners. These systems may be used prior to mining or during mining activities.

Degree Day (see also Cooling and Heating Degree Days): The difference between the average of the daily high and low temperatures and 65 degrees Fahrenheit.

Degrees of Freedom or df (Statistics - see also Alpha, P-Value, T-Value, and Confidence Interval): Degrees of freedom are the number of values (observations or data) that are free to vary. The number of degrees of freedom equals the number of observations minus the number of required relations among the observations (e.g., the number of parameter estimates which are the mean and standard deviation of a *normal distribution*). *The general result is that you lose one degree of freedom for each parameter estimated prior to estimating the (residual) standard deviation*. For a 1-sample t-test, one degree of freedom is spent estimating the mean, and the remaining *n* - 1 degrees of freedom estimate variability. Calculating the degrees of freedom for a regression analysis is more difficult because a parameter is estimated for every variable and consumes a degree of freedom.

Deliverability (from Natural Gas Storage): The output of gas from a storage reservoir, as expressed as a rate in thousand cubic feet

(Mcf) per 24 hours, at a given total volume of gas in storage with a corresponding reservoir pressure and at a given flowing pressure at the wellhead.

Delivered Price Test: **Delivered Price Test** (DPT- see also Hirschman-Herfindahl Index - HHI). FERC, since 1996 in its "Merger Policy Statement," referred to DPT as a secondary screen to the HHI that considers native load commitments for an electricity supplier's available economic capacity and attendant energy available for offer in the electricity market over several seasons. The analysis also considers available supply from other generators in the region. FERC may find that an HHI of less than 2,500 in the relevant market for all seasons, in combination with a demonstration that the applicants are not pivotal suppliers and do not possess more than a 20% market share, would constitute a showing of a lack of horizontal market power.

Delivery Point (Electricity): The location on a transmission system to which electricity is transported.

Delivery Point (Natural Gas): A point along a pipeline at which the pipeline delivers natural gas to its customers. The city gate is a common delivery point for pipeline deliveries to an LDC.

Delivery Year: The 12 months beginning June 1 and extending through May 31 of the following year. Delivery Year may also be referred to as Planning Year or Planning Period.

Delphi Group: This refers to the Oracle of Delphi. For forecasting and problem solving, the Delphi method entails experts working together on a problem. This can be an informal process or a more formal process. The more formal process entails a series of questionnaires that are submitted to a panel of experts with the expectation their responses are anonymous. The experts, typically, are not be in the same location. After each round of questionnaires, the panelists are told about the prevalent views of the group as well as individual perspectives without attribution. The panel of experts may alter their views in each successive round of questionnaires. A facilitator is often used to achieve the ultimate goal of reaching a consensus. One of the benefits of this technique is that the experts are likely to be more objective and candid since the responses are anonymous and they do not know the other experts that are participating.

Delta Configuration: A way of connecting three-phase electric lines, achieved by connecting three independent transformer or generator windings head to toe (end to end).

Demand: The rate of electricity usage (measured in kilowatt - or megawatts) by a customer. Demand is typically measured in kilowatts (kW), megawatts (MW), or gigawatts (GW). It could be measured in kilovolt amperes (kVa). The difference between kW and kVA is the *power factor.* Demand refers to the maximum amount of electric energy being used at any instant in time. The peak demand for a utility is the maximum usage of all of their customers at a specific moment. Usage by any customer at this moment is referred to as *coincident peak demand.* However, individual customers may have their highest demand at times other than the utility's peak demand. This is referred to as *non-coincident peak demand.* The amount of energy consumed is in kWh. For example, A 100 Watt light bulb used for 10 hours = 1 kWh. Forecasting the short and long-term utility peak demand is necessary for establishing the amount of resources – including adequate reserve resources for *contingencies* - needed to serve customers demand. This is referred to as *Resource Adequacy.*

Demand Bid: A bid into the power exchange indicating a quantity of energy or an ancillary service that an eligible customer is willing to purchase and, if relevant, the maximum price that the customer is willing to pay. (see also "BID")

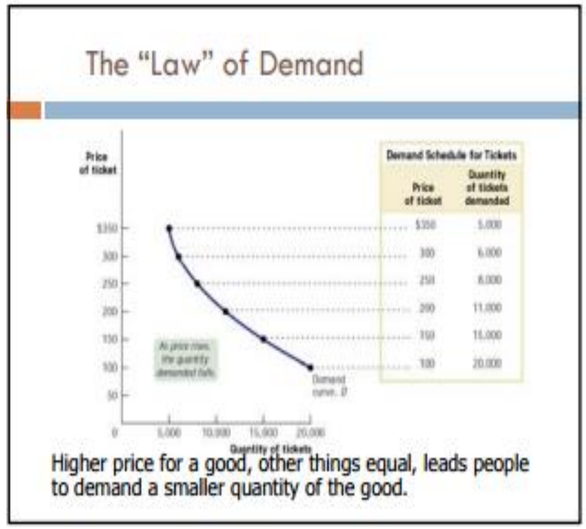
Demand Bid (fixed): An hourly bid, expressed in MWh, that may be submitted into the Day-Ahead Energy Market to purchase a certain amount of energy at Day-Ahead LMP. Fixed Demand Bids must specify hourly quantity and location (transmission zone, aggregate or single bus).

Demand Bid (price – sensitive): An hourly bid, expressed in MWh, that may be submitted into the Day-Ahead Energy Market to purchase a certain amount of energy at Day-Ahead LMP only if the Day- Ahead LMP value is less than or equal to the specified bid price. Price-sensitive Demand Bids must specify hourly quantity, bid price and location (transmission zone, aggregate or single bus).

Demand Bidding (see also FERC Order 745): Demand bidding is to the ability of customers to *bid* a price at which they will reduce demand. In most RTO / ISO markets, aggregators can bid customer demand resources into day-ahead energy markets, and are dispatched if economically warranted. As part of the *Measurement* and *Valuation* process, RTOs estimate customers' baseline usage. *Aggregators* may combine customers that rely on various forms of demand response and energy efficiency but most participants are large industrial facilities and commercial/educational establishments.

Demand Charge: That portion of the consumer's bill for electric service based on the consumer's maximum electric capacity usage and calculated based on the billing demand charges under the applicable rate schedule. Traditionally, demand charges have been determined as a customer's maximum usage without regard to the time of use or the customer's contribution to the utility's maximum demand (coincident demand). As a result of demand being determined by a customer's non-coincident demand, some customers might establish their maximum usage at a time when the utility would benefit from additional use.

Demand Curves (see also supply curves, consumer surplus, producer surplus, subsidies and shifts in supply and demand curves, and welfare economics): The demand curve captures the relationship between the price and demand by showing the quantities purchased at different prices. It is downward sloping and to the right on which demonstrates as the price of a good or service increases, the demand for the good decreases (the law of demand is an inverse relationship between the price and the quantity demanded to demonstrate decreasing marginal benefit or utility). The slope of the demand curve is a function of *elasticity.* A perfectly inelastic demand is vertical and a perfectly elastic demand curve is horizontal (parallel to the X axis). Factors that can shift the demand curve include: A) Changes in the price; B) Technological improvements (more efficient end uses); C) The prices of other goods or services; D) Taxes and subsidies; E) Expectations (e.g., future price); F) Number of buyers in the market.

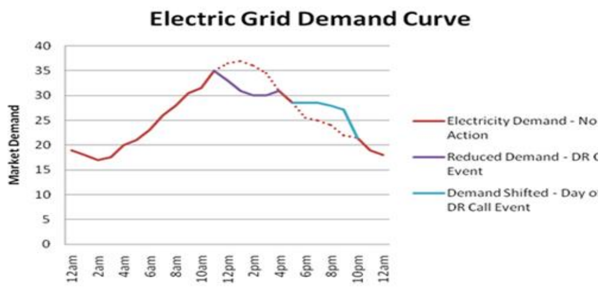


Demand Flexibility: LBL defines this as the capability provided by distributed energy resources (DERs) to adjust load profiles across different timescales which can provide significant benefits to the electric utility system through a combination of actions that control or reduce electricity consumption to avoid system costs. Grid-interactive efficient buildings are an important source of demand flexibility.

Demand Interval: The time period during which flow of electricity is measured (usually in 5-, 15, 30, or 60-minute increments.). This can be used for billing and / or load research to better understand when electricity is consumed.

Demand Response (DR) (A subset of Demand Side Management and Distributed Energy Resource which includes "Price Response" which is a subset of Demand Response): The ability of a customer to reduce use in response to changing price signals provided by Regional Transmission Organization / Independent System Operator or the relevant load serving utility in areas not served by an RTO/ISO.

"Demand Response," as the U.S. Department of Energy (DOE) used in its February 2006 report to Congress, are "Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized. Demand Side Management does not include demand reductions attendant with improvements to end use efficiency."



Demand Response Resources (DRRs) may provide Ancillary Services as defined in FERC Order 888-A. That is, DR can provide services necessary to support the transmission of capacity and energy from resources to loads while maintaining reliable operation of the Transmission Service Provider's transmission system in accordance with good utility practice. This can also be regarded as Demand Response resources displacing generation deployed as operating reserves or regulation. That is, treating ***Load as a Capacity Resource*** **(LCR)** By making pre-specified Load reductions when system contingencies arise. ***Regulation Product*** **Type** is a type of Demand Response product in which a DR increases and decreases load in response to real-time signals. Demand resources providing *Regulation Service* are subject to continuous dispatch during a commitment period. ***Spinning and non-spinning requirements*** may also be met by Demand Response resources that are obligated to be available to provide demand reduction upon deployment by the System Operator.

Demand Response Availability Data System (DADS) (NERC statistics): DADS is a recognition by the North American Electric Reliability Corporation (NERC) that Demand Response is important to the reliability of the electric system. DADS is a data collection effort that is intended to quantify the benefits of DR and to assure that DR is properly considered in the planning of the *bulk power system.* This means there is a need for better Evaluation, Measurement, and Verification (EM&V) of DR and how it is integrated into the electric system. Currently, DADS is being implemented across four phases. Phase I began in 2010 and consisted of voluntary reporting of dispatchable (Demand-Side Management resource that is curtailed according to a signal from a System Operator) and controllable Demand Response (System Operator has physical command of the resource). In 2011, Phase II made reporting of dispatchable and controllable Demand Response programs mandatory under NERC Rules of Procedures Section 1600 and includes program registration data, event data, market participation data, and ancillary services. The data is currently gathered semi-annually for the Summer and Winter seasons. Future phases III and IV will consist of voluntary and mandatory reporting of non-dispatchable and economic Demand Response programs. DADS collects the following:

1. Enrollment Metrics;
2. Number of enrolled resources;
3. Number of enrolled MW;
4. MW Density;
5. Event Metrics;
6. Realization Rate;
7. Event Deployment Rate;
8. Hour Deployment Rate;
9. Mean Load Reductions;
10. Mean Length of Event;
11. Mean Time of Event;
12. Types of Programs Being Implemented;
13. Frequency of Use;
14. Trend of Enrolled MW, by Product and Area;
15. The amount of DR Capacity is Committed Over How Many Hours Per Year.

http://www.nerc.com/page.php?cid=4|357

Demand Response FERC Orders: Order 719 permits demand response participation in RTO / ISO markets unless state laws do not permit customers or aggregators of customers to participate. Order 745 provides RTOs / ISOs to compensate demand response resources that participate in *day-ahead* or *real-time* wholesale energy markets – including *locational marginal cost pricing* (LMP); provided demand response is dispatchable by the RTOs / ISOs for balancing supply and demand and are determined by the RTOs to be cost-effective by a *net benefits* test. Order 676-F and 676-G require *Measurement* and *Verification* (M&V) for demand response and energy efficiency. Generally, these orders provide for the utilization of traditional utility generation and demand response and energy efficiency to be utilized on as comparable a basis as possible routine operations - including ancillary services, and for emergencies. The U.S. Supreme Court issued a decision in *FERC v. EPSA**in January 2016 that fully upheld FERC's jurisdiction of wholesale demand response. The Court held FERC did possess adequate regulatory authority under the Federal Power Act (FPA) and FERC's decision to compensate demand response providers at locational marginal price was not arbitrary and capricious. *Elec. Power Supply Ass'nv. FERC*,753 F.3d 216 (D.C. Cir. 2014), *rev'dsub nom. FERC v. Elec. Power Supply Ass'n*, 136 S. Ct. 760 (2016).

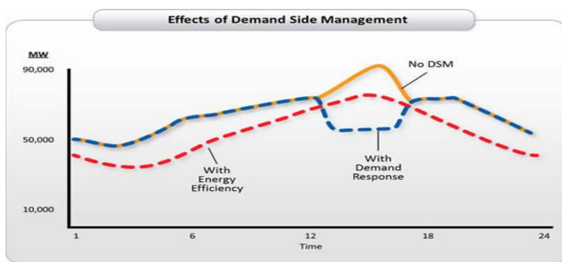
RTO/ISO	2014 Potential Peak Reduction (MW)	2014 Percent of Peak Demand	2015 Potential Peak Reduction (MW)	2015 Percent of Peak Demand
California ISO (CAISO)	2,316	5.1%	2,160	4.4%
Electric Reliability Council of Texas (ERCOT)	2,100	3.2%	2,100	3.0%
ISO New England, Inc. (ISO-NE)	2,487	10.2%	2,696	11.0%
Midcontinent Independent System Operator (MISO)	10,356	9.0%	10,563	8.8 %
New York Independent System Operator (NYISO)	1,211	4.1%	1,325	4.3%
PJM Interconnection, LLC (PJM)	10,416	7.4%	12,910	9.0%
Southwest Power Pool, Inc. (SPP)	48	0.1%	0	0%
Total ISO/RTO	**28,934**	**6.2%**	**31,754**	**6.6%**

Demand Metered: Having a meter to measure peak demand (in addition to total consumption) during a billing period. Demand (kW or MW) is not usually metered for other energy sources.

Demand Resource Modification: Transaction used by RTOs to track an increase or decrease of the nominated value of the demand resource in a partys resource portfolio in the Capacity Exchange tool.

Demand Response Factor: One of the parameters used to determine the Unforced Capacity value of demand resources in the capacity market. The DR Factor is calculated by PJM, approved and posted by Feb. 1 prior to the Base Residual Auction.

Demand Side Management (DSM or Demand-Side Resources): The planning, implementation, and monitoring of utility activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand. It refers to only energy and load-shape modifying activities that are undertaken in response to utility-administered programs. It does not refer to energy and load-shaped changes arising from the normal operation of the marketplace or from government-mandated energy-efficiency standards. Demand-Side Management covers the complete range of load-shape objectives, including strategic conservation and load management, as well as strategic load growth.



Demand-Side Management Costs: The costs incurred by the utility to achieve the capacity and energy savings from the Demand-Side Management Program. Costs incurred by customers or third parties are to be excluded. The costs are to be reported in thousands of dollars (nominal) in the year in which they are incurred, regardless of when the savings occur. The utility costs are all the annual expenses (labor, administrative, equipment, incentives, marketing, monitoring and evaluation, and other incurred by the utility for operation of the DSM Program), regardless of whether the costs are expensed or capitalized. Lump sum capital costs (typically accrued over several years prior to start up) are not to be reported. Program costs associated with strategic load growth activities are also to be excluded.

Demonstrated Reserve Base (Coal): A collective term for the sum of coal in both measured and indicated resource categories of reliability, representing 100 percent of the in-place coal in those categories as of a certain date. Includes beds of bituminous coal and anthracite 28 or more inches thick and beds of subbituminous coal 60 or more inches thick that can occur at depths of up to 1,000 feet.

Includes beds of lignite 60 or more inches thick that can be surface mined. Includes also thinner and/or deeper beds that presently are being mined or for which there is evidence that they could be mined commercially at a given time. Represents that portion of the identified coal resource from which reserves are calculated.

Density Forecasting (statistics): A probabilistic technique to capture probability distributions around predicted values or the expected variance. Ideally, the density prediction function (PDF) would equal the distribution from which the future observation is drawn. Continuous Ranked Probability Score can be used to compare density forecasts.

Dependable Capacity: The load-carrying ability of a station or system under adverse conditions for a specified period of time.

Dependent Variable: In a statistics experiment, the dependent variable is the event studied and expected to change whenever the independent variable is altered. In the design of experiments (e.g., for verifying customer demand response or energy efficiency programs), an independent variable's (or variables) values are controlled or selected by the experimenter to determine its relationship to an observed phenomenon (i.e., the dependent variable). In such an experiment, an attempt is made to find evidence that the values of the independent variable determine the values of the dependent variable. (see also Independent Variable)

Depreciation: Depreciation recognizes that fixed assets such as power plants, equipment, etc. are assets that will not last indefinitely. During each accounting period (year, quarter, month, etc.) a portion of the cost of these assets is being "used up". The portion being used up is reported as depreciation. In effect, depreciation is the transfer of a portion of the asset's cost from the balance sheet to the income statement during each year of the asset's life. The *depreciation life* estimate is used to determine depreciation expense.

Derating, is a reduction in the capability or capacity of a facility such as a transmission line or a generating unit. Derating generating capacity occurs for several reasons such as environmental constraints on the operations of a generating unit.

Deregulation: The process of decreasing or eliminating government regulatory control over industries and allowing competitive forces to drive the market. Some states have deregulatied some aspects of electric utilities such as generation believing that competitive markets would provide a lower cost outcome. These states promote retail competition which is sometimes referred to as "unbundling" or "retail access." State regulatory commissions typically have little authority over generating resources.

Derivatives (as used in finance, see also Collars, Hedging Contracts, Swaps and Options): A derivative is a security with a price that is dependent upon or derived from one or more underlying assets. The derivative itself is a contract between two or more parties based upon the asset or assets. Its value is determined by fluctuations in the underlying asset. The most common underlying assets include stocks, bonds, commodities, currencies, interest rates and market indexes. Derivatives either be traded over-the-counter (OTC) or on an exchange. OTC derivatives constitute the greater proportion of derivatives in existence and are unregulated, whereas derivatives traded on exchanges are standardized. OTC derivatives generally have greater risk for the counterparty than do standardized derivatives.

Descriptive Statistics (see also Inferential Statistics)**:** Statistics that quantitatively describe or summarize features of a collection of data such as measures of central tendency (e.g., mean, mode, median) and measures of variability such as variance and standard deviation. Descriptive statistics are distinguished from inferential statistics, in that descriptive statistics summarize a sample rather than use the data to learn about the entire population. This generally means that descriptive statistics, unlike inferential statistics, are not developed on the basis of probability theory.

Design Capacity (Natural Gas): (see also certificated capacity.) The design capacity of pipeline sections having bidirectional flow capacity associated with the direction of the flow observed on the peak day.

Design Day: (Natural Gas) A 24-hour period of demand which is used as a basis for planning gas capacity and service requirements.

Design Margin (Nuclear): Refers to the relationship of the nuclear power plants normal operating parameters (temperature, pressure, flow) compared with the maximum allowable engineering design parameters.

Deterministic vs. Probabilistic (Statistical - see also Probabilistic Risk Assessment and Stochastic): In general terms, probabilistic (also known as "stochastic" or random outcomes) entails the element of chance such as the outcome from the role of dice while deterministic you know the answer such as predicting the amount of money in a bank account at the end of one year by knowing both the interest rate and the initial deposit. In the electric industry, deterministic approaches have been used to quantify the amount of reserve margin requirements (Resource Adequacy) by planning to a given standard such as a Loss of Load Expectation of 1 day in 10 years.

Diffusion Curves: These create smooth shaded images by partitioning them into 2 diminisions and different colors that are spread into both sides to create the diffusion effect.

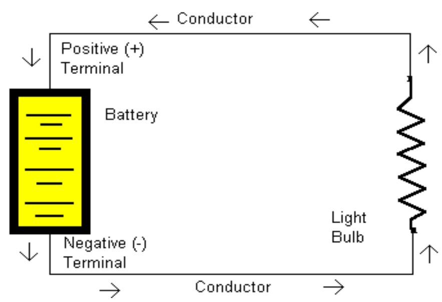
Diminishing Marginal Utility: Consumer surplus declines with additional consumption due to the *law of diminishing marginal utility* (customer satisfaction). That is, the first unit of a good or service consumed generates much greater utility than the second, which generates greater utility than the third and subsequent units.

Direct Access: Buying power from the wholesale electricity market instead of from a supplier or local distribution company.

Direct Assignment: The Direct Assignment of costs, as part of a *Cost of Service Study* is consistent with the concept of *cost causation.* That is, specific customers or customer classes that cause certain unique costs to be incurred by a utility should pay for those specific costs. By way of examples, an industrial customer that requires redundant services might constitute a direct allocation. An underground distribution system serving a business district might constitute a direct assignment of those costs that are different than those customers served by over-head distribution. Consistent with Dr. James Bonbright's objective criteria for ratemaking, direct assignment of unique costs to specific customers or classes is desirable. In an extreme hypothetical example, if a very large customer uses electricity entirely coincident with the relevant utility's coincident peak demand and new generation and transmission was built to serve that customer, that customer should incur significant direct costs including generation and transmission related costs that would normally be allocated to all customers. Direct Assignment, then, is in contrast to *joint and common costs* that required shared responsibilities for cost recovery. The cost of generation and bulk power transmission, with some exceptions, are required to serve all customers.

Direct Costs (see also Indirect Costs): A direct cost for an electric utility can be completely attributed to the production, transmission, or distribution of electricity. Some costs, such as depreciation or administrative expenses, are more difficult to assign to a specific product and therefore are considered to be indirect. *Assigning* direct costs to specific customers tends to be more difficult. For example, in an Alternating Current environment, power flows on the paths of least resistance and not to specific customers. Customers in distant locations may receive power from power plants that were intended for specific customers. Two popular ways of tracking these costs include last in, first out (LIFO) or first in, first out (FIFO). In contrast, examples of *Indirect Costs* include materials and supplies needed for the company's day-to-day operations. These items cannot be assigned to a specific aspect of production.

Direct Current (DC): The flow of electricity that is controllable as to direction and amount, and does not oscillate in voltage or current.



Direct Injection Carbon Engine (DICE): A diesel engine that has been modified to enable combustion of water based slurry of *micronized refined carbon* (MRC). Improvements in engine technology and coal water system advancements have resulted in interest in this technology. Especially for states with coal resources, this technology may be attractive if it achieves the clean burning objective and reduces the cost of carbon capture and storage. Experimentation with biofuels may also prove to be feasible. Typically a DICE is in the 60 MW range.

Direct Load Control (DLC), is a subset of Demand Response (DR) that allows customers to exercise greater control over their use of electricity (or natural gas) and reduce their energy bill. From the utility's perspective, DLC enhances reliability and cost savings by effectuating a positive - but short-term change - in the utility's resource requirements and resulting load shape (typically by reducing a customer's contribution to the utility's system coincident peak demand with possibly some shifting to off-peak periods). For decades, many customers have permitted their utilities to control various end-uses such as water heaters, air-conditioners, and thermostats during peak periods. Farmers have benefited from DLC on irrigation, crop drying, and other processes. Commercial customers have also realized benefits from DLC on specific end-uses. Increasingly, the dispatachability of DLC and DR will be enhanced by two-way communications between system operators and the customer (or the customer's representative that may be an *aggregator*) through the use of Advanced Metering Infrastructure (AMI) and Smart Grid applications that are capable of instantaneously verifying the temporary changes in demand.

Direct Normal Irradiance (DNI): Straight line solar radiation. In conjunction with Diffuse Horizontal Irradiance (DIF) is used to assess locations for solar installations.

Discount Rate (see also Discounted Cash Flow or DCF, Weighted Average Cost of Capital or WACC, Capital Asset Pricing Model or CAPM, Capital Structure, and Capital Recovery Factor or CRF): Refers to the interest rate used in financial analysis. By way of example, the discount rate is used in the development of *discounted cash flow* (DCF) to determine the present value of future cash flows. The discount rate in DCF analysis takes into account not just the time value of money but also the risk or uncertainty of future cash flows. That is, the greater the uncertainty of future cash flows, the higher the discount rate. For example, you expect $1,000 in one year. To determine the present value (PV) of this $1,000 (what it is worth to you today), you would need to discount it by a particular interest rate. Assuming a discount rate of 10%, the $1,000 in a year's time would be equivalent to $909.09 to you today (1,000 / [1.00 + 0.10]). If you expect to receive the $1,000 in two years, its present value would be $826.45.

Discounted Cash Flow Model (DCF)**:** A valuation method used to estimate the attractiveness of an investment opportunity. DCF uses future free cash flow projections and discounts them to arrive at a present value estimate, which is used to evaluate the potential for investment. If the value arrived at through DCF analysis is higher than the current cost of the investment, the opportunity may be appropriately selected.

Discrete Variable (statistical - see also Continuous Variable): Over a particular range of real values is one for which, for any value in the range that the variable is permitted to take on, there is a positive minimum distance to the nearest other permissible value. The number of permitted values is either finite. Common examples are variables that must be integers, non-negative integers, positive integers, or only the integers 0 and 1. The probability distribution of discrete functions can be expressed by *probability mass functions.*

Disptach: The act of a system operator ordering a generating unit to come on line or to change its current level of output.

Dispatch Order: Dispatch rules such that, given a specific amount of load to serve, an approximate generation dispatch can be determined. To accomplish this, each generator is ranked by priority.

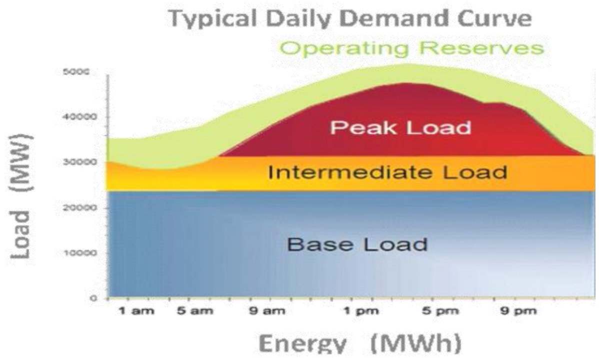
Disptach Stack: A list, typically in order from least cost to highest cost, of power plants scheduled to run at a specific point in time in order to match electric supply to demand.

Dispatchable Generation: Generation that can follow dispatch instructions between economic minimum and economic maximum.

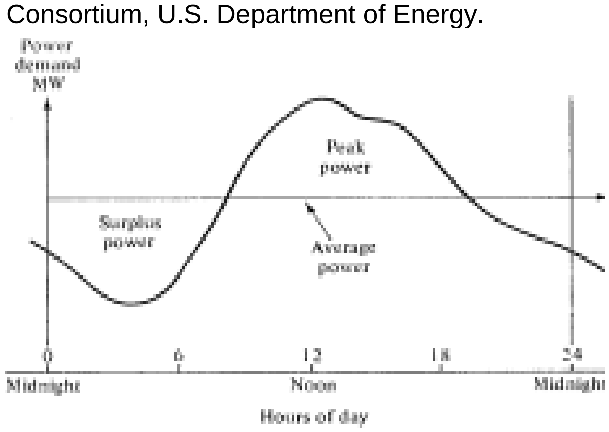
Dispatching: The operating control of an integrated electric system involving operations such as:

1. the assignment of load to specific generating stations and other sources of supply to effect the most economical supply as the total or the significant area loads rise or fall;
2. the control of operations and maintenance of high-voltage lines, substations, and equipment;
3. the operation of principal tie lines and switching; and
4. the scheduling of energy transactions with connecting electric utilities.

See also "Economic Dispatching" or Security Constrained Economic Dispatching" that dispatch the lowest cost combination of generating units, at any point in time, subject to transmission constraints.



Distributed Energy Resources (DER): DERs are a resource sited close to customers that can provide all or some of their electric and power needs and can also be used by the system to either reduce customer demand or provide supply to satisfy the energy, capacity, or ancillary service needs of the distribution grid. The resources, if providing electricity or thermal energy, relatively small scale, connected to the distribution system, and close to load. Examples of different types of DER include solar photovoltaic (PV), wind, combined heat and power (CHP), energy storage, demand response (DR), electric vehicles (EVs), microgrids, and energy efficiency (EE).Note the IEEE Standard 1547 does not include Demand Response (DR) but this is a matter for policymakers. DER can provide back-up power, used to displace relatively high cost energy such as at the time of system peak demand, can stabilize the grid, firm up other resources, potentially reduce back-feed problems, and enhance power quality. Source: Grid Modernization Laboratory Consortium, U.S. Department of Energy.



Some of the potential advantages of DER include: 1) reduced demand on system elements and peak demand which may result in a deferral of transmission and distribution upgades, 2) increase the diversity of the resource mix, 3) provides voltage and frequency support, 4) reduce line losses, 5) provides back-up power in emergencies and may provide spinning reserves and black start capabilities to help restore the system, 6) reduced emissions in heavily populated areas.

DER are smaller power sources that can be aggregated to provide power necessary to meet regular demand. As the electricity grid continues to modernize, DER such as storage (Distributed Energy Storage) and advanced renewable technologies can help facilitate the transition to a smarter grid. Deploying DER in a widespread, efficient and cost-effective manner requires complex integration with the existing electricity grid.

Distributed Energy Resource Management Systems (DERMS) (see also Virtual Power Plants): This provides the utility with greater situational awareness to better dispatch, monitor, and control DERs that integrated into the distribution system. This could include photovoltaic resources with or without smart inverters, energy storage, electric vehicles, and demand responsive load. DERMS is likely to be more successful with Smart Grid and Advanced Metering Infrastructure. By reliance on real-time communication, DERMS facilitates optimized control and dispatch of DERs on the distribution system, including Volt/VAR optimization (VVO) and enhanced power quality on individual feeders. From reductions in system peak to reduction of congestion on distribution feeders, DERMS can adjust, turn on, and turn off devices – including behind the meter resources - connected to the system.

Distributed Energy Storage (DES), is an energy storage device, such as a battery, located at the distribution level of the electrical as opposed to a storage device connected at the transmission level of the grid. An example of a distributed energy device would be one on the customer side of the meter.

Distributed Generation (DG), is an electricity generator connected at the distribution level of the grid. While DG, in various forms, have been around since the inception of the electric industry, the Public Utility Regulatory Policies Act (PURPA 1978), required electric utilities to purchase power from qualifying facilities (QFs) at the utility's "avoided cost." These QFs included combined heat and Power facilities and small power production facilities with 80 MW or less of installed renewable generation capacity. By and large, customers with DG maintain connected to their utility's distribution system for backup power and to sell surplus energy back to their utility. For residential customers that typically use about 3.5 kW, DG installations are typically tailored to the customers' needs. DG installations of 10 megawatts (MW) are greater are typically installed for commercial and industrial customers. In addition to solar PV, DG includes small wind turbines, Combined Heat and Power, fuel cells, and microturbines.

Distribution: The delivery of electricity from the transmission system to the customer meter over medium- and low-voltage lines (typically with a voltage of 50 kV or lower).

Distribution Automation (DA): Enables the monitoring, coordination, and operation of distribution system components in real-time mode, while adjusting to changing loads and failure conditions of the distribution system, usually without intervention. These functions require telemetry, analytics, and control which, in turn, require communication and computational resources. Successful DA results in outages of shorter durations and improved system reliability metrics, the ability to recover from storm and other outages more expeditiously, more effective maintenance of equipment. DA may also facilitate the integration of Distributed Energy Resources (DERs).

Distribution Contingency Studies (also referred to as Restoration Studies or Tie Capacity Studies)**:** While Contingency Studies are common in electric transmission systems (including generating resources and DSM), however, they have not typically performed by distribution planning engineers. Contingency studies are used to identify potential overloads and other problems that may occur during a planned or unplanned "contingency event," such as an outage of power lines and bulk power generators, as well as the closure of normally open lines (EPRI 2010). Modern electric utility operating policies for transmission systems (those of the *North American Electric Reliability Corporation*, [NERC], for example) require that all system loads can be restored on the system if any single component fails (i.e., N−1 components are still available). This requires a level of redundancy in both generation and transmission. Some critical policies may extend to an "*N−2 contingency*" requirement so that the power system is able to withstand and recover from any subsequent single failure. A relatively small number of urban distribution systems are networked to provide some redundancy, and they can be designed to meet N−1 or N−2 requirements. Typically, only large cities are *networked*, but small cities and rural areas are not. Due to the meshed topologies and the typically large loads served by most transmission systems, contingency analysis is widely applied in transmission system studies. Because most 4 distribution systems are radial by design, the failure of a single system element will result in loss of downstream loads for hours, unless there are cross-connections to other adjacent *radial feeders*. In that case, power can be restored from alternative feeds via manual or automated switching operations. In radial distribution systems, contingency studies are often referred to as *"tie capacity studies*" or "*restoration studies*." For radial distribution systems, a restoration study is used to optimize the number of utility customers that can be reenergized without overloading any part of the power system. In distribution-system restoration studies, valid contingencies are listed and weighted by likelihood of occurrence, and an outage simulation is performed for each one. Decisions will be made on whether part of the feeder will be dropped to solve overloads and voltage problems. If available, the de-energized feeder segments will be reenergized by adjacent feeders or possibly by other power sources (e.g., a mobile diesel generation unit), depending on the locations of the switches, overloading limits of the feeder lines and equipment (e.g., transformers, regulators), and feeder voltage limits (Carr 1999). Restoration studies are among the major analyses conducted in distribution systems. Utilities differ in the level of detail and complexity of their studies. Source: Grid Modernization Laboratory Consortium, U.S. Department of Energy.

Distribution Factor: The portion of an Interchange Transaction, typically expressed in per unit that flows across a transmission facility (Flowgate). (NERC)

Distribution Line (Natural Gas): A pipeline network that transports natural gas from the transmission line (such as an interstate pipeline) to end-users' service line or other distribution lines. Large pipelines are laid in principal streets with smaller lateral lines connecting with the large pipeline via perpendicular side streets to form a grid.

Distribution Mains *(*Natural Gas): Pipelines transporting natural gas within a designated service area of an LDC.

Distribution Planning Process (DPP – see also IRPs. DPP is used in planning CHPs, DERs, DR, and EE etc): Increasingly, DPP is regarded as part of *Integrated Resource Planning* (IRP) because of the increasing interrelationships of distribution, transmission, and resource planning. Moreover, DPP recognizes new technologies – some of which will be customer-owned. It is also useful to be mindful that most of the outages occur on distribution systems which affect transmission and resource operations. DPP includes foundational concepts of safety, reliability and affordability in planning distribution systems. DPP provides both a basic understanding of the distribution planning process is essential to determine the potential levels at which Distributed Energy Resources (DERs – including Combined Heat and Power (CHP), storage, utility scale DERs and Distributed Generation), Demand Response (DR), Energy Efficiency (EE) can be deployed on a distribution system as well as integration of new technologies such as microgrids, electric vehicles (EV), and fuel cells. Because of the operational uniqueness of these various resources and their locations, it is essential that the requisite data be developed which entails a heavy reliance on Advanced Metering Infrastructure (AMI). The planning scenarios provide relevant data for a utility's DPP to help determine the desired geographic areas (e.g., for nodal pricing) for potential future growth of these resources. This planning may result in additional distribution capacity investments to enable these various resources and to maximize their value while that result from deferred or cancelled distribution capacity investments.

Distribution Provider (Electric): Provides and operates the "wires" between the transmission system and the end-use customer. For those end-use customers who are served at transmission voltages, the Transmission Owner also serves as the Distribution Provider. Thus, the Distribution Provider is not defined by a specific voltage, but rather as performing the Distribution function at any voltage. (NERC definition.)

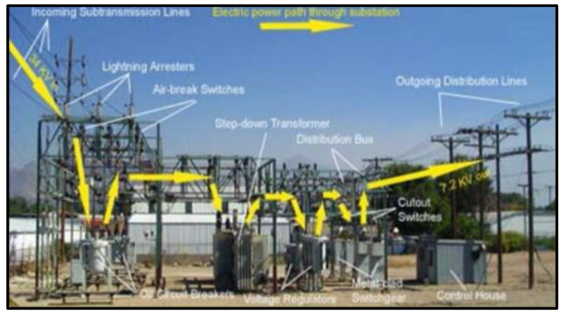
Distribution Reliability Indices: The majority of power outages are not attributed to the transmission or area-wide high-voltage distribution system, but are instead due to events that affect the local low-voltage distribution system**.** See the following frequently used indices or metrics: AISI, CAIDI, CAIFI, SAIDI, SAIFI, MAIFI, Worst CKAIDI, Worst CKAIFI, CELID X, CEMI X, and CEMMI X which should be reported by voltage level (e.g., below 34kV, 34kV to 138kV, and above 138kV). It is important to note the "Number of Customers" used in SAIDI, CAIDI, and SAIFI could be a major office building with a single tenant which could be counted as one (1) customer. This is one of the factors that may affect comparisons of different utilities. It should also be noted that comparisons among utilities may be difficult because data may not be directly comparable since Data collection & system differences exist. Moreover, there may be differences in the definition of exclusions. IEEE 1366-2003/2012 addresses data basis issues by clearly defining the rules but it does not address the data collection issues. Companies may not report all forms of outages, due to data collection issues or other reasons. The U.S. electricity industry uses several indices to measure electricity system safety, reliability and power quality. However, Lawrence Berkeley National Laboratory and others have pointed out that there is a lack of consistency in reporting and there is no national comparison or rating system that would hold utilities accountable for their performance (comparing downtown underground networks that have very high reliability to a remote rural area would not be very instructive). In fact, many utilities and the commissions that regulate them have different definitions of what constitutes a major outage or even an outage itself. Some of the actions used to reduce SAIFI and SAIDI may cause the number of momentary outages to increase. For example, this can be the case when the system is designed using automated reclosers. Some recommend that SAIFI, SAIDI and MAIFI should be evaluated together. Unfortunately, as of 2011, only 13 states require the reporting of MAIFI and only on circuits where it is practicable.

As Smart Grid becomes increasingly prevalent, more data on all outages - including momentary outages – will make it increasingly feasible to trace improvements. As such, the electric industry should become increasingly focused on momentary outages, voltage dips, voltage swells, harmonic disruptions, phase imbalance, and dropped phase(s). In sum, reliability metrics should be redefined as conditions warrant and data allows.

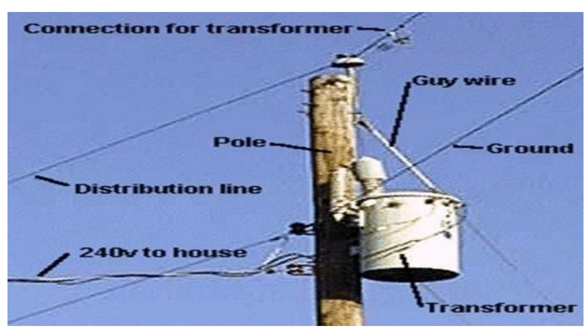
Distribution Reliability Studies (sometimes referred to as Sectionalizing Studies)**:** Contingency and restoration studies assess responses to operational disturbances, whereas reliability studies (*sectionalizing studies*), are used to identify or predict the probability that the system can provide utility customers with continuous service (with the voltage and frequency kept within ANSI or similar limits) given potential disturbances. Model results inform the utility about what types of options are available for engineering and operations to improve reliability, including *sectionalization* (e.g., fuses, *reclosers, sectionalizers*), switches, tree removal, etc., and the associated improvement in outage duration and frequency. Reliability indices have been standardized and codified; these include *System Average Interruption Frequency Index* (SAIFI), *System Average Interruption Duration Index* (SAIDI), *Customer Average Interruption Duration Index* (CAIDI), *Momentary Average Interruption Frequency Index* (MAIFI), *Average Service Availability Index* (ASAI) and *Energy Not Supplied* (ENS), and are used to characterize system and feeder reliability performance (IEEE 2012). Reliability indices are generally categorized into three types: load interruption indices, loss of load probability, and frequency and duration indices (Prada 1999). Source: Grid Modernization Laboratory Consortium, U.S. Department of Energy

Distribution Resource Plan (DRP)**:** A planning process for distribution systems that identifies the optimal locations for deployment of DERs and identifies values DERs can provide to the distribution grid. There is Increasing interest in integrating the DRP with a utility's IRP and with the RTOs planning proceses.

Distribution Substation: A substation located on the distribution system, usually where the transmission grid meets the distribution system or where distribution voltage is reduced from a primary feeder to a secondary feeder.

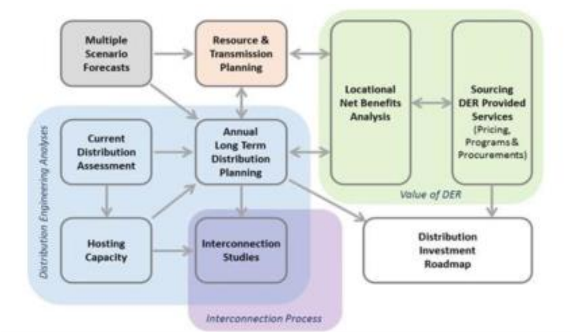


Distribution System: Generally, the low-voltage lines and transformers that transmit electricity from the large, bulk-power system to retail customers. Distribution voltages are typically 35 kV or less (in contrast to transmission voltages that are usually greater than 69 kV). Conductors for distribution may be carried on overhead pole lines, or in densely populated areas, buried underground. Urban and suburban distribution is done with three-phase systems to serve residential, commercial, and industrial loads. Whether electricity is delivered by overhead or underground lines, the voltage has to be stepped down from transmission voltage to be suitable for homes and businesses. In North American cities, network distribution may be used, with multiple transformers interconnected with low voltage distribution buses over several city blocks. The Rural electric cooperative systems, in contrast, tend to use higher distribution voltages because of the longer distances covered by distribution lines. 7.2, 12.47, 25, and 34.5 kV distribution is common in the United States.



Distribution System Operator (DSO): Similar functions to an Independent System Operator.

Distribution System Planning (see also Integrated Resource Planning and Distribution Resource Plan)**:** Historically, distribution system planning focused solely on a utility's distribution system(s). Increasingly, utilities, commissions, and stakeholders, recognize that the distribution system planning should be integrated with transmission and resource planning. Battery storage technology, for instance, transcends the three segments. The increased integration of Distributed Energy Resources (DERs) –including solar and other renewable resources, microgrids, DSM, and future technologies may have implications for distribution, transmission, and the resource mix. The graphic below from Grid Modernization Laboratory Consortium of the U.S. Department of Energy illustrates the complex interrelationships.



Distribution Transformer: The distribution system is generally comprised of sub-100kV lines that deliver power to customers, such as a home or business. Once power is generated and transferred over transmission lines to the vicinity of the load, the voltage must once again be lowered to move along the distribution lines. This happens at a substation that uses transformers to step-down the voltage. From the substation, energy can be transferred either directly to the load or must be stepped down again. Some large industrial and commercial customers take service at intermediate voltage levels (12,000 to 115,000 volts), but most residential customers take electrical service at 120 and 240 volts. Electric utilities ensure this voltage stays within a specified range.

District Chilled Water: Chilled water from an outside source used as an energy source for cooling in a building. The water is chilled in a central plant and piped into the building. Chilled water may be purchased from a utility or provided by a central physical plant in a separate building that is part of the same multibuilding facility (for example, a hospital complex or university).

District Heat: Steam or hot water from an outside source used as an energy source in a building. The steam or hot water is produced in a central plant and piped into the building. The district heat may be purchased from a utility or provided by a physical plant in a separate building that is part of the same facility (for example, a hospital complex or university).

Disturbance: 1) An unplanned event that produces an abnormal system condition; 2) any perturbation to the electric system; or 3) the unexpected change in Area Control Error (ACE) that is caused by the sudden failure of generation or interruption of load. (NERC)

Disturbance Control Standard (DCS): NERC DCS measures the ability of a control area to return Area Control Error either to zero or to its initial value following the loss of a large generating unit.

District heating: A system that makes use of heat generated at a central location, often in a thermal power plant, to heat water that is then fed through a communal system, delivering heat to businesses and / or homes.

Diversity: The electric utility system's load is made up of many individual loads that make demands upon the system usually at different times of the day. The individual loads within the customer classes follow similar usage patterns, but these classes of service place different demands upon the facilities and the system grid. The service requirements of one electrical system can differ from another by time-of-day usage, facility usage, and/or demands placed upon the system grid. See also “coincidence.”

Diversity Exchange: An exchange of capacity or energy, or both, between systems whose peak loads occur at different times.

Diversity Factor: The ratio of the sum of the individual non-coincident maximum demands to the maximum demand of the complete system.

Divestiture: The stripping off of one utility function from the others by selling (spinning-off) or in some other way changing the ownership of the assets related to that function usually as a means of preventing market power. Stripping off assets is most commonly associated with spinning-off generation assets so they are no longer owned by the shareholders that own the transmission and distribution facilities.

Double Circuit Line: A transmission line having two separate circuits. Because each carries three-phase power, at least six conductors, three per circuit, are required.

Double Declining Balance Depreciation: Declining balance depreciation occurs when the constant percentage used to multiply by book value in determining the depreciation charge for the year is 2/n and n is the depreciable life in periods.

Downstream Oil and Gas Activities (Natural Gas): Activities and expenditures in the areas of refining, distribution, and retailing of oil and gas products.

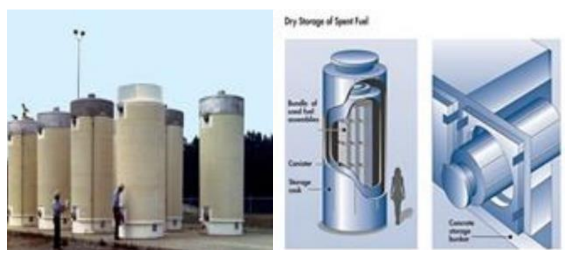
Downstream Pipeline (Natural Gas): A pipeline (State) closer to the market area, as opposed to an upstream one, which is closer to the production area.

Drilled Uncompleted Wells (DUC – see also Rig Count as a measure of short-term natural gas and oil capability): A drilled but uncompleted well (DUC) is a new well after the end of the drilling process, but its first completion process has not been concluded. When producers are under economic duress, as has been the case following the large decline in oil prices since mid-2014 that triggered a significant slowdown in drilling and completion activity, the number of DUCs can provide useful insight into upstream industry conditions. EIA now estimates Drilled but Uncompleted Wells.

Driver: Refers to a specific *variable* that, if changed, results in a different outcome of a scenario. Significant drivers in load forecasting and resource planning include, but are not limited to, changes in: the price of electricity, fuel prices, environmental policies, capital costs, demographic changes, macro-economic changes, and weather. To isolate the unique effects of each driver on a scenario, it is best to change only one driver at a time.

Droop: The expected response of a turbine-generator's governor to frequency deviations, Droop settings on governors are necessary to enable multiple generators to operate in parallel while on governor control while not competing with each other for load changes. (NERC Frequency Response Initiative Report 2012)

Dry Cask Storage (Nuclear) (see also "spent fuel pool"): Spent fuel that has cooled in spent fuel pool for at least one year can be encapsulated in a steel dry cask. The cask is pumped with inert gas inside, and then is contained into another cask made of steel, concrete, or other radiation shielding material. Subsequently, this leak-tight and radiation-shielded dry cask can be stored either horizontally in concrete over-pack or vertically on a concrete pad. The primary design for casks is vertically oriented and is called the *thick-walled cask*, whereas cask with over-pack is normally the design for horizontal storage. Spent fuel is the nuclear fuel that has been "burned" in a nuclear reactor. It is often highly radioactive and it generates huge amount of decay heat as a result of beta decay of fissile products, although the fissile chain reaction has ceased. Quantitatively, spent fuel, five minutes after reactor shutdown, still releases about 800 kilowatts of heat per metric ton of uranium. Even though the production rate of decay heat will continue to slow down over time (for instance, decay heat will fall to 0.4% of the original core power level after a day), spent fuel has to cool down and store securely before being sent for reprocessing or long term disposal. Source: Hoi Ng, Submitted as coursework, Stanford University, Winter 2014.



Dry Electrostatic Precipitators (ESP dry see also Wet ESP) Uses electrodes to place an electric charge on large particulates then captured by an oppositely charged plate.

Dry Natural Gas: Natural gas which remains after: 1) the liquefiable hydrocarbon portion has been removed from the gas stream (i.e., gas after lease, field, and/or plant separation); and 2) any volumes of non-hydrocarbon gases have been removed where they occur in sufficient quantity to render the gas unmarketable. Note: Dry natural gas is also known as consumer-grade natural gas. The parameters for measurement are cubic feet at 60 degrees Fahrenheit and 14.73 pounds per square inch absolute.

Dry Tons: A dry ton has the same mass value but the materials, such as switch grass, miscanthus, sugar cane, compost, sludge, slurries in which solid material is soaked with or suspended in water has been dried to a relatively low consistent moisture level.

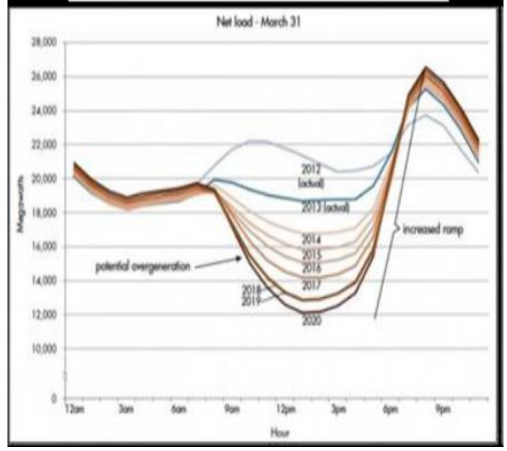
Distribution System Operator (DSO): This is an evolving concept, especially in Europe, primarily to faciliate the development of Disributed Energy Resources. It is similar to an Independent System Operator or Regional Tranmission System for distribution systems and would operate cooperatratively with an RTO/ISO. There are several potential functions for a DSO that might include hosting DERs, integration of distribution system planning with integrated resource planning, and RTO planning. It could offer some ancillary services including real-time pricing.

Dual-Fired Unit: A generating unit that can produce electricity using two or more input fuels. In some of these units, only the primary fuel can be used continuously; the alternate fuel(s) can be used only as a start-up fuel or in emergencies.

Dual Fuel Capability: When a generator has the flexibility and storage capacity to use oil as well as natural gas.

Duck Curve: A consequence of increased reliance on renewable resources – especially solar generation – is that conventional supply resources may have difficulty responding (e.g., ramping up or ramping down) economically. The difficulty of traditional generating resources to increase or decrease generation is particularly observable during periods of minimum load conditions (the duck's belly in the graph) and the periods of ramping down and up following a minimum load condition. The minimum load problem is heightened if the renewable resource is abruptly diminished or increased. This operational dynamic may pose reliability risks. However, this phenomenon may provide opportunities for back-up generation, storage and demand-side management – including demand responsive rates. There is also a concern for over-supply. This would occur when more renewable and other supply is added without a corresponding increase in demand.

Figure 1: California's Duck Curve Chart



Dummy Variables: Dummy variables are used in statistical regression analysis. Dummy variables are independent variables which take the value of either 0 or 1. Just as a "dummy" is a stand-in for a real person, in quantitative analysis, a dummy variable is a numeric stand-in for a qualitative fact or a logical proposition. Explanatory variables are often qualitative in nature (e.g., wartime versus peacetime, smokers versus non-smokers, summer versus non-summer), so that some proxy must be constructed to represent them in a regression. Dummy variables are used for this purpose. A dummy variable takes the value of one whenever the qualitative phenomenon it represents occurs, and zero otherwise. The use of dummy variables should be carefully considered to avoid injecting unnecessary bias into the equation.

Durbin-Watson Statistic (DW or DWS): A number which determines whether there is autocorrelation (a relationship between values separated from each other by a given time lag) in the residuals of a time series regression analysis. The statistic ranges from 0 to 4 with 0 indicating positive autocorrelation and 4 indicating negative correlation. A value of 2 indicates no *auto-correlation* in the residuals (prediction errors in the sample).

Dynamic Capability Rating: Dynamic capability rating adjusts the thermal rating of power equipment based on factors such as air temperature, wind speed, and solar radiation to reflect actual operating conditions. These systems are primarily used on high capacity or critical power system elements such as transmission lines and large power transformers.

Dynamic Interchange or Scheduling: A telemetered reading or value that is updated in real time and used as a schedule in the AGC/ACE equation and the integrated value of which is treated as a schedule for interchange accounting purposes. Commonly used for scheduling jointly owned generation to or from another Balancing Authority Area.

Dynamic Pricing: Time differentiated pricing where the price of electricity is set day-ahead or close to real-time based on anticipated or actual wholesale prices with appropriate retail cost components. Critical Peak Pricing and Real-Time Pricing are examples. Dynamic pricing should be considered as strategic rate design and included in Integrated Resource Planning.

Dynamic Reserves: Used during system restoration to make sure that the system will remain stable if the largest generator trips. Dynamic reserve consists of two components:

1. Reserve on generators that are available via generator governor action during a frequency disturbance to a level at which generators will normally separate from the system (i.e., 57.5 Hz).
2. System load with under-frequency trip levels above the frequency at which generators will normally separate from the system during a frequency disturbance (i.e., 57.5 Hz).

Dynamic Schedule: A telemetered value that is updated in real time and used to adjust the interchange schedule in the Automatic Generation Control/Area Control Error equation. Commonly used for generation or load to or from another Control Area.

Dynamic Shunt Compensation (see also FACTS – Flexible Alternating Current Transmission Systems): A technology used to stabilize voltage by introducing or absorbing reactive power at specific points of a power transmission grid. The system helps to improve power transmission capacity as well as the overall stability of the grid. Dynamic shunt compensation is one of the three main Flexible Alternating Current Transmission Systems technologies, the others being series compensation and dynamic energy storage.

Dynamic Transfer: The provision of the real-time monitoring, telemetering, computer software, hardware, communications, engineering, energy accounting (including inadvertent interchange), and administration required to electronically move all or a portion of the real energy services associated with a generator or load out of one Balancing Authority Area into another.

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Eastern Interconnection (EI- see Western Interconnection map of the boundaries.

Interconnection Data Sharing Network (EIDSN): Enables the sharing of operating reliability data, including both Supervisory Control and Data Acquisition (SCADA) and synchrophasor data, among appropriate entities to promote the reliable and efficient operation of the Eastern and Quebec Interconnections.

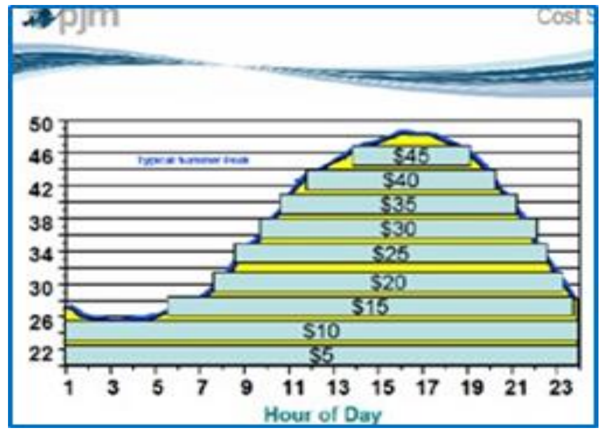
EBITDA: A measure of profits. While there is no legal requirement, according to Generally Accepted Accounting Principles (GAAP), for companies to disclose EBITDA, it is sometimes reported. The earnings, tax and interest figures are found on the income statement, while the depreciation and amortization figures are normally found in the notes to operating profit or on the cash flow statement. The usual shortcut to calculate EBITDA is to start with operating profit, also called earnings before interest and tax (EBIT), and then add back depreciation and amortization.

Econometrics (Economics and Statistical Forecasting Term): In statistics it is referred to as Regression). Econometrics are used for forecasting such as future demand and energy use.

Economic Demand Response: Programs that offer end-use customers the opportunity to modify their electric usage in response to price signals or other economic rewards.

Economic Development and Economic Development Rates: Organized efforts to attract new business into an area or to encourage existing business to expand. Historically, economic development rates have been used by utilities to encourage business development; especially if a utility had surplus electrical resources that would result in better utilization of the utility's resources. These rates were subject to the approval of the state regulatory body and were often in concert with state agencies wishing to attract new development.

Economic Dispatch: Operating a generating system by running the combination of generating units that have the lowest operating costs at any point in time. In RTO / ISO markets, economic dispatch is subject to security and economic concerns and congestion. As a result, RTO markets with locational marginal cost pricing (LMP) have "security constrained economic dispatch" that internalizes the relevant security and economic factors.



Economic Generation: Units producing energy at an offer price less than, or equal to, the Locational Marginal Price (LMP).

Economic Maximum Generation (EcoMax): The highest incremental MW output level a unit can achieve while following economic dispatch. The highest unrestricted level of electric energy (MW) a resource is able to generate, representing the highest megawatt output available from the resource for economic dispatch.

Economic Minimum Generation (EcoMin): The lowest MW output level a unit can achieve while following economic dispatch. The minimum amount of electric energy (MW) that a generating resource must be allowed to produce while under economic dispatch. A generator may request to self-schedule and increase its offered Economic Minimum to the desired level of MW.

Economic Potential: The portion of technical potential that is determined to be both achievable and cost-effective based on the economic test (or tests) used by a jurisdiction. Economic potential is determined using one of two analytical processes. The most common simply applies a "cost-effectiveness limit" to all measures that comprise the technical potential in a jurisdiction. Such limits can be as simple as a maximum cost per kilowatt-hour, or involve a more complex evaluation of a measure's energy savings, its peak demand reduction benefits, other power system benefits, as well as other non-power system benefits. The second approach involves energy efficiency resources competing directly against supply-side resources to assess whether developing more energy efficiency at varying cost levels increases or decreases the total cost i.e., economically achievable potential is a subset of achievable potential. (LBL)

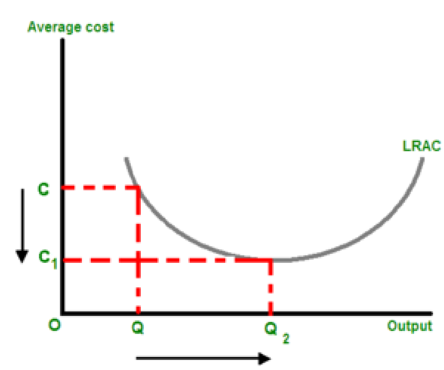
Economic Optimization Logic is the selection criterion used in capacity expansion models, which typically search for resource expansion portfolios that meet system reliability criteria at the lowest cost, using the net present value of utility system revenue requirements as the cost metric. In the more sophisticated capacity expansion models, alternative resource portfolios are tested across wide range of future conditions (e.g., load growth, fuel prices, market prices) to assess their economic risk. The economic optimization logic in these models typically compares the market value of electricity with the cost of a new resource. That is, when these models' forecast that a resource would make money in the market based on their estimates of future market prices, they proceed with construction of that resource. However, these models will build resources to meet reliability criteria regardless of whether they are economic, i.e., are forecast to recover their cost in the market. (LBL)

Economically Recoverable Resources (see also Continuous Oil & Gas Accumulations, Technically Recoverable. Proved Reserves, Unconventional Oil Accumulation): That part of the assessed technically recoverable resource for which the costs of finding, development, and production, including a return to capital, can be recovered by production revenues at a given price.

Energy Efficiency Supply Curve represents the quantity of savings across a range of acquisition costs in each of the years including in the resource planning period. Supply curves can represent technical, economic or achievable potential. In their simplest form energy efficiency supply curves represent the amount of savings that could be achieved at a specific cost during a specific period. However, when the economic potential of energy efficiency is determined through the use of capacity expansion models multiple supply curves are generally required. In order to accurately represent the range of energy efficiency resources available, measures with similar characteristics, such as common load shapes and availability through time, are typically represented by different supply curves. (LBL)

Economic Rents: In economics, an economic rent is any payment to a factor of production (e.g., the price of fuel to generate electricity) in excess of the cost needed to bring that factor into production. Economic rents increase as scarcity increases. A single supplier of an essential or highly valued product (e.g., an unregulated monopoly) is able to charge economic rents - getting people to pay more for no increase in an essential service. A firm or person with a highly inelastic supply curve is able to exact economic rents where a firm with a very elastic (approaching infinity) would not be able to impose economic rents.. The concept of economic rents was attributed to the early 19th century economist David Ricardo. In classical economics, economic rent is any payment made (including imputed value) or benefit received for assets that were created by market power which, in some cases, may be the result of government action (e.g., patents) or inaction (failing to regulate a monopoly provider of a good or service). *Rent Seeking* are people or businesses that seek *rents* or excess profits beyond what they are able to produce. Rent Seeking might manifest itself as a business seeking government to impose a tariff or other regulation on a competitor. Firms seeking subsidies are also rent seeking.

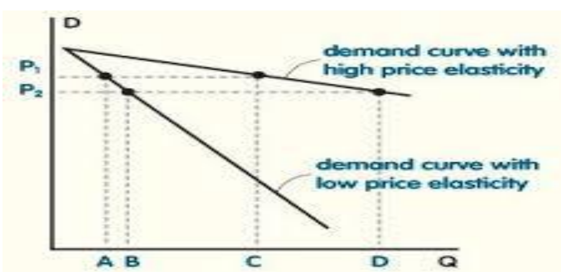
Economies of Scale: Economies of scale exist where the industry exhibits decreasing average long-run costs with size. In other words, circumstances in which costs of production decline as plant size and the amount of goods or services produced increase. As electric utilities move down the Average Cost curve, the cost of providing one more kWh declines.



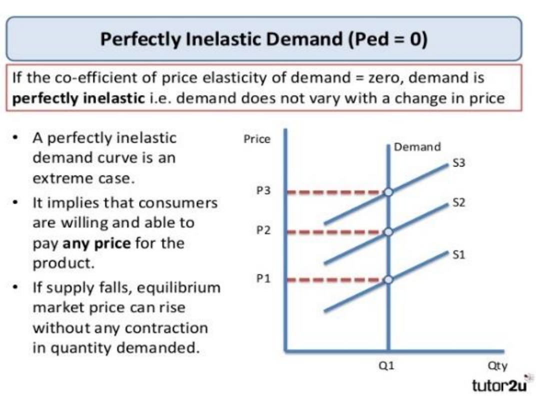
Thomas Edison's Pearl Street Station in 1882 in New York City. A model of efficiency for its time, Pearl Street used 1/3-third the fuel of its predecessors, burning about 10 pounds of coal per kilowatthour (kWh), a "heat rate" equivalent of about 138,000 Btu per kWh. Initially the Pearl Street utility served 59 customers for about 24 (nominal) cents per kWh or about $5.00 in 2002 dollars. In 1902, a 5-MW turbine was installed at the Fisk St. Station in Chicago. Within the span of less than 100 years, economies of scale enabled generating units to go from a few MWs to thousands of MW.

Effective Load Carrying Capability (ELCC): The ELCC of a power generator represents its ability to increase generating capacity available to a utility or a RTO / ISO without increasing the utility's loss of load probability risk. ELCC is derived from the analysis of coincident supply of the resource with demand.

Elastic and Inelastic Demand Curves and Perfectly Inelastic Demand Curve: Most demand curves are relatively elastic or inelastic compared to the perfectly elastic or inelastic demand curves. Elasticity determines the customer's willingness to pay for a good or service. A low (0 at the extreme) price elasticity indicates that the customer is willing to pay a



high price – perhaps and extremely high price for a good or service. A high price elasticity of demand implies that the customer is unwilling to pay very high prices for a good or service.



Elastic Demand (see also Price Elasticity and Inelastic Demand): Elastic demand means that consumers are sensitive to the price at which a product is sold and will not buy it if the price rises by what they consider too much.

Electric Current: The flow of electric charge. The preferred unit of measure is the ampere.

Electric Industry Restructuring: The process of replacing a monopolistic system of electric utility suppliers with competing sellers, allowing individual retail customers to choose their supplier but still receive delivery over the power lines of the local utility. It includes the reconfiguration of vertically-integrated electric utilities.

Electric Power: The rate of work that can be accomplished by electricity; commonly measured in units of watts, kilowatts, or megawatts. Also commonly used to refer to electricity in general.

Electric Power Grid: A system of synchronized power providers and consumers connected by transmission and distribution lines and operated by one or more control centers. In the continental United States, the electric power grid consists of three systems: the Eastern Interconnect, the Western Interconnect, and the Texas Interconnect. In Alaska and Hawaii, several systems encompass areas smaller than the State (e.g., the interconnect serving Anchorage, Fairbanks, and the Kenai Peninsula; individual islands).

Electric Storage Resource: As defined by FERC, an "electric storage resource" is a resource "capable of receiving electric energy from the grid and storing it for later injection of electricity back to the grid regardless of where the resource is located on the electrical system." In January 2017, FERC issued a Policy Statement giving guidance on the ability of electric storage resources to provide transmission or grid support services at cost-based rates while, at the same time, providing other services, such as power sales, at market-based rates. In mid-November 2016, FERC issued a Notice of Proposed Rulemaking (NOPR) to amend its regulations under the FPA and remove barriers that prevented electric storage resources and distributed energy resource aggregators to participate in the capacity, energy, and ancillary service markets operated by the six RTOs and ISOs subject to FERC jurisdiction. These RTOs and ISOs are NYISO, ISO-NE, PJM, MISO, SPP and CAISO.

Electric System Losses: Transmission, transformation and distribution losses of electric energy between sources of supply and points of delivery (generally, losses are due to heating of transmission and distribution elements).

Electric System Reliability: The degree to which the performance of the elements of the electrical system results in power being delivered to consumers within accepted standards and in the amount desired. Reliability encompasses two concepts, adequacy and security. Adequacy implies that there are sufficient generation and transmission resources installed and available to meet projected electrical demand plus reserves for contingencies. Security implies that the system will remain intact operationally (i.e., will have sufficient available operating capacity) even after outages or other equipment failure. The degree of reliability may be measured by the frequency, duration, and magnitude of adverse effects on consumer service.

Electrical Energy: The generation or use of electric power measured in kilowatt-hours (kWh), megawatt-hours (MWh), or gigawatt-hours (gWh).

Electrical Field: The part of the generator that induces an electric field in the armature (for large synchronous generators it is the rotor, a spinning electromagnet). The *Exciter* is the part of a synchronous generator that provides the field current.

Electricity: The flow of electrons through a conductor.

Electrocution and Electrical Shock: Electrocution causes death from the passage of an electric current. Electric shock does not cause death but is the physiological reaction or injury caused by electric current passing through the body.

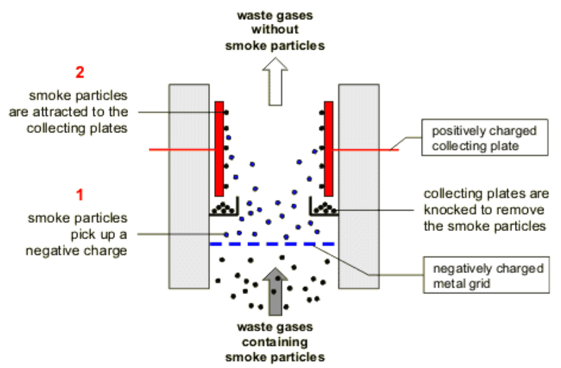
Electromagnetic Field (EM field): A physical field produced by electrically charged objects. It affects the behavior of charged objects in the vicinity of the field. The electromagnetic field extends indefinitely throughout space and describes the electromagnetic interaction. Plugging a wire into an outlet creates electric fields in the air surrounding the appliance. The higher the voltage the stronger the field produced. Since the voltage can exist even when no current is flowing, the appliance does not have to be turned on for an electric field to exist in the room surrounding it.

Magnetic fields are created only when the electric current flows. Magnetic fields and electric fields then exist together in the room environment. The greater the current the stronger the magnetic field. High voltages are used for the transmission and distribution of electricity whereas relatively low voltages are used in the home. The voltages used by power transmission equipment vary little from day to day, currents through a transmission line vary with power consumption.

Static fields differ from time-varying fields. A static field does not vary over time. A direct current (DC) is an electric current flowing in one direction only. In any battery-powered appliance the current flows from the battery to the appliance and then back to the battery. It will create a static magnetic field. The earth's magnetic field is also a static field. So is the magnetic field around a bar magnet which can be visualized by observing the pattern that is formed when iron filings are sprinkled around it.

Electromagnetic Pulse (EMP): An electromagnetic pulse, also sometimes called a transient electromagnetic disturbance, is a short burst of electromagnetic energy. Such a pulse's origination may be a natural occurrence (e.g., solar flare) or man-made and can occur as a radiated, electric or magnetic field or a conducted electric current, depending on the source.

Electrostatic Precipitators (ESP): ESPs are a filtration device that uses electrostatic forces of applying high voltage to form an electrical field between the discharge wires and collecting plates to remove fine particulate matter, dust, and smoke.



Element: Any electrical device with terminals that may be connected to other electrical devices such as a generator, transformer, circuit breaker, bus section, or transmission line. An element may be comprised of one or more components. (NERC).

Embedded Cost: A cost that cannot be avoided by reducing output because the cost was incurred previously, such as the original cost of an asset (less depreciation, but including the operating and maintenance expenses and all taxes).

Emergency: The failure of an electric power system to generate or deliver electric power as normally intended, resulting in the cutoff or curtailment of service.

Emergency Backup Generation: The use of electric generators only during interruptions of normal power supply.

Emergency Demand Response (EDR): Emergency demand response was created to encourage greater participation by load in managing capacity during emergency conditions. These resources serve to reduce the costs to all market participants during emergency conditions and are compensated for their services based on their offers and the Locational Marginal Price (LMP). EDR is a commitment to reduce load or consume electricity only up to a certain level when the RTO / ISO or Planning Authority needs assistance under expected emergency conditions (also called Load Management).

Emergency Energy: Electric energy provided for a limited duration, intended only for use during emergency conditions.

Emergency Maximum Generation Limt: The maximum output of energy a generating unit can produce and still maintain a stable level of operation.

Emergency Minimum Generation Limit: The least amount of energy a unit can produce and still maintain a stable level of operation.

Emergency Rating: The rating as defined by the equipment owner that specifies the level of electrical loading or output, usually expressed in megawatts (MW) or Mvar or other appropriate units, that a system, facility, or element can support, produce, or withstand for a finite period. The rating assumes acceptable loss of equipment life or other physical or safety limitations for the equipment involved.

Emergency Response Timing (ERT): Power restoration after the occurrence of a natural event involves handling intricate tasks safely and efficiently. Executing a quick restoration process requires management of significant logistics, skilled workers and equipment. When there is a forecast for a pending natural event, utilities organize skilled workers, equipment, materials and support staff. After utilities perform a damage assessment and follow priorities to ensure:

1. affected generation is restored,
2. transmission facilities are repaired,
3. substations are brought back on line,
4. power is restored to emergency services critical to public health and safety – including hospitals, police, fire stations, water treatment facilities, and communications systems,
5. crews are dispatched to return service to the largest number of customers in the least amount of time, and distribution lines, and
6. once major repairs are completed, service lines to individual homes and businesses are restored.

As soon as possible after an outage occurs, customers need to receive information on the magnitude of the storm, the duration of the storm, and an estimate of the how long customers should expect to be without power.

Emergency Standby Power (ESP): The emergency standby rating is the most commonly applied rating and represents the maximum amount of power that a generator set is capable of delivering. An ESP generator set is normally used to supply emergency power to a facility in the event of a utility outage until power is restored.

Eminent Domain: Eminent domain is used as a last resort if a landowner and the project proponent cannot reach agreement on compensation for use or purchase of property required for the project. The project proponent is still required to compensate the landowner for the use or purchase of the property, and for any damages incurred during construction. However, the level of compensation would be determined by a court according to state law.

Emission Rates Credits (ERC): An ERC is an administratively created, tradable instrument with a unique serial number that "represent[s] one MWh of actual energy generated or saved with zero associated CO_2 emissions" (40 C.F.R. §60.5790). When held and retired by an Electric Generating Unit (EGU), an ERC allows that EGU to adjust its emission rate as follows: Adjusted emission rate = EGU CO_2 Emissions / $MWh\ EGU\ Generation + MWh\ ERCs$. For instance, a NGCC Unit may have the following operating parameters: Annual Generation: 1,000,000 MWh; Operating Emission Rate: 900 lbs. CO_2 per MWh; and therefore Total Annual Emissions: 900 × 1,000,000 = 900,000,000 lbs. If that unit also holds ERCs representing 250,000 MWh of zero-emission energy, it will have an adjusted emission rate of 720 lbs. CO_2 per MWh, as illustrated: **Adjusted emission rate** = 900,000,000 lbs.1,000,000 MWh + 250,000 MWh $ERCs$ = 720 lbs. CO_2 per MWh. To demonstrate compliance, the EGU must retire a sufficient number of ERCs to adjust its emission rate downward to the rate allowed under the plan.

Emissions: Anthropogenic releases of gases, solids, and / or particulate matter to the atmosphere. In the context of global climate change, they consist of radiatively (a process that alters the energy balance between incoming solar radiation and outgoing infrared radiation from the Earth, including greenhouse gases) important greenhouse gases (e.g., the release of carbon dioxide during fuel combustion).

Enabling Technology: A set of on-site hardware and software that enables a particular end-use or set of end-uses to provide DR service across one or more products. LBL 2018

End Effects (see also Planning Horizon or Event Horizon)**:** Used in long-term resource planning to consider potential changes in the analysis beyond the planning horizon to reduce the chance that a significant event (or resource) will not be considered and, as a result, distort the long-term analysis. For example, at the end of a planning horizon (or beyond), long-term resource planning models may select a relatively low cost resource rather than a resource that is more capital intensive but has other significant benefits at the end of a planning horizon because, in essence, the model assumes the world would end. A resource plan with a 20 year planning horizon may extend the analysis to 30 or 40 years to avoid end effects but may only report the analysis for the 20 year planning horizon.

Endogenous Variables (Statistical): Endogenous variables determined within the modeling framework as opposed to *Exogenous Variables* that are specified outside of the models and are used as inputs. Endogenous variables are important in econometrics and economic modeling because they show whether a variable causes a particular effect. Economists employ causal modeling to explain outcomes (dependent variables) such as future electricity use based on a variety of factors (independent variables such as the price of electricity, population, income and others), and to determine to which extent a result can be attributed to an endogenous or exogenous cause. In a econometric or statistical model, a variable or parameter is considered to be endogenous when there is a correlation between the variable and the error term. Endogeneity can arise as a result of measurement error, autocorrelation, simultaneity, and omitted explanatory variables. Generally, a situation where there is causality between the independent and dependent variables contributes to endogeneity.

End-Use Econometric Model: Recognizes that electrical demand as a function of the number, characteristics and usage of electrical equipment and prices. This forecasting approach requires information such as the number and type of electric appliances in the home, number and size of households, size and type of commercial and industrial users, etc. These models combine the ability to reflect relationships between economic factors (income, employment, energy prices) and energy demand, while also providing a detailed explanation of how changes in technology or structural changes in the economy such as new loads from data centers and EVs and codes and standards as well as consumer behavior affect electricity use. (LBL)

Energy: The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy). Energy has several forms, some of which are easily convertible and can be changed to another form useful for work. Most of the world's convertible energy comes from fossil fuels that are burned to produce heat that is then used as a transfer medium to mechanical or other means in order to accomplish tasks. Electrical energy is usually measured in kilowatthours, while heat energy is usually measured in British thermal units (Btu).

Energy Audit: A program carried out by a utility company in which an auditor inspects a home and suggests ways energy can be saved.

Energy Charge: That portion of the charge for electric service based upon the electric energy (kWh) consumed or billed.

Energy Density: The nominal battery energy per unit volume, sometimes referred to as the volumetric energy density. Specific energy is a characteristic of the battery chemistry and packaging. For automobiles, it is the energy consumption of the vehicle, it determines the battery size required to achieve a given electric range

Energy Efficiency (EE): Refers to programs that are aimed at reducing the energy used by specific end-use devices and systems, typically without affecting the services provided. These programs reduce overall electricity consumption (reported in megawatthours), often without explicit consideration for the timing of program-induced savings. Such savings are generally achieved by substituting technologically more advanced equipment to produce the same level of end-use services (e.g. lighting, heating, motor drive) with less electricity. Examples include high-efficiency appliances, efficient lighting programs, high-efficiency heating, ventilating and air conditioning (HVAC) systems or control modifications, efficient building design, advanced electric motor drives, and heat recovery systems. Simply put, it is a reduction in electricity consumption due to the improvement of efficiency in the end use.

Energy Efficiency Potential – Assessment Methods (EPA):

Technical Potential. The theoretical maximum amount of energy use that could be displaced by efficiency, without regard to non-engineering constraints such as costs and the willingness of energy consumers to adopt the efficiency measures. It often assumes immediate implementation of all technologically feasible energy saving measures, with additional efficiency opportunities assumed as they arise.

Economic Potential. Refers to the subset of the technical potential that is economically cost-effective. Definition of “economic potential” can vary to some degree by study.

Some estimate economic potential by evaluating technology upfront cost, operating costs that considers energy prices, product lifetime and discount rate, compared to a conventional alternative or the supply-side energy resources. Others incorporate consideration of consumer preferences in addition to consumers’ out-of-pocket expenditure when evaluating the economic potential. Both technical and economic potential estimates assume immediate implementation of efficiency measures without regard to technology adoption process or real-life program implementation. In addition, these estimates do not always reflect market failures or barriers that impede energy efficiency and often fail to capture transaction costs (e.g., administration, marketing, analysis, etc.) beyond the costs of efficiency measures.

- **Market Potential Study** (or Achievable Potential): Refers to the subset of economic potential that reflects the estimated amount of energy savings that can realistically be achieve taking into account factors such as technology adoption process, market failures or barriers that inhibit technology adoption, transaction costs, consumer preferences, social and institutional constraints, and possibly the capability of programs and administrators to ramp up program activity over time.
- Program Potential: Refers to the subset of market potential that can be realized given specific program funding levels and designs. Program potential studies can consider scenarios ranging from a single program to a full portfolio of programs.

Energy Efficiency Resource Standards (EERS): Molina et al. (2010) defines an EERS as “a quantitative, long-term energy savings target for utilities.” Utilities may administer their own programs or use an authorized program administrator to achieve energy savings.

Energy Efficiency Standard (EES): The same long-term energy savings target as an EERS and implemented in some states, including Arizona.

Energy Emergency Alert (EEA): The NERC Energy Emergency Alert 1 declaration means that all available resources are in use; EEA2 indicates that demand management procedures are in effect.

Energy Factor (EF): This is a measurement of the efficiency of different types of appliances but is most often applied to water heaters. It is the amount of hot water produced per unit of fuel consumed over a typical day. The higher the energy factor, the more efficient the water heater.

Energy Imbalance (see also Ancillary Services Market): Energy imbalance provides energy correction for any hourly or sub-hourly mismatch between a transmission customer's energy supply and the demand served at the lowest cost. Compared to the capabilities of individual utilities to match supply and demand (maintaining higher levels of operating and spinning reserves, a lack of resource diversity, difficulties in integrating renewable resources), RTO / ISO markets provide 5 to 15 minute security-constrained economic dispatch of generation resources to reliably and economically rectify energy imbalances. In addition to the comparative reliability and economic efficiency, energy imbalance markets have the added benefit of better utilizing resources.

Energy Intensity (EI) (see also Electricity Intensity): Economy-wide energy intensity measures units of energy to units of gross domestic product (GDP). EIA uses energy consumption (measured in Btu) to the constant dollar value of the GDP. Energy intensity can also be measured at the sector level using sector-specific data. For example, energy intensity in the commercial sector is measured by the ratio of energy consumption measured in millions of Btu to square feet of commercial floor space.

Energy Management and Control System (EMCS): An energy conservation feature that uses mini/microcomputers, instrumentation, control equipment, and software to manage a building's use of energy for heating, ventilation, air conditioning, lighting, and/or business-related processes. These systems can also manage fire control, safety, and security. Not included as EMCS are time-clock thermostats.

Energy Market: An energy market is a type of spot market in which energy is sold or purchased for immediate delivery. Because electricity is a commodity that is consumed the same moment it is produced, by its nature, energy is delivered immediately upon sale or purchase. RTO / ISO energy markets function at a wholesale level. These energy markets operate every day and participants in the market establish a price for electricity by matching supply (what generators want to sell) and demand (what utilities and customers want to buy). Utilities and competitive retailers that purchase energy from a wholesale market resell it to final consumers at retail rates or prices.

Energy Market Opportunity Costs: Energy Market Opportunity Cost is the value associated with an externally imposed environmental run-hour restriction on a generation unit. Examples would include a limit on emissions for the unit imposed by a regulatory agency or legislation, a direct run hour restriction in the operating permit, or a heat input limitation defined by a regulatory decision or operating permit.

Energy Policy Act of 1992 and 2005 (EPACT): This legislation creates a new class of power generators, exempt wholesale generators, that are exempt from the provisions of the Public Holding Company Act of 1935 and grants the authority to the Federal Energy Regulatory Commission to order and condition access by eligible parties to the interconnected transmission grid.

Energy Services Company (ESCO): A company that provides services to end users relating to their energy usage. Common services include energy efficiency and demand side management.

Enhanced Oil Recovery: Injection of steam, gas, or other chemical compounds into hydrocarbon reservoirs to stimulate the production of usable oil beyond what is possible through natural pressure, water injection, and pumping at the wellhead.

Enrichment (Nuclear): Natural uranium ore is 99 % U-238 and 1% U-235. The process of increasing the ratio of U-235 to U-238 is called enrichment. The enrichment process is very energy intensive and requires a highly sophisticated workforce and infrastructure. The enrichment process raises proliferation concerns because highly enriched material can also be used in nuclear weapons as well as reactors.

Nuclear Fuel Pellets

Environmental Assessment (EA)**:** An Environmental Assessment evaluates the consequences of a proposed action on the environment and recommends measures to minimize any potentially adverse effects. An EA is prepared when the environmental scoping process has determined that the project would not significantly affect the quality of the human environment.

Environmental Impact Statement: The statement required of federal agencies by Section 102 (C) of the National Environmental Policy Act of 1969, for major Federal actions that may significantly affect the quality of the human environment.

Enthalpy (see Thermodynamics 1st law and Entropy)**:** This is a process that occurs at constant pressure, The heat involved (either released or absorbed) equal to the change in enthalpy. Mathematically, enthalpy (H) is the sum of the *internal energy* (U) and the product of pressure and volume (PV) given by the equation: H = U + PV.

Entropy (see Thermodynamics 2nd law and Enthalpy): Entropy is a thermodynamics concept that is defined as the quantitative measure of disorder or randomness in a system. Entropy involves the transfer of heat energy within a system. Instead of talking about some form of "absolute entropy," physicists generally talk about the change in entropy that takes place in a specific thermodynamic process. The change in entropy (delta-*S*) is the change in heat (*Q*) divided by the absolute temperature (*T*): delta-*S* = *Q*/T.

EPRI (Electric Power Research Institute): is funded by utilities (and their customers) to conduct specified research such as the cost of new generation, demand-side management, and etc.

Equal Life Group (ELG): ELG depreciation rates are designed to fully accrue the cost of the asset group by the time of retirement. For both the *Broad Group* and Equal Life Group procedures the full cost of the investment is credited to plant in service when the retirement occurs and likewise the depreciation reserve is debited with an equal retirement cost. No gain or loss is recognized at the time of property retirement because of the assumption that the retired property was at average service life. Group depreciation procedures are utilized to depreciate property when more than one item of property is being depreciated. Such a procedure is appropriate because all of the items within a specific group typically do not have identical service lives, but have lives which are dispersed over a range of time. Utilizing a group depreciation procedure allows for a condensed application of depreciation rates to groups of similar property in lieu of extensive depreciation calculations on an item by item basis. The two more common group depreciation procedures are the *Broad Group* (BG) and *Equal Life Group* (ELG) approach.

Equipment Rating: The maximum and minimum voltage, current, frequency, real and reactive power flows on individual equipment under steady state, short-circuit and transient conditions, as permitted or assigned by the equipment owner.(NERC)

Equivalent: When “E” is used in a reliability statistic it is meant to be “Equivalent” unless otherwise stated (e.g., Equivalent Availability Factor or Equivalent Forced Outage Rate). A method of converting deratings into full outages. A 100 MW derate for 4 hours is equivalent to a 400 MW outage for 1 hour.

Equivalent Availability Factor (EAF): EAF is the percent of time that a generating unit was available to run for a given period of time.

EAF = (AH – EPDH – EFDH – EMDH – ESEDH) / PH X 100%

Where:

AH = Available Hours

EPDH = Equivalent Planned Derated Hours

EFDH = Equivalent Forced Derated Hours

EMDH = Equivalent Maintenance Derated Hours

ESEDH: Equivalent Seasonal Derated Hours

PH = Period Hours

Equivalent Demand Forced Outage Rate (EFORd): EFORd has been developed to respond to the deregulated capacity and energy markets during demand times (say during peak demand hours of 1 – 5 PM). The EFORd is used by various Independent System Operators (ISOs) to calculate Unforced Capacities. The EFORd is not to be confused with the Equivalent Forced Outage Rate (EFOR). That is, EFORd is the probability that a unit will not meet its demand periods for generating requirements.

Best measure of reliability for all loading types (base, cycling, peaking, etc.)

Best measure of reliability for all unit types (fossil, nuclear, gas turbines, diesels, etc.)

For demand period measures and not for the full 24-hour clock.

Equivalent Demand Forced Outage Rate = EFORD (%) = (f f *FOH + f p * EFPOH) / SH + f f * FHOH

Where:

f f = F- Factors = f f = (1/r + 1/ T) / !/r +I/T + !/D)

r = Average Forced Outage Duration = FOH / (number of forced outages)

T= Average time between calls for a unit to run = RSH / number of attempted starts

D / average run = SH / number of successful starts

And

f_p = (SH / AH)

Note: EFPOH = EFOH – FOH

Equivalent Forced Derated Hours (EFDH): Each individual Forced Derating (D1, D2, D3) is transformed (D1, D2, D3) into equivalent full outage hour(s). This is calculated by multiplying the actual duration of the derating (hours) by the size of the reduction (MW) and dividing by the Net Maximum Capacity (NMC). These equivalent hour(s) are then summed.

(Derating Hours **x** Size of Reduction*) / NMC

NOTE: Includes Forced Deratings (D1, D2, D3) during Reserve Shutdowns (RS).

Equivalent Forced Outage Factor (EFOF): EFOF is used to assess the probability that a generating unit or transmission facility was unavailable for a period of time (PH or period hours) because of an outage or derate event when the facility cannot reach its full capacity. A lower EFOF is preferred. The historical EFOF is used as a measure to assess the future probability that a generating unit or transmission facility will not be able to meet its output capability.

EFOF = (FOH + EFDH) / PH X 100%

Where:

FOH = Forced Outage Hours

EFDH = Equivalent Forced Derated Hours

PH = Period Hours

Equivalent Forced Outage Rate (EFOR): EFOR are the hours of unit failure (unplanned outage hours and equivalent unplanned derated hours) given as a percentage of the total hours of the availability of that unit (unplanned outage, unplanned derated, and service hours). A lower EFOR is preferred. The historical EFOR is used as a measure to assess the future probability that a generating unit or transmission facility will not be able to meet its output capability.

EFOR = [(FOH + EFDH) / FOH + SH + EFDHRS] X 100%

Where:

FOH = Forced Outage Hours

EFDH = Equivalent Forced Derated Hours

SH = Service Hours

EFDHRS = Equivalent Forced Derated Hours during Reserve Shutdowns

Equivalent Forced Outage Rate (EFORd-5): An EFORd determined based on five years of outage data through Sept. 30 prior to the Delivery Year.

Equivalent Outage Hours: = $E = \sum i \ (Di * Ti) / Ci)$

Where:

E = Equivalent Outage Hours,

Di = Capacity Deration for the outage i MW,

T*i* = Time accumulated during the outage i hours,and,

Ci = Unit Monthly Net Dependable Capacity at the time of the outage, MW

Equivalent Planned Outage Factor (EPOF): The proportion of hours in a year that a unit is unavailable because of planned outages.

Equivalent Scheduled Outage Factor (ES0F): ESOF is the Planned Outage Rate used for reliability and Reserve calculations. NERC definition of Scheduled Outage Hours = Sum of all hours experienced during Planned Outages (PO) **+** Maintenance Outages (MO) **+** Scheduled Outage Extensions (PE and ME) of any Maintenance Outages (MO) and Planned Outages (PO).

ESOF = EPOF + (¾) * EMOF

Equivalent Seasonal Net Maximum Capacity (NMC) **=** Derated Hours - ESEDH Net Dependable Capacity (NDC) **x** Available Hours (AH) ***/*** Net Maximum Capacity (NMC).

This is equal to: $\frac{(NMC - NDC) \times AH}{NMC}$

ERCOT (Electric Reliability Council of Texas): This is the Texas Interconnection that includes most of Texas. The ERCOT is not subject to regulation by the Federal Energy Regulatory Commission.

ERISA: The Employee Retirement Income Security Act of 1974 **(**ERISA**)** (Pub.L. 93–406, 88 Stat. 829, enacted September 2, 1974, codified in part at 29 U.S.C. ch. 18) is a federal law that establishes minimum standards for pension plans in private industry and provides for extensive rules on the federal income tax effects of transactions associated with employee benefit plans.

ERO - Electric Reliability Organization (see North American Electric Reliability Corporation): NERC is a non-profit corporation based in Atlanta and was formed on March 28, 2006, as the successor to the North American Electric Reliability Council (also known as NERC). The original NERC was formed on June 1, 1968, by the electric utility industry to promote the reliability and adequacy of bulk power system in the electric utility systems throughout North America. NERC oversees eight (8) Regional Reliability Entities (e.g., Reliability First) and encompasses all of the interconnected power system of the contiguous United States, Canada and a portion of Baja, California in Mexico. NERC's major responsibilities include working with all stakeholders to develop standards for power system operation, monitoring and enforcing compliance with those standards, and assessing resource adequacy. NERC also investigates and analyzes the causes of significant power system disturbances in order to help prevent future events.

Essential Reliability Services (ERS – NERC definition): The NERC Whitepaper states "*Sufficiency Guidelines are processes rather than specific values as the need for frequency response* [*including* Synchronous Inertial Response]*, generation ramping, and voltage tend to be specific to the characteristics of particular areas, balancing areas, or interconnections*." Restoration of frequency is critical after an event, such as the sudden loss of a major resource. The frequency within an interconnection will immediately fall upon such an event, requiring a very fast response from some resources to slow the rate of fall, a fast increase in power output (or decrease in power consumption) to stop the fall and stabilize the frequency, then a more prolonged contribution of additional power (or reduced load) to compensate for the lost units and bring system frequency back to the normal level. Ramping is related to frequency, but more in an "operations as usual" sense rather than after an event. Changes in the amount of non-dispatchable resources, system constraints, load behaviors, and the generation mix can impact the ramp rates needed to keep the system in balance. Voltage must be controlled to protect the system and move power where it is needed. This control tends to be more local in nature, such as at individual transmission substations, in sub-areas of lower voltage transmission nodes, and the distribution system. Ensuring sufficient voltage control and "stiffness" of the system is important both for normal operations and for events impacting normal operations (i.e., disturbances).

Estimated Ultimate Recovery (EUR) is a production method commonly used in the oil and gas industry. EUR is an approximation of the quantity of oil or gas that is potentially recoverable or has already been recovered from a reserve or well.

Evaporative Cooling: An evaporative cooling system is also referred to as a swamp cooler. In hot climates with low humidity, evaporative cooling flows air across water saturated pads and cools air through the evaporation of water. Evaporative cooling differs from typical air conditioning systems which use vapor-compression or absorption refrigeration cycles and provide a steady stream of fresh air into the house rather than recirculates the same air. Evaporative cooling works by employing water's large enthalpy of vaporization.

Event Analysis: Utilization of a systematic approach to analyze an event which had negative consequences, with the goal of finding the causal factors of the event and develop recommendations to prevent a of the event.

Event Horizon (see also End Effects and Planning Horizon): Event horizon is more often called the Planning Horizon in long-term resource planning. Often, utility resource planners (and others) go beyond the prescribed planning horizons to reduce the chances that some viable option is excluded merely because the option occurred just beyond the planning horizon. In the physics of general relativity, an event horizon is a boundary in space-time beyond which events cannot affect an outside observer. In layman's terms, it is defined as the shell of "points of no return", i.e., the points at which the gravitational pull becomes so great as to make escape impossible, even for light. An event horizon is most commonly associated with black holes.

Evergreen Contract: A contract between parties that automatically renews unless one party provides notice that it will terminate the contract after a specified time or event.

Excess Capacity (see Unfavorable Capacity Balances, Resource Adequacy, Reserve Margins, Loss of Load Probability)**:** Having more resources than is required to meet the utility's load requirements, including a reasonable reserve requirement to meet Resource Adequacy requirements. The cause of the excess could be due to poor planning or to circumstances beyond the control of the utility, such as the loss of a major customer(s). Until the early 1970s, electric utilities benefited from *economies of scale* characterized by *declining average cost* which resulted in opportunities to construct ever larger baseload generating units which, in turn, resulted in lower electric rates for customers in *real dollars*. Beginning in the mid-1970s, due largely to the ramifications of the oil embargos, inflation, and recessions, economies of scale largely disappeared and the incremental cost of serving additional electric demand increased. Another characteristic of the electric industry for most of the 20th century and prior to the Regional Transmission Organizations / Independent System Operators was that each utility planned their systems as if they were islands. The need for each utility to plan the resources needed to serve their customers was necessary because there was very little foundation for regional power grids prior to RTOs / ISOs. Future electric utilities may be faced with excess capacity conditions as a result of declining reliance on traditional generating capacity due to renewable resources, energy efficiency (EE), demand response (DR), and customer-owned and other distributed energy resources (DER).

Excess Deferred Income Tax (EDIT see also ADIT): On December 22, 2017, H.R. 1 (also referred to as "Tax Cuts and Jobs Act –that would reduce the maximum corporate income tax rate from 35% to 21% effective for tax years beginning after 31 December 2017 and contains other provisions that would affect the determination of deferred tax assets and liabilities at 31 December 2017) was enacted. Consistent with the Tax Reform Act of 1986, Excess Deferred Taxes for privately owned public utilities provides for the use of the *average rate assumption method* (ARAM) for the determination of the timing of the return of excess deferred taxes. However, the new law also allows for an alternative method if the books and underlying records do not contain the vintage account data necessary to apply ARAM. A new provision is added to address a violation of the normalization requirement. A violation would result in an increase in tax by the amount by which the taxpayer reduces its excess deferred tax reserve more rapidly than permitted under the normalized method of accounting. Excess deferred taxes are the portion of previously deferred taxes that, according to the Tax Reform Act of 1986, no longer need to be paid. Utilities' deferred taxes arise from differences in how their capital assets are depreciated for utility ratemaking purposes versus how they are depreciated for federal income tax purposes. Excess deferred taxes were created when the Tax Reform Act of 1986 reduced the maximum corporate income tax rate from 46 percent to 34 percent and thereby cancelled some future expected income tax payments of privately owned utilities. Section 203(e) of the Tax Reform Act of 1986 requires that the return of excess deferred taxes to ratepayers be normalized. Under *normalization accounting rules*," utilities transfer excess deferred taxes to ratepayers through reductions in utility service rates over a period at least as long as the remaining life of the capital assets that gave rise to them. Congress chose normalization rather than flow-through treatment, which permits a more rapid return of the excess deferred taxes to ratepayers. Under flow-through accounting for the return of excess deferred taxes, public utility commissions would determine how rapidly the taxes would be returned, which could range from an immediate, one-time flow-through to flow-through over several years.

Excise Tax: Taxes imposed on the manufacture, sale, or consumption of commodities and services.

Excludable Events: An adjustment to reliability standards. See Major Event Days (MED).

Exempt Wholesale Generator (EWG): This market participant was created as part of the Public Utility Regulatory Policies Act (PURPA) of 1978. EWGs and other Independent power producers (IPPs) are facilities that generate electricity for sale in wholesale power markets that do not meet the size, efficiency or ownership requirements for Qualifying Facility (QF) status. The Federal Energy Regulatory Commission determines EWG status.

Exogenous Variables: In contrast to Endogenous Variables, an Exogenous Variable is specified outside the model and are independent variables that affect the dependent variable but without being affected by it. In other words, Exogenous Variables are factors in a causal model or causal system whose value is determined by factors or variables outside the causal system under study. By way of examples, rainfall is exogenous to the causal system constituting the process of farming and crop output. In a supply and demand curve, both price and quantity are determined within the model (endogenous) and all other factors that influence the supply and demand curve are held constant and are outside of the supply and demand model. For example, a change in income or preferences can cause a shift in the demand curve but they are exogenous to the supply and demand model.

Expected Cost: The mean (average) of cost estimates from a probabilistic analysis of potential costs. The rigor and sophistication of the analysis should increase as the cost (capital intensiveness and corresponding risk) of the project increases.

Expected Unserved Energy (EUE see also Total Unserved Energy): The expected amount of energy curtailment per year due to demand exceeding available capacity, usually expressed in MWh.

Expected Value (Statistics): In probability theory and statistics, the expected value (or expectation value, mathematical expectation, mean, or first moment) of a random variable is the integral of the random variable with respect to its probability measure. For discrete random variables this is equivalent to the probability-weighted sum of the possible values, and for continuous random variables with a density function it is the probability density - weighted integral of the possible values. The term "expected value" can be misleading. It must not be confused with the "most probable value." The expected value is in general not a typical value that the random variable can take on. It is often helpful to interpret the expected value of a random variable as the long-run average value of the variable over many independent repetitions of an experiment.

Exponential Smoothing (Statistics): A smoothing technique used to in forecasting to reduce irregularities (random fluctuations) in time series data, thus providing a clearer view of the true underlying behavior of the series. There are other smoothing techniques such as the **Moving Average Smoothing** to allow for seasonal or cyclical components of a time series. When a variable, like the number of unemployed is graphed against time, there are likely to be considerable seasonal or cyclical components in the variation. These may make it difficult to see the underlying trend. These components can be eliminated by taking a suitable moving average. That is, by reducing random fluctuations, moving average smoothing makes long term trends clearer.

Extended LMP (ELMP) (see also Convex-Hull pricing): Extended Locational Marginal Cost Pricing was developed for the Midcontinent Independent System Operator (MISO) to provide a more accurate means of calculating the true cost of energy because it incorporates commitment costs for fast-start resources and emergency demand response resources. ELMP incorporates commitment costs for fast start and emergency demand response resources, better ensures that prices reflect start-up, no-load and incremental energy costs of fast start resources in determining the price of energy, fulfills FERC's directive to the MISO to allow emergency demand response resources to set prices, and allows comparisons of LMP and ELMP results during the parallel operations phase of staged implementation. It has been suggested that even ELMP may not accureately reflect all of the costs associated with real-time dispatch. This is referred to as as the *LMP Pricing Paradox* which might be mitigated by *Convex-Hull Pricing..*

Externalities: Benefits or costs, generated as a byproduct of an economic activity, that do not accrue to the parties involved in the activity. Environmental externalities are benefits or costs that manifest themselves through changes in the physical or biological environment. In other words, externalities' refers to situations when the effect of production or consumption of goods and services imposes costs or benefits on others which are not reflected in the prices charged for the goods and services being provided.

Externality: The effect of a purchase or decision by one set of parties on others who did not have a choice and whose interests were not taken into account. In a hypothetical free market, an inefficient amount - too much or too little of the good or service - will be consumed from the point of view of society. Pollution is often cited as an example. A polluter in one state, for instance, may be affecting other states but has no financial incentive to mitigate the pollution.

Extra High Voltage (EHV): Generally, voltage of 345,000 volts (345kV) or higher.

Extra High Voltage Transmission: Typically Extra High Voltage transmission lines are used to transmit bulk power over long distances more economically due primarily to lower losses. EHV (AC or DC) is regarded as the most efficient means of transmitting power over vast distances. For example, transmitting wind power from the wind rich upper Midwest to load centers in the Eastern U.S. may only be economically viable using EHV or, eventually, Ultra High Voltage (UHV AC or DC). Extra High Voltage is typically regarded as 345 kV or 500 kV or above.

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Facility: A set of electrical equipment that operates as a single Bulk Electric System Element (e.g., a line, a generator, a shunt compensator, transformer, etc.) (NERC)

Facilities Charge: An amount to be paid by the customer in a lump sum, or periodically as reimbursement for facilities furnished. The charge may include operation and maintenance as well as fixed costs.

Facilities Rating: The maximum or minimum voltage, current, frequency, or real or reactive power flow through a facility that does not violate the applicable equipment rating of any equipment comprising the facility.

FACTS (Flexible Alternative Current Transmission System): A power electronic based system and other static equipment that provide control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability. FACTS is one of a number of technical advancements that are taking place that will drive transmission development in upcoming years. These include the use of Flexible AC Transmission Systems (FACTS), further development of a smarter grid enabling advance system monitoring and control, the use of advanced materials and superconductors in transmission lines, and maintaining cyber security.

FERC Order 841: Requires RTOs to remove barriers to storage projects (batteries, compressed air energy storage, pumped hydroelectric, fly wheels and any other process that satisfies the definition of a *Stored Energy Resource* (SER). FERC articulates 74 requirements which include, but are not limited to, establishing minimum size requirements, modeling the effects of storage, accurate metering and accounting. These are resources that may be connected to the transmission or distribution systems or *behind the meter*.

False Negative and False Positive for Demand Response: A false negative is an estimate that no load reduction occurred when, in fact, a customer did reduce load. A false positive is an estimate that load reduction occurred when the customer did not reduce load.

Fast Breeder Reactor (FBR): A reactor in which the fission chain reaction is sustained primarily by fast neutrons rather than by thermal or intermediate neutrons. Fast reactors require little or no moderator to slow down the neutrons from the speeds at which they are ejected from fissioning nuclei. This type of reactor produces more fissile material than it consumes.

Fast Frequency Response (FFR): Active power injection that is automatically deployed in the arresting phase of a frequency event aimed at providing full response before the frequency nadir is reached. According to NERC, FFR is critically needed at low-system-inertia conditions to counteract the higher rate of change of frequency (if the voltage oscillation is not a problem). Fast frequency-responsive load resources (e.g., large industrial loads, heat pumps, industrial refrigerator loads, storage devices, etc.) can provide full response in a few hundred milliseconds of the under frequency events. Recent research studies suggest that frequency response can be provided by nonsynchronous generators that reserve operating margin for providing frequency support. *Synthetic Inertial Response from Wind Generation* [from Type 3 and 4 wind turbines] is an example. When the wind turbine plant controller senses a drop in system frequency, it can very quickly extract kinetic energy from the rotating mass of the wind turbine. This results in an increase in active power injection during the arresting period. The effectiveness of the response and recovery of the wind generation resource to its pre-disturbance state depends on operating conditions of that resource.

Fault: An event occurring on an electric system such as a short circuit, a broken wire, or an intermittent connection.

Fault Analysis: Power system faults and outages occur due to lightning, animals, trees, vehicles striking poles, switching surges that cause overvoltage, insulation contamination, or other mechanical or natural causes. Protective equipment may be installed on the system to quickly restore power after a fault, or to isolate a line section to minimize the number of utility customers affected by a fault. Fault analyses (Arc Flash Hazards, Protection Coordination, Fault Location Identification) are conducted to help design the settings and locations of the protective devices, based on calculated fault current, feeder topology, and a variety of factors that are unique to each feeder. This fault-current calculation is very similar to power flow analysis, except that loads are either ignored or linearized. Source: Grid Modernization Laboratory Consortium, U.S. Department of Energy

Fault-Closing Device: A system of circuit breakers that serves to contain a fault in a grid, preventing it from spreading to other areas and causing widespread disruption.

Fault Location Analysis: When a fault occurs, the fast detection of the fault and the identification of the fault location are helpful to reduce outage durations. Detection and location require microprocessor-based relays that usually reside at the substation breaker. Fault location analysis assists in quickly troubleshooting outages by accurately predicting the locations of equipment to repair. Accurate and fast fault location identification can help utilities improve their standard reliability metrics such as SAIDI. Fault location identification is a function for system operation. The protection coordination study addresses the same function in the planning stage. The most common method for utilities to learn about system faults, and thus dispatch line crews to repair the faults, is though their customer service centers that receive customer calls. When a fault occurs, utilities will dispatch "trouble crews" to the locations near customers that reported the power outage. Crews will search for blown fuse(s) and locked out recloser(s), and patrol the line to locate the fault location. The line crew will then restore power by switching lines, clearing tree branches or animals, or by repairing or replacing any damaged devices. It may be necessary to reconfigure the line segment through switching; line reconfiguration is executed by manual switching operations in the field, or automatic switching by a dispatcher, to temporarily restore service from possible alternative power sources after the fault location is identified. Reconfiguration occurs during system operation. The contingency and restoration study addresses the same function in the planning stage. Substation relays may be capable of identifying fault locations based on current and voltage values measured during events, which require modern microprocessor-based relays and detailed modeling inputs for the location calculations. Due to various topologies of distribution systems, the integration of Distributed Energy Resources and their varying sources of current, and underground distribution cables and equipment, fault location identification by this method may be significantly more complicated in distribution systems than in transmission systems. *Fault Location, Isolation, and Service Restoration* (FLISR) is one of the key distribution automation applications and is increasingly being deployed. FLISR is an automated or semi-automated system that attempts to keep as many customers energized as possible following a fault in the distribution system. FLISR involves automated feeder switches and reclosers, distribution management systems, outage management systems, SCADA, and other technologies (DOE 2014). FLISR systems are likely to reduce outage time significantly and improve overall reliability. A typical FLISR system process includes four steps (Parikh et al. 2013): 1) identification of the fault location after a fault occurs. 2) isolation of both sides of the fault after the fault location is identified 3) estimation of the capability to restore power from an alternative line section or power source 4) restoration of power based on capability estimation results. Projects using FLISR technologies have been deployed by several utilities, and the results reveal that FLISR has reduced the number of customers interrupted by up to 45%, and reduced the customer minutes of interruption by up to 51% for one outage event (DOE 2014). Some of the challenges that remain in FLISR applications include the requirement of greater resilience in communication networks, firmware and software upgrades, and utility operations training. Grid Modernization Laboratory Consortium, U.S. Department of Energy.

Faulted Circuit Indicator: Provides a binary indication of the passage of a fault current (based on magnitude) past the sensing point. PNNL definition.

Fault Ride-Through (FRT): This is the ability of an electrical device (such as a wind turbine converter) to respond to a temporary fault or voltage change in the transmission and distribution grid, including a zero-voltage dip, and to help the system return to normal operation. Fault ride-through specifications are part of many grid code requirements.

Favored Nation Clause: A form of an indefinite price escalator clause which ties the price to be paid for natural gas to the highest price, or average of the three highest prices, paid for gas in a producing field or larger geographic area.

Federal Energy Regulatory Commission (FERC): The Federal Energy Regulatory Commission regulates the price, terms and conditions of power sold in interstate commerce and regulates the price, terms and conditions of all transmission services. *Section 205 and 206 of the Federal Power Act, rates must not be unjust, unreasonable, unduly discriminatory or preferential. FERC is the federal counterpart to state utility regulatory commissions.* The Federal Power Commission, the predecessor of the Federal Energy Regulatory Commission, was established in 1920 to regulate hydroelectric power. Like the Indiana Commission, the FERC is an independent government agency. The FERC is under the Department of Energy. Under the Federal Power Act of 1935 and the Natural Gas Act of 1938 gave the FPC the power to regulate the sale and transportation of electricity and natural gas and is responsible for:

Regulating the *interstate transmission* of natural gas, oil, and electricity – this includes responsibility for monitoring wholesale markets to prevent abuses;

Regulating the *wholesale* sale of electricity (individual states regulate *retail* sales);

Approving the construction of interstate natural gas pipelines, storage facilities, and liquefied natural gas (LNG) terminals;

Approving certain mergers and relation-ships of utilities with affiliated interests.

Certification of an "Electric Reliability Organization" (ERO) to replace the North American Electric Reliability Council. Sections 215(a)(2), (c), establishment of enforceable standards and delegation of authorities to Regional Reliability Organizations (RROs) such as Reliability First that was organized January 1, 2006 for much of the Midwest to the Mid-Atlantic Region under Section 215 (e)(1)(2)(5), no authority to order construction of new transmission and generation or preemption of states 215(i)(2)(3), and establishment of Regional State Advisory bodies 215(j) of EPAct05.

Federal Power Agency: An agency of the U.S. government that markets the output of electric generating units owned by the federal government (e.g., the Bonneville Power Administration - BPA).

Feed in Tariff (FIT)**:** A FIT is a policy tool designed to encourage the development of renewable electricity generation. Small-scale renewable energy technologies that use solar, wind, and/or biomass to produce energy often initially require subsidies to compete with traditional generation fueled by coal or gas. Feed-in tariffs frequently have the following characteristics: 1) Utilities are required to purchase all the electricity produced by qualifying generators at a fixed price under a standard contract which can be as long as 20 years. 2) Feed-in rates are usually based on the levelized cost of the renewable energy generation. 3) There are different rates for different types of renewable energy generation; higher costs technologies have higher rates than lower cost technologies. 4) Feed-in rates are not based on market prices. 5) Feed-in rates are designed to pay a premium above the market price to encourage the development of renewable energy resources.

Feeder Line (or Feeder): An electrical line that extends radially from a distribution substation to supply electrical energy within an electric area or sub-area.

Feeder Meter: Provides meter quality measurements of feeder primary quantities, including voltage, current, real, and reactive power. PNNL definition.

Feedstock: A term that refers to crude oil, natural gas liquids, natural gas or other materials used as raw ingredients for making gasoline, other refined products or chemicals.

FERC Form 1: Form 1 is a comprehensive financial and operating report submitted annually for FERC's regulation of major electric utilities detailed in 18 CFR § 101(Uniform System of Accounts Prescribed for Public Utilities and Licensees Subject to the Provision of the Federal Power Act. The forms require *Comparative Balance Sheet*, *Statement of Income, Statement of Retained Earnings, Statement of Cash Flows, and Notes to Financial Statements.*

FERC Form 2: Is the functional equivalent to FERC Form 1 for major natural gas utilities. FERC Form 2 requires submission of a *Comparative Balance Sheet, Statement of Income, Statement of Retained Earnings, Statement of Cash Flows,* and *Notes to Financial Statements.*

FERC Orders: affecting the operations and planning of the Regional Transmission Organizations/Independent System Operators and the role of the North American Electric Reliability Council (NERC). See chart below that detail some of the formative Orders:

1996: Order No. 888 requires open-access transmission tariffs

1999: Order No. 2000 establishes requirements for RTOs

2006: Order No. 679 establishes incentives for transmission infrastructure investment

2007: Order No. 693 approves first set of legally enforceable NERC reliability standards.

2007: Order No. 890 requires coordinated, open and transparent regional transmission planning processes

2011: Order No. 1000 requires:
- Transmission providers to participate in regional plans
- Neighboring regions to coordinate transmission plans
- Regional and interregional cost allocation methods
- Elimination of ROFR for regional transmission projects

Fiduciary Duty: From the Latin fiducia, meaning "trust," a person (or a business like a bank or stock brokerage) who has the power and obligation to act for another (often called the beneficiary) under circumstances which require total trust, good faith and honesty. The most common is a trustee of a trust, but fiduciaries can include business advisers, attorneys, guardians, administrators of estates, real estate agents, bankers, stock brokers, title companies, or anyone who undertakes to assist someone who places complete confidence and trust in that person or company. Characteristically, the fiduciary has greater knowledge and expertise about the matters being handled. A fiduciary is held to a standard of conduct and trust above that of a stranger or of a casual business person. He/she/it must avoid "self-dealing" or "conflicts of interests" in which the potential benefit to the fiduciary is in conflict with what is best for the person who trusts him/her/it.

FIFO – First In and First Out (see also LIFO or Last in First Out)**:** The valuation of inventory based on the assumption by which ending inventory cost is determined from most recent purchases, and cost of goods sold is determined from oldest purchases including beginning inventory.

Final Zonal RPM Scaling Factors: In the PJM markets, this is a factor applied to an Load Serving Entity's (LSE's) Daily Obligation Peak Load for purposes of calculating an LSE's Daily Unforced Capacity Obligation.

Financial Services Company: An entity that provides risk management and financing services.

Financial Transmission Rights (FTRs): FTRs are used to hedge the costs associated with transmission congestion. That is, FTRs allow market participants to offset potential losses (hedge) related to the price risk of delivering energy to the grid. FTRs are a financial contract entitling the FTR holder to a stream of revenues (or charges) based on the day-ahead hourly congestion price difference across an energy path. More specifically, values are determined by the transmission congestion charges that arise in the Day-Ahead Energy and Operating Reserve Market, leading to differences in the Marginal Congestion Components (MCCs) of Day-Ahead Locational Marginal Prices (LMPs) at different locations. In the Midcontinent ISO (MISO), for example, the primary function is the allocation of Auction Revenue Rights (ARRs) and the auction of Financial Transmission Rights (FTRs). ARRs/ FTRs get issued based on transmission capacity and as a means to provide a financial hedging mechanism to the Load Serving Entities and other Market Participants against congestion charges in MISO's Day-Ahead Market. MISO facilitates annual and monthly FTR Auctions. The annual FTR auction is conducted prior to the beginning of each planning year, and it is conducted in three rounds. Each round is comprised of eight separate markets – peak and off-peak for four seasons.

Firm Capacity: Power-producing capacity intended to be available at all times during the period covered by a commitment, even under adverse condition.

Firm Customer (Natural Gas): A pipeline customer (i.e., shipper) who has contracted for firm pipeline service.

Firm Power: Power or power-producing capacity, intended to be available at all times during the period covered by a guaranteed commitment to deliver, even under adverse conditions. Of course, even firm transactions are subject to termination (using Transmission Line Loading Relief or TLRs) in the event of a system Emergency.

Firm Service (Electric): A service offered to utilities or customers with the expectation there would be no interruptions in service. However, firm service was subject to interruptions in the event that a Planning Authority or Reliability Coordinator issued a Transmission Loading Relief (TLR) to curtail even firm transactions protect the reliability of the utility and, perhaps, region from extreme consequences such as blackouts. Arguably, there firm service was somewhat illusory.

Firm Service (Natural Gas): A service offered to customers under contract with no interruptions, regardless of service class, except in the case of force majeure.

Firm Transmission Rights: Transmission service that is intended to be available at all times to the maximum extent practicable, subject to an emergency, and unanticipated failure of a facility, or other event beyond the control of the owner or operator of the facility, or other event beyond the control of the owner or operator of the facility. *(see also Non-Firm Transmission Service and Point-to-Point Transmission Service).*

Firm Transmission Service: A transmission service that is intended to be available at all times. However, the firmness of the service is subject to emergencies such as an unanticipated failure of a facility, or other event beyond the control of the owner or operator of the facility or of the relevant RTO / ISO.

First Contingency Basis: The bulk power system is planned to protect against adverse consequences of a failure or malfunction of any single bulk power facility (transmission, generation, and other resources). This is often referred to as *N-1 contingency***.** The loading on all bulk power facilities are intended to be within normal continuous ratings and maintenance of Voltages within predetermined normal schedules at all load levels; such that, immediately following any single facility malfunction or failure, the loading on all remaining facilities can be expected to be within emergency ratings. That is *System Stability* – including an acceptable Voltage profile - is maintained to prevent a cascading outage. When a contingency does occur, system operators are required to identify and plan for the next contingencies based on the changed conditions. They must also promptly make any adjustments needed to ensure that if one of these contingencies were to occur, the system would still remain operational and safe. Generally, the system must be restored to normal limits as soon as practical but within no more than 30 minutes, and to a condition where it can once again withstand the next-worst single contingency without violating thermal, voltage, or stability limits. Most areas of the grid are operated to withstand the concurrent loss of two or more facilities (*i.e., "N-2" or "N-3")*. This may be done, for example, as an added safety measure to protect a densely populated metropolitan area or when lines share a common structure and could be affected by the same event (e.g., a single lightning strike).

Fischer-Tropsch (F-T): The origin for the F-T synthesis was in Germany in 1926. It was used by the Germans in World War II to supplement limited stocks of petroleum resources and, later, by South Africa during the U.N.(1980) and OPEC (1973) apartheid embargos to replace imported energy. The first step in the F-T GTL process is converting the natural gas, which is mostly methane, to a mixture of hydrogen, carbon dioxide, and carbon monoxide. This mixture is called syngas. The syngas is cleaned to remove sulfur, water, and carbon dioxide, in order to prevent catalyst contamination. The F-T reaction combines hydrogen with carbon monoxide to form different liquid hydrocarbons. These liquid products are then further processed using different refining technologies into liquid fuels. The F-T reaction typically happens at high pressure (40 atmospheres) and temperature (500^o-840^oF) in the presence of an iron catalyst. The cost of building a reaction vessel to produce the required volume of fuel or products and to withstand these temperatures and pressures can be considerable. Several companies are pursuing an alternative method that uses a different reactor design (called a micro-channel reactor) and proprietary catalysts that allow GTL production at much smaller scales.

Fission (Nuclear): All nuclear reactors generate heat with the energy released by splitting atoms with neutrons. These neutrons have different energy levels. Three isotopes Uranium-233, Uranium-235, and Plutonium-239 are fissionable by neutrons of all energies and called fissile material. Uranium-235 is the only one that occurs naturally and in very small amounts.

Two other materials Thorium-232 and Uranium-238 are abundant naturally and are fissionable only if split with highly energetic neutrons. However, these materials can be converted to fissile isotopes within a reactor.

Fission: The splitting of an atom, which releases a considerable amount of energy (usually in the form of heat) that can be used to produce electricity. Fission may be spontaneous, but is usually caused by the nucleus of an atom becoming unstable (or "heavy") after capturing or absorbing a neutron. During fission, the heavy nucleus splits into roughly equal parts, producing the nuclei of at least two lighter elements. In addition to energy, this reaction usually releases gamma radiation and two or more daughter neutrons. Nuclear Regulatory Commission, *April 23, 2018*.

Fissionable Material: A nuclide that is capable of undergoing fission after capturing either high-energy (fast) neutrons or low-energy thermal (slow) neutrons. Although formerly used as a synonym for fissile material, fissionable materials also include those (such as uranium-238) that can be fissioned *only* with high-energy neutrons. As a result, fissile materials (such as uranium-235) are a subset of fissionable materials. Uranium-235 fissions with low-energy thermal neutrons because the binding energy resulting from the absorption of a neutron is greater than the critical energy required for fission; therefore uranium-235 is a fissile material. By contrast, the binding energy released by uranium-238 absorbing a thermal neutron is less than the critical energy, so the neutron must possess additional energy for fission to be possible. Consequently, uranium-238 is a fissionable material. Source Nuclear Regulatory Commission April 23, 2018

Fixed Assets: Tangible property used in the operations of an entity, but not expected to be consumed or converted into cash in the ordinary course of events. With a life in excess of one year, not intended for resale to customers, and subject to depreciation (with the exception of land), they are usually referred to as property, plant, and equipment.

Fixed Carbon: The nonvolatile matter in coal minus the ash. Fixed carbon is the solid residue other than ash obtained by prescribed methods of destructive distillation of a coal. Fixed carbon is the part of the total carbon that remains when coal is heated in a closed vessel until all matter is driven off.

Fixed Charge Coverage: The ratio of earnings available to pay so-called fixed charges to such fixed charges. Fixed charges include interest on funded debt, including leases, plus the related amortizations of debt discount, premium, and expense. Earnings available for fixed charges may be computed before or after deducting income taxes. Occasionally credits for the "allowance for funds used during construction" are excluded from the earnings figures. The precise procedures followed in calculating fixed charge or interest coverages vary widely.

Fixed Resource Requirement (FFR): An alternative method for an eligible load-serving entity to meet a fixed resource requirement with its own capacity resources as opposed to having the RTO / ISO procure capacity resources on the load-serving entity's behalf in capacity auctions. See also MISO's Fixed Resource Adequacy Plan (FRAP).

Fixed Variable (Natural Gas - see also Modified Fixed Variable and Straight Fixed Variable)**:** Rate design used in the 1940s for interstate pipelines and superseded by Seaboard. It places all fixed costs in demand. The commodity portion of the rate only contains a system's variable costs. The rationale behind this design is that the pipeline is sized (designed) to meet the systems peak load.

Flashover: An electrical discharge through air around or over the surface of insulation, between objects of different electrical potential, caused by placing a voltage across the airspace that results in ionization of the airspace. (NERC)

Flexible Fuel Vehicle (FFV): Vehicles that can operate on:

1. alternative fuels (such as M85 or E85);
2. 100-percent petroleum-based fuels; or
3. any mixture of an alternative fuel (or fuels) and a petroleum-based fuel.

Flexible fuel vehicles have a single fuel system to handle alternative and petroleum-based fuels. Flexible fuel vehicle and variable fuel vehicle are synonymous terms.

Flexibility: The ability of a generator (or group of generators to change (ramp) up or down quickly and start up or stop on short notice in response to changes in frequency.

Float Voltage The voltage at which the battery is maintained after being charge to 100 percent SOC to maintain that capacity by compensating for self-discharge of the battery.

Flow Gate: A designated point on the transmission system through which the Interchange Distribution Calculator calculates the power flow from Interchange Transactions.

Flue Gas Desulfurization (FGD): Equipment used to remove sulfur oxides from the combustion gases of a boiler plant before discharge to the atmosphere. Also referred to as scrubbers. Chemicals such as lime are used as scrubbing media.

Flue-Gas Particulate Collector: Equipment used to remove fly ash from the combustion gases of a boiler plant before discharge to the atmosphere. Particulate collectors include electrostatic precipitators, mechanical collectors (cyclones), fabric filters (baghouses), and wet scrubbers.

Fluidized-Bed Combustion: A method of burning particulate fuel, such as coal, in which the amount of air required for combustion far exceeds that found in conventional burners. The fuel particles are continually fed into a bed of mineral ash in the proportions of 1 part fuel to 200 parts ash, while a flow of air passes up through the bed, causing it to act like a turbulent fluid.

Fluorescent Lamp: A glass enclosure in which light is produced when electricity is passed through mercury vapor inside the enclosure. The electricity creates a radiation discharge that strikes a coating on the inside surface of the enclosure, causing the coating to glow. *Note:* Traditional fluorescent lamps are usually straight or circular white glass tubes used in fixtures specially designed for them. A newer type of fluorescent lamp, the compact fluorescent lamp, takes up much less room, comes in many differently-shaped configurations, and is designed to be used in some fixtures originally intended to house incandescent lamps.

Flux Material: A substance used to promote fusion, e.g., of metals or minerals.

Fly Ash: Particulate matter mainly from coal ash in which the particle diameter is less than 1 x 10^4 meter. This ash is removed from the flue gas using flue gas particulate collectors such as fabric filters and electrostatic precipitators.

Fly Wheel: A mechanical device used to store electricity by converting electricity to kinetic energy of a rotating wheel with low friction.

FOA: Funding Opportunity Announcement

FOIA: Freedom of Information Act

Force Majeure (see also Market Out)**:** Generally refers to include events that are beyond the control of a party that prevent them from fulfilling their contractual obligations. The *casus fortuitus* means chance occurrence or unavoidable accident that can free both parties from liability or obligation when an extraordinary event outside the control of either party occurs (e.g., war, earthquake, hurricane, etc). Force Majeure is not intended to immunize any party from negligence or malfeasance.

Forced Derating (D1, D2, D3): An unplanned component failure (immediate, delayed, postponed) or other condition that requires the load on the unit be reduced immediately or before the next weekend.

Forced Outage: Generally, it is the removal from service of a generating unit, transmission line, or other facility for emergency reasons due to the condition in which the equipment is unavailable as a result of unanticipated failure. More technically, it is *an* unplanned component failure (immediate, delayed, postponed, startup failure referred to as *U1, U2, U3, SF)* or other condition that requires the unit be removed from service immediately or before the next weekend. The shutdown of a generating unit, transmission line, or other facility for emergency reasons or a condition in which the generating equipment is unavailable for load due to unanticipated breakdown.

Forced Outage Hours (FOH): FOH is the sum of all hours experienced during Forced Outages (U1, U2, U3) **+** Startup Failures (SF).

Forced Transmission Outage: Immediate removal from service of a transmission facility by reason of an emergency, threatened emergency, unanticipated failure or other cause beyond control of Transmission Owner.

Forms of Energy: kinetic energy - energy of motion; potential energy - energy of ``location'' with respect to some reference point; chemical energy - energy stored in chemical bonds, which can be released in reactions; electrical energy - energy created by separating charges – for example energy stored in a battery; thermal energy - energy given off as heat, such as friction.

Formula Rates: Formula Rates are essentially a comprehensive tracker or automatic adjustment clause to better ensure the utility achieves its approved revenue requirement. In essence Formula Rates compare earned Return on Equity (ROE) to the target (benchmark) ROE and then calculate the rate adjustment needed to reduce the ROE difference. Unlike *Earnings Sharing* mechanisms or rates tied to a utility's performance in a specific area(s) where over or under earnings are shared between the utility and its customers (often with a dead-band or stratified sharing of costs and benefits), Formula Rates typically don't share costs and benefits. Often, major investments by utilities, such as the addition of a power plant, are decided in separate proceedings and incorporated into Formula Rates. Proponents of Formula Rates contend that this process will streamline regulation by, among other things, reducing the proliferation of "trackers" and expediting rate proceedings. Proponents also argue Formula Rates better address *Regulatory Lag* (the time between rate cases). That is, some utilities postpone rate cases if they are over-earning and, historically, some utilities filed frequent rate cases due to ambitious construction programs. One of the criticisms of Formula Rates is, by having a target ROE and limited scrutiny of utility costs and revenues, it comes close to violating the regulatory tenant that a regulatory commission does not guarantee a utility will achieve its authorized revenue or even the utility's survival (e.g., default or bankruptcy) if there are factors like imprudent, fraudulent, or other improper conduct.

Forward Capacity Auction (FCA): The mechanism utilized for the procuring resources for the Forward Capacity Market. The "descending-clock" annual auction of the Forward Capacity Market during which the price for capacity will be decreased until the quantity of capacity remaining in the auction equals the quantity of capacity needed.

Forward Capacity Market (FCM): The purpose of the capacity market is to provide reliability in the region at the lowest delivered cost reasonably possible. By its design, the regional capacity market is intended to encourage suppliers to build more capacity by offering them stable revenue streams on which they can finance electricity generation investments. PJM's Reliability Pricing Model (RPM) or the New England ISO's Installed Capacity Market (ICAP).

Forward Market: A market in which delivery of the item purchased is at some future point in time. In electric markets, the delivery is at least two days away from the day of purchase.

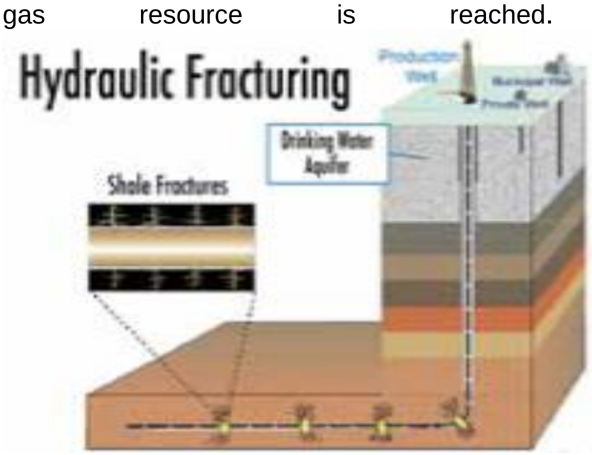
Forward Reserve Market (FRM): In New England, a market used for acquiring the generating resources needed to satisfy the requirements for 10-minute non-spinning reserves and 30-minute operating reserves.

Four Wire Service: A three-phase service from the utility to a customer that has threephase wires connected at a common point at the transformer plus a ground.

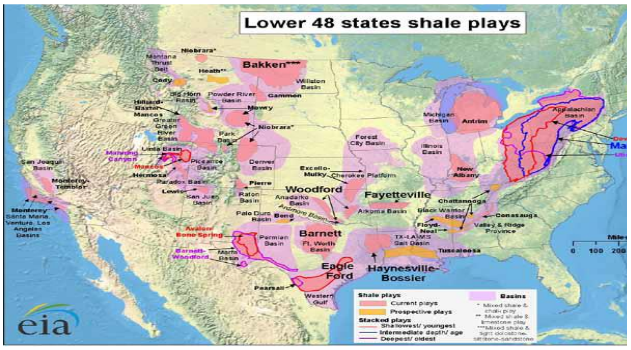
FPA (Federal Power Act 1935): 1935 Act and subsequent amendments comprise the primary statutory authority of the Federal Energy Regulatory Commission.

Fracking (or Hydraulic Fracturing): Is the fracturing of rock by a pressurized liquid. **Hydraulic fracturing** is a technique in which typically water is mixed with sand and chemicals, and the mixture is injected at high pressure into a wellbore to create small fractures to extract oil and natural gas. Oil and Natural Gas *Plays* have been discovered in almost every state.

Hydraulic Fracturing enables recovery of oil and gas from unconventional sources that remained outside the reach of economic extraction until recently. Tight gas is a form of unconventional natural gas that is trapped in rock formations where the permeability is too low for it to be extracted using conventional drilling. Shale gas is another form of unconventional resource trapped within porous shale rock formations lacking the permeability required for conventional extraction. In order to extract tight gas and shale gas resource, producers free the resources by fracturing the formations in which unconventional gas is trapped. According to the American Petroleum Institute's *Hydraulic Fracturing Primer* (2010) fracking is accomplished by drilling a well with a depth of up to10,000 feet, then drilling along a horizontal path once the tight gas or shale gas resource is reached.



According to the US Department of Energy's report entitled Modern Shale Gas Development in the United States: A Primer (2009). Once the drilling is completed and the well casing is in place, a mixture known as fracking fluid is injected into the ground to fracture the rock. This liquid consists of approximately 90 percent water, 9.5 percent sand and 0.5 percent chemical additives. Depending on the depth of the well and the characteristics of a given formation, the average hydraulic fracturing well requires between 2 and 4 million gallons of water.

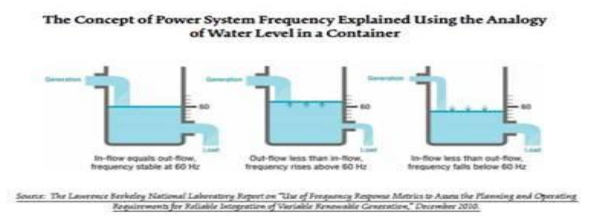


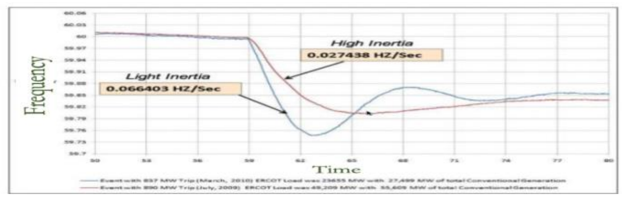
Franchised Service Territory: Regulated utilities are typically granted an *exclusive franchise* – a *monopoly* with the corresponding obligation to provide reliable and economic service to all customers within the service territory on an non-discriminatory basis. The regulated utility is, then, entitled to recover prudently incurred costs and earn a fair and reasonable return on invested capital. Even with the grant of an exclusive franchise, there are exceptions such as state commission approval of *merchant or independent power producers* that sell into wholesale markets and do not sell directly to other retail customers, *customer-owned generation* that is for the customer's own use, *and Demand Side Management.* Especially in retail competition (a/k/a restructured states), the franchise may not be exclusive and the *obligation to serve* may be different than in traditionally regulated states.

Free On Board (FOB): As used in the electric utility industry this is *mine mouth*. In general and in electric utility terms, FOB indicates whether the seller or the buyer has liability for goods that are damaged or destroyed during shipment between the two parties. "FOB shipping point" (or origin) means that the buyer is at risk while the goods are shipped and "FOB destination" states that the seller retains the risk of loss until the goods reach the buyer. Price spreads between different coal basins and suppliers will reflect differences in usage costs and in transport costs to the relevant market.

Free Rider (Economics Term): Receiving benefits without paying costs associated with the production of those benefits (a subsidy).

Frequency: The rate in cycles per second (Hertz) at which voltage and current oscillate in electrical power systems (reference frequency is 60 Hz in N. America).





Frequency Bias: The Balancing Authority's obligation to provide or absorb energy to assist in stabilizing frequency. If frequency goes low, each Balancing Authority is asked to contribute extra generation in proportion to its system's established bias value.

Frequency Converter (also called a frequency changer): A device used to adjust the frequency of alternating current. Frequency converters are used in variable-speed drives to control the speed, torque or power on the shaft of an electric motor by adjusting the frequency and voltage of the electricity powering the machine. Frequency converters are used to control the rotational speed of wind turbines to stabilize the frequency of the electricity they produce. Frequency converters are also used to connect electrical systems operating at different frequencies (e.g., electrical systems running at 60 Hz, to 50 Hz).

Frequency Disturbance: A system frequency deviation from normal as a result of a generation/load imbalance.

Frequency Error: The difference between the actual and scheduled frequency. (FA – FS) (NERC)

Frequency Nadir (see also frequency): The point at which frequency decline is arrested.

Frequency Regulation: The ability of a Balancing Authority to help the Interconnection maintain Scheduled Frequency. This assistance can include both turbine governor response and Automatic Generation Control. Frequency Response (Equipment) The ability of a system or elements to react or respond to a change in system frequency.

Frequency Ride Through (FRT see also Low Frequency Ride Through, Low Voltage Ride Through, and Voltage Ride Through): The prime movers directly coupled to synchronous generators experience speed variations as the grid frequency varies. These speed variations, and rate of speed change, can pose mechanical and combustion problems for prime movers. Speed variations can cause excitation of mechanical oscillations modes, and acceleration can cause blowout of gas turbine flames. These problems are usually associated with much larger turbine generators than used as DR. Excessively stringent FRT requirements, however, could potentially pose problems even for smaller gas turbines that might be connected to distribution systems. NERC addressed the concern that distributed energy resources (DER) that have sensitive voltage and frequency trip points with short delay times, as mandated by the current version of IEEE Standard 1547, pose a risk to bulk power system security. This issue is described in the NERC Integration of Variable Generation Task Force Task 1-7 report.1 This NERC report recommends that IEEE 1547 be modified to incorporate voltage and frequency ride-through requirements (VRT and FRT, or collectively V/FRT). IEEE Standard 1547 is presently being amended to provide more flexibility in the "must trip" requirements, which allow V/FRT to be implemented by utilities or other local entities, but do not mandate these ride-through capabilities. The base IEEE 1547 standard, however, is required by recently-changed IEEE Standards Association rules to undergo full review and potential revision. Sandia National Laboratories April 2014.

Frequency Stability: The ability of an oscillator to maintain a desired frequency, usually as a percent deviation from the desired frequency.

Frequency Support: The use of electric resources to maintain system frequency at acceptable levels.

Frequency Swings: Constant changes in frequency from its nominal or steady-state value.

Frequently Mitigated Unit (FMU): A generating unit that was offer-capped for more than a defined proportion of its real-time run hours in the most recent 12-month period. FMU thresholds are 60 percent, 70 percent and 80 percent of run hours. Such units are permitted a defined adder to their cost-based offers in place of the usual 10 percent adder.

Fuel Cell: A device capable of generating an electrical current by converting the chemical energy of a fuel (e.g., hydrogen) directly into electrical energy. Fuel cells differ from conventional electrical cells in that the active materials such as fuel and oxygen are not contained within the cell but are supplied from outside. It does not contain an intermediate heat cycle, as do most other electrical generation techniques.

Fuel cells are an emerging technology that converts the chemical energy in natural gas or hydrogen into electricity and water through an electrochemical reaction with oxygen. A fuel cell does not result in combustion which makes fuel cells environmentally attractive and safer. Fuel cells have similar characteristics to batteries except that fuel cells rely on an external source for fuel instead of stored chemical reactants. While there are different types of fuel cells, they all have an anode layer, an electrolyte layer, and a cathode layer. As of 2018, there are few commercial applications due to technical challenges such as the need for a cost-effective and efficient *fuel reformer* to convert the fossil fuel into hydrogen. Fuel cells also require *rare earth metals* such as yttrium and zirconium that are expensive.

Fuel Cost: The cost of the fuel used by each unit expressed in $/MBTU. When multiplied by the incremental heat rate (MBTU/MWh), the incremental fuel cost ($/MWh) results.

Fuel Cycle: The entire set of sequential processes or stages involved in the utilization of fuel, including extraction, transformation, transportation, and combustion. Emissions generally occur at each stage of the fuel cycle.

Fuel Diversity (see also Resource Diversity, Load Diversity, and Weather Diversity)**:** In an electric system, fuel diversity may be defined as utilizing multiple resource types to meet demand. Fuel diversity is closely related to *Resource Diversity* and, to a lesser extent, *Load Diversity.* A more diversified system is intuitively expected to have increased flexibility and adaptability to: 1) mitigate risk associated with equipment design issues or common modes of failure in similar resource types, 2) address fuel price volatility and fuel supply disruptions, and 3) reliably mitigate instabilities caused by weather and other unforeseen system shocks. In this way, fuel diversity can be considered a system-wide hedging tool that helps ensure a stable, reliable supply of electricity. "*PJM's Evolving Resource Mix and System Reliability*," PJM Interconnection LCC March 30, 2017. The Value of fuel diversity changes with the dynamics of the different fuels and this can influence the selection of new resources. By way of example, if there was very high confidence that the operating cost of natural gas-fired units (primarily combined cycle) were going to be lower than coal for several years, coal-fired units would not be as desirable to operate or build; new coal-fired units have very high capital costs compared to a natural gas combined cycle units that might perform as more of a baseload unit. In addition to the lower capital costs and construction lead times compared to coal-fired units, the flexible operations of natural gas-fired units (lower start up times, greater ramping capability, lower heat rates, lower O&M costs) also has some inherent operational advantages (reliability and economics) over coal-fired units so some of the traditional values of resource diversity may not be as significant.

Fuel Switching (Electric-DSM Program Assistance): DSM program assistance where the sponsor encourages consumers to change from one fuel to another for a particular end-use service. For example, utilities might encourage consumers to replace electric water heaters with gas units or encourage industrial consumers to use electric microwave heaters instead of natural gas-heaters.

Electric utility Fuel switching, typically, resulted in changing from coal to natural gas as the fuel for an electric generator. This type of coal to natural gas fuel switching replaces relatively high emissions (including carbon content) fossil fuels with natural gas that has lower emissions. In addition to lower emissions, natural gas-fired units have been cheaper to operate, maintain, and build. Their reduced ramp times also provides reliability and operational advantages.

Fuel Switching (Natural Gas): The substitution of one fuel for another based on price and supply availability. A number of power generators have fuel-switching capabilities and are able to switch between natural gas and fuel oil, depending on the price differential between the two, as well as supply availability of fuel.

Fuel Switching Capability: The short-term capability of a manufacturing establishment to have used substitute energy sources in place of those actually consumed. Capability to use substitute energy sources means that the establishment's combustors (for example, boilers, furnaces, ovens, and blast furnaces) had the machinery or equipment either in place or available for installation so that substitutions could actually have been introduced within 30 days without extensive modifications. Fuel-switching capability does not depend on the relative prices of energy sources; it depends only on the characteristics of the equipment and certain legal constraints.

Fukishima: The Fukushima Daiichi Nuclear Power Plant accident in Ōkuma was initiated primarily by the tsunami following the Tōhoku earthquake on 11 March 2011. Immediately after the earthquake, the active reactors automatically shut down their sustained fission reactions. However, the tsunami disabled the emergency generators that would have provided power to control and operate the pumps necessary to cool the reactors. The insufficient cooling led to three nuclear meltdowns, hydrogen-air explosions, and the release of radioactive material in Units 1, 2 and 3 from 12 March to 15 March. Loss of cooling also raised concerns over the recently loaded spent fuel pool of Reactor 4, which increased in temperature on 15 March due to the decay heat from the freshly added spent fuel rods but did not boil down to exposure. On 5 July 2012, the Fukushima Nuclear Accident Independent Investigation Commission (NAIIC) found that the causes of the accident had been foreseeable, and that the plant operator, Tokyo Electric Power Company (TEPCO), had failed to meet basic safety requirements such as risk assessment, preparing for containing collateral damage, and developing evacuation plans. The Fukushima disaster was the most significant nuclear incident since the April 26, 1986 Chernobyl disaster and the second disaster to be given the Level 7 event classification of the International Nuclear Event Scale. However, there have been no fatalities linked to radiation due to the accident. The United Nations Scientific Committee on the Effects of Atomic Radiation and World Health Organization report that there will be no increase in miscarriages, stillbirths or physical and mental disorders in babies born after the accident.

Full Forced Outage: The net capability of main generating units that are unavailable for load for emergency reasons.

Full Requirements Service: This is a term used by Distribution Companies to characterize their commitments to supply all the customer's wholesale load requirements.

Funds from Operations (FFO): Cash flows generated by the operations of a business. The term is most commonly used in relation to the cash flows from real estate investment trusts (REITs). This measure is commonly used to judge the operational performance of REITs, especially in regard to investing in them. Funds from operations does not include any financing-related cash flows, such as interest income or expense. It also does not include any gains or losses from the disposition of assets, or any depreciation or amortization of fixed assets.

Functionalization (Cost-of-Service term – see also Classification, Allocation, and Revenue Requirement): For an electric utility, functionalization separates the cost of electrical operations into its various components: 1) Power Supply, 2) Transmission, 3) Distribution, and 4) Customer Service. The costs associated with these (e.g., O&M, debt service) are placed in one of these four functions. A more limited functionalization process is used by natural gas local distribution companies.

Fusion: Fusion is the power source of the sun and, perhaps, a future power source for producing electricity that would be limitless and clean. Nuclear fusion is a reaction in which two or more atomic nuclei (e.g., a hydrogen isotope called deuterium and tritium) come close enough or are forced together to form one or more different atomic nuclei and subatomic particles (neutrons or protons). The difference in mass between the products and reactants is manifested as the release of large amounts of energy. More specifically, if the combined nuclear mass is less than iron at the peak of the *binding energy curve,* then the nuclear particles will be more tightly bound than they were in the lighter nuclei. The decrease in mass takes the form of energy according to the Einstein relationship. The prospect of fusion energy is limited by the ability to contain the intense heat (270 F million degrees). The reaction that takes place when lighter elements join together to create heavier ones produces energy, creating plasma—a state of matter—in the process. The reactor where this takes place must somehow confine and suspend the superheated plasma produced without it touching (and therefore damaging) the walls. Scientists are working with magnets to control the plasma but, to date, the fusion reactions have failed to produce more energy than they take to initiate and run the reaction. The control of runaway electrons to avoid collisions with the wall that could be destructive is one of a range of challenges, including materials development for the wall and exhaust regions, which must be tackled in the development of fusion energy.

Fusion, the same process that powers the sun and other stars, offers the potential for high energy yields to produce electricity with very low amounts of nuclear waste. Fusion, like fission does not produce air pollution that is a concern for fossil fuel power plants. Occurs when two light atoms bond together, or fuse, to make a heavier one. The total mass of the new atom is less than that of the two that formed it; the "missing" mass is given off as energy, as described by Albert Einstein's famous "$E=mc^2$" equation. Unlike a fission reaction that splits atoms, for the nuclei of two atoms to overcome their aversion to another atom caused their having the same charge, high temperatures and pressures are required to initiate and control the reaction. Temperatures must reach approximately six times those found in the core of the sun. At this heat, the hydrogen is no longer a gas but a plasma, an extremely high-energy state of matter where electrons are stripped from their atoms.

Future Value (FV): If you choose Option A and invest the total amount at a simple annual rate of 4.5%, the future value of your investment at the end of the first year is $10,450, which of course is calculated by multiplying the principal amount of $10,000 by the interest rate of 4.5% and then adding the interest gained to the principal amount:

Future value of investment at end of first year.

= ($10,000 x 0.045) + $10,000

= $10,450

Futures Contract: A supply contract between a buyer and seller whereby the buyer is obligated to take delivery and the seller is obligated to provide delivery of a fixed amount of commodity at a predetermined price and location. Futures are bought and sold through an exchange.

Futures Market: A trade center for quoting prices on contracts for the delivery of a specified quantity of a commodity at a specified time and place in the future.

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GAAP (see also Generally Accepted Accounting Principles): Defined by the Financial Accounting Standards Board (FASB) as the conventions, rules, and procedures necessary to define accepted accounting practice at a particular time, includes both broad guidelines and relatively detailed practices and procedures.

Gantt Chart: Common in project management tool. Project managers use Gantt Charts to display when expected major activities, tasks, and events begin and end over the course of the project. The Critical Path Method (CPM) or Critical Path Analysis (CPA) is often used in conjunction with the Gantt Chart for scheduling a set of project activities. The benefit of using CPA and CPM within the planning process is to help you develop and test your plan to ensure that it is robust. CPA and CPM formally identifies tasks which must be completed on time for the whole project to be completed on time. It also identifies which tasks can be delayed if resource needs to be reallocated to catch up on missed or overrunning tasks.

Game Theory: A mathematical study of conflict and cooperation among rational decision-makers. Game theory models *zero sum games* where one person's gains result in losses for the other participants but the net change in wealth or benefit has not changed. ENRON, for example, hired experts in game theory to develop methods for testing and, in some cases, manipulating energy markets. Game theory is mainly used in economics and a variety of other disciplines such as biology, computer science, and political science.

Gas Cooled Fast Reactors (GFR): Like other helium-cooled reactors which have operated or are under development, GFRs will be high-temperature units – 850°C. They employ similar reactor technology to the VHTR, suitable for power generation, thermochemical hydrogen production or other process heat. The reference GFR unit is 2400 MWt/1200 MWe, large enough for breakeven breeding, with thick steel reactor pressure vessel and three 800 MWt loops. For electricity, an indirect cycle with helium will be on the primary circuit, in the secondary circuit the helium gas will directly drive a gas turbine (Brayton cycle), and a steam cycle will comprise the tertiary circuit. It would have a self-generating (breeding) core with fast neutron spectrum and no fertile blanket. Robust nitride or carbide fuels would include depleted uranium and any other fissile or fertile materials as ceramic pins or plates, with plutonium content of 15 to 20%. As with the SFR, used fuel would be reprocessed on site and all the actinides recycled repeatedly to minimise production of long-lived radioactive wastes. While General Atomics worked on the design in the 1970s (but not as fast reactor), none has so far been built. It is the only Gen IV design with no operating antecedent, so a prototype is not expected before 2022.

Gas Day (Natural Gas): A 24-hour period of time used by a pipeline for the operation of its system. Unlike the Electric Day, the Gas Day is currently uniform across the United States.

Gas to Liquids (GTL): A process that converts natural gas to liquid fuels such as gasoline, jet fuel, and diesel. The most common technique used at GTL facilities is Fischer-Tropsch (F-T) synthesis. There are other processes which produce synthetic liquid hydrocarbons (SLH) from other hydrocarbon or biomass feedstocks such as Coal to Liquid (CTL) and Biomass or Biogas to Liquid – biofuels (BTL). Although F-T synthesis has been around for nearly a century, it has gained recent interest because of the growing spread between the value of petroleum products and the cost of natural gas. There are currently five GTL plants operating globally, with capacities ranging from 2,700 barrels per day (bbl/d) to 140,000 bbl/d. Shell operates two in Malaysia and one in Qatar, Sasol operates one in South Africa, and the fifth is a joint venture between Sasol and Chevron in Qatar. One plant in Nigeria is under construction. Three plants in the United States—in Lake Charles, Louisiana; Karns City, Pennsylvania; and Ashtabula, Ohio—are proposed. Of these, only the Lake Charles facility is a large-scale GTL plant. To improve the long-term profitability of GTL plants, developers have reconfigured their designs to include the production of waxes and lubricating products, which are another primary product of the F-T process.

Gas Turbine Plant: A plant in which the prime mover is a gas turbine. A gas turbine consists typically of an axial-flow air compressor and one or more combustion chambers where liquid or gaseous fuel is burned and the hot gases are passed to the turbine and where the hot gases expand drive the generator and are then used to run the compressor.

Gasification: A process that converts liquefied natural gas (LNG) from a liquid back to a gas. This is done by increasing the temperature and decreasing the pressure of the LNG.

Gathering System (Electric) a network of relative small electric lines to several renewable energy resources that ties into a larger electric transmission facility.

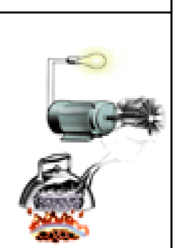
Gathering System (Natural Gas): A network of small pipelines which connect producing wells with a pipeline transmission system.

General Equilibrium Model: An estimation of the flows of goods and services and the corresponding monetary flows among all sectors of the US economy that achieve equilibrium. The model attempts to explain the behavior of supply, demand, and prices in a whole economy with several or many interacting markets, by seeking to prove that the interaction of demand and supply will result in an overall general equilibrium. General equilibrium theory contrasts to the theory of *partial* equilibrium, which only analyzes single markets. **A computable general equilibrium** (CGE) model is a type of simulation that tracks the flows of goods and services and the corresponding monetary flows among all sectors of the US economy. For example, this model may be useful to assess the ramifications of changes in public policy such as environmental regulations on the energy sector of the economy.

Generation: Conversion of nuclear, thermal, etc. energy into electricity. Generation describes both the process of producing electrical energy from other forms of energy (e.g., a power plant burning coal or a windmill turning moving air into energy) as well as the amount of electrical energy produced, which is usually expressed in kilowatt-hours (kWh) or megawatt-hours (MWh).

A Very Simple Explanation of Generation

Burning fuel (the flame) heats water to boiling (in the teapot), making steam. The steam spins a turbine (the fan blades) turning its shaft which connects to a generator rotor (a magnet). As the rotor spins, electricity is produced in the generator stator (coils of wire).



Generation Availability Data System (GADS) (see also Transmission Availability Data System): A compilation, by the North American Electric Reliability Corporation of publicly available data on the performance of generating units in the United States for the purpose of reliability studies. Reporting is mandatory for all conventional generating units of 20 MW or larger. For smaller generation as well as for wind and solar, reporting is currently voluntary. NERC's GADS is similar to TADS for Transmission. GADS includes: information about the age, capacity, fuels, and operating statistics such as *Equivalent Availability Factor (EAF), Equivalent Forced Outage Factor (EFOF), Capacity Factor, Net Heat Rate, Non-Fuel Costs ($/KW capacity)* that is critical to operations and planning.

Generation I–IV Nuclear Generating Units: The first nuclear generating units in the United States (including Shippingport) were prototypes built in the 1950s through the mid-1960s. Generation 2 were the first commercial units (Pressurized Water, Boiling Water, and CANDU). Generation 3 were Light Water Reactors and evolutionary designs like Advanced Boiling Water reactors. Generation 4 are considered *revolutionary* designs that are safer, more sustainable, more economic, more secure and less likely to add to nuclear proliferation.

"Walk-Away Safe" Advanced Reactor Technology that is intended to substantially reduce radioactive waste. Its molten salt reactor uses molten fluoride salt as its coolant and to carry its liquid fuel. Unlike existing reactors, Transatomic Power Corporation's reactor design operates in atmospheric pressures, cannot suffer a meltdown, and does not need external power to shut down and cool its fuel. The technical study also concluded that Transatomic's estimated $2 billion reactor design, with a net electric capacity of 520 MWe, can operate for decades using commercially-available 5% low-enriched uranium while reducing long-lived radioactive byproducts known as actinides by more than 50% as compared to a light-water reactor. SNL February 6, 2017.

Generation Offers (see also Bids): Generators *offer* their generation on schedules for the amount of capacity (MWs) and their price for energy (MWhs).

Generator Operator: The entity that operates generating Facility(ies) and performs the functions of supplying energy and Interconnected Operating Services. (NERC)

Generation Shift Factor: A factor to be applied to a generator's expected change in output to determine the amount of flow contribution that change in output will impose on an identified transmission facility or Flowgate. (NERC)

Generator Trip: Electrical or mechanical malfunctions that result in a generator failing to operate. This is often called a "generator trip" and causes a contingency condition on the power system. A generator trip occurs very quickly (typically within a few cycles). Contingency reserves are held so that there is sufficient online generation that can replace the generator that tripped offline.

Generation to Load Distribution Factor (GLDF – see also Generation Shift Factor, Load Shift Factor, Total Distribution Factor, Transmission Loading Relief): A calculation of a specific generator's effects on a specific flowgate to determine Network and Native Load (NNL) obligations under a TLR Level 5 obligation. Generators with a 5% or greater GLDF are subject to NNL redispatch. GLDF is the difference between the Generation Shift Factor (GSF) and the Load Shift Factor (LSF) to determine the total effect of a generator serving a Balancing Authority on a specific transmission element (e.g., a transmission line) or flowgate. NNL MW = Scaled MW x GLDF x Percent Ownership. Where scaled MW = (Load / Available Assigned Generation) x Pmax. A generator with a GLDF of 10% on a specific flowgate means 10% of the generator's output flows on that flowgate.

Generation To Load Shift Factor: The algebraic sum of a Generator Shift Factor and a Load Shift Factor to determine the total impact of an Interchange Transaction on an identified transmission facility or Flowgate. (NERC)

Generator Capacity: The maximum output, commonly expressed in megawatts (MW), that generating equipment can supply to system load, adjusted for ambient conditions.

Generator Nameplate Capacity: The maximum rated output of a generator under specific conditions designated by the manufacturer. Generator nameplate capacity is usually indicated in units of kilovolt-amperes (kVA) and in kilowatts (kW) on a nameplate physically attached to the generator.

Generator Step-Up Transformer: The transformer that converts low voltage power from a generator to high voltage power, and connects the generator to the high voltage transmission system.

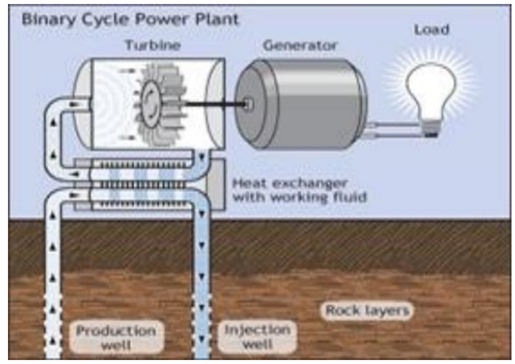
Geospatial Information System (GIS see also Global Positioning System) is data referenced to a specific location from a set of geographic coordinates. This information can be in real time. A GIS is a computer data system capable of capturing, storing, analyzing, and displaying geographically referenced information. Electric and natural gas utilities use GIS as part of their efforts to monitor distribution and transmission facilities. Increasingly, GIS can be used to track distributed energy resources (DERs). One example of the practical application of GIS is Argonne's EVS Division and Decision and Information Sciences Division are providing technical support to the ***Eastern Interconnection States' Planning Council*** (EISPC) for an *Energy Zones Mapping Tool*. The EISPC study includes nine types of energy resources to be considered for development of clean energy generation facilities in the U.S. portion of the Eastern Interconnection (see map below). These types are (1) biomass, (2) clean coal technologies with carbon capture and sequestration, (3) geothermal, (4) natural gas, (5) nuclear, (6) solar (photovoltaic and concentrated solar thermal, as well as rooftop photovoltaic solar), (7) storage (pumped-hydro storage and compressed-air energy storage), (8) water (hydroelectric power), and (9) wind (both land-based and offshore). For each of these major categories, the resource data and information have been compiled, reviewed, and assembled into a geographic information system (GIS) database. The information in the database is being made accessible in a web-based EISPC Energy Zones Mapping Tool that will allow stakeholders to identify potentially suitable areas for developing clean energy resources or to determine potential Clean Energy Zones. https://ezmt.anl.gov/

Geothermal Energy: Hot water or steam extracted from geothermal reservoirs in the earth's crust. Water or steam extracted from geothermal reservoirs can be used for geothermal heat pumps, water heating, or electricity generation.

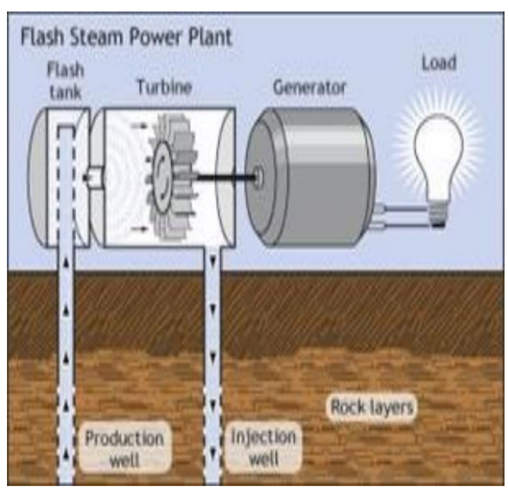
Geothermal Plant: A plant in which the prime mover is a steam turbine. The turbine is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rock

Geothermal Power Plants – Power plants can be designed to use steam produced from geothermal reservoirs to generate electricity. There are three geothermal power plant technologies being used to convert hydrothermal fluids to electricity—dry steam, flash steam and binary cycle. The type of conversion used (selected in development) depends on the state of the fluid (steam or water) and its temperature. Sufficient fluid must exist naturally or be pumped into the reservoir. The earth's temperature naturally increases with depth and varies based on geographic location. In order to access heat, the fluid must come into contact with the heated rock, either via natural fractures or through stimulating the rock. Conventional hydrothermal resources contain all three elements naturally. Increasingly, however, geothermal systems where subsurface fluid and permeability are lacking are being engineered or enhanced to access the earth's heat by adding fluid to these hot subsurface resources. Known as enhanced geothermal systems (EGS). The United States of America continues to generate the most geothermal electricity in the world: more than 3.5 gigawatts, predominantly from the western United States. Enough to power about three and half million homes. (source: DOE. Office of Energy Efficiency & Renewable Energy).

- **Binary:** Binary cycle geothermal power generation plants differ from Dry Steam and Flash Steam systems in that the water or steam from the geothermal reservoir never comes in contact with the turbine/generator units. Low to moderately heated (below 400°F) geothermal fluid and a secondary (hence, "binary") fluid with a much lower boiling point that water pass through a heat exchanger. Heat from the geothermal fluid causes the secondary fluid to flash to vapor, which then drives the turbines and subsequently, the generators. Binary cycle power plants are closed-loop systems, and virtually nothing (except water vapor) is emitted to the atmosphere. Because resources below 300°F represent the most common geothermal resource, a significant proportion of geothermal electricity in the future could come from binary-cycle plants.



- **Geothermal – Dry Steam:** Dry steam plants use hydrothermal fluids that are primarily steam. The steam travels directly to a turbine, which drives a generator that produces electricity. The steam eliminates the need to burn fossil fuels to run the turbine (also eliminating the need to transport and store fuels). These plants emit only excess steam and very minor amounts of gases. Dry steam power plants systems were the first type of geothermal power generation plants built (they were first used at Lardarello in Italy in 1904). Geysers in northern California, the world's largest single source of geothermal power.
- **Geothermal – Dual Flash:** Flash steam plants are the most common type of geothermal power generation plants in operation today. Fluid at temperatures greater than 360°F (182°C) is pumped under high pressure into a tank at the surface held at a much lower pressure, causing some of the fluid to rapidly vaporize, or "flash." The vapor then drives a turbine, which drives a generator. If any liquid remains in the tank, it can be flashed again in a second tank to extract even more energy.



Global Horizontal Irradiance (GHI): The total amount of shortwave radition recived by a surface horizontal to the ground.

Gigawatt (GW): A gigawatt is a unit of power that is equal to one billion watts or 1,000 megawatts. One gigawatt of electricity generated would power between 800,000 and one million homes.

Gigawatt-Electric (GWe): One billion watts of electric capacity.

Gigawatthour (GWh): A gigawatt-hour is a unit of measurement used to describe the amount of electricity produced or consumed. One gigawatthour equals one billion watthours or 1,000 megawatt hoursj.

Global Positioning System (GPS see also Geospatial Information System) The GPS is a U.S.-owned utility that provides users with positioning, navigation, and timing (PNT) services. This system consists of three segments: the space segment, the control segment, and the user segment. The U.S. Air Force develops, maintains, and operates the space and control segments. The United States is committed to maintaining the availability of at least 24 operational GPS satellites, 95% of the time. To ensure this commitment, the Air Force has been flying 31 operational GPS satellites for the past few years. GPS satellites fly in medium Earth orbit (MEO) at an altitude of approximately 20,200 km (12,550 miles). Each satellite circles the Earth twice a day. The satellites in the GPS constellation are arranged into six equally-spaced orbital planes surrounding the Earth. Each plane contains four "slots" occupied by baseline satellites. This 24-slot arrangement ensures users can view at least four satellites from virtually any point on the planet.

Global Warming: An increase in the near surface temperature of the Earth. Global warming has occurred in the distant past as the result of natural influences, but the term is today most often used to refer to the warming some scientists predict will occur as a result of increased anthropogenic emissions of greenhouse gases.

Global Warming Potential (GWP): An index used to compare the relative radiative forcing of different gases without directly calculating the changes in atmospheric concentrations. GWPs are calculated as the ratio of the radiative forcing that would result from the emission of one kilogram of a greenhouse gas to that from the emission of one kilogram of carbon dioxide over a fixed period of time, such as 100 years.

Good Utility Practice: Any of the practices, methods, and acts engaged in or approved by a significant portion of the electric utility industry during the relevant time period, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision is made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. Good Utility Practice is not intended to be limited to the optimum practice, method, or act to the exclusion of all others, but rather is intended to include practices, methods, or acts generally accepted in the region.

Governor: Turbine-generator units use turbine speed control systems, called governors, to control shaft speed by sensing turbine shaft speed deviations and initiating adjustments to the mechanical power input to the turbine.

Gradualism: Gradualism means smoothing economic efficiency's hard edges. Strict benefit-cost calculation does not sympathize with citizens' short-term situations. Sympathetic gradualism means moderating efficiency's short-term pain to preserve the public acceptability necessary to long-term gain. Scott Hempling, *The Effective Regulator* September 2007.

Greenfield Pipeline (Natural Gas): The construction of a new pipeline.

Greenfield Site (see also “Brownfield Site”): A section of land that has been set aside for industrial or commercial development, previously undeveloped.

Greenhouse Effect: The Green House Effect is the result of water vapor, carbon dioxide, and other atmospheric gases trapping radiant (infrared) energy, thereby keeping the earth's surface warmer than it would otherwise be. Greenhouse gases within the lower levels of the atmosphere trap this radiation, which would otherwise escape into space, and subsequent re-radiation of some of this energy back to the Earth maintains higher surface temperatures than would occur if the gases were absent.

Greenhouse Gases (GHG): Those gases, such as water vapor, carbon dioxide, nitrous oxide, methane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride that are transparent to solar (short-wave) radiation but opaque to long-wave (infrared) radiation, thus preventing long-wave radiant energy from leaving Earth's atmosphere. The net effect is a trapping of absorbed radiation and a tendency to warm the planet's surface.

Grid: The interconnected power lines and generators that supply, transmit and distribute electric power to the customers connected to it at various points.

Grid Enhancing Technologies (GET): Storage, power flow control, transmission switching, advanced line-rating technologies to improve transmission line utilization.

Grid Interative Efficient Building (GIEB): Lawrence Berkeley National Laboratory's characterization of GIEB is equipped with one or more DERs that make the building both grid-interactive and energy-efficient, such as energy-efficient heating, ventilating, and air-conditioning (HVAC) equipment, interactive electric water heaters, battery storage, or managed electric vehicle charging. These features enable buildings to provide load flexibility to the grid—primarily by shedding or shifting load in response to price or other signals. Demand flexibility, coupled with efficient building design and equipment, can provide persistent low energy use and minimize demand on electricity resources and grid infrastructure.

A grid-interactive efficient building also is connected and smart, meaning it is networked and supported by sensors and controls to enable operation, automation, and optimization by the building owner, utility, or other authorized entity. Individual buildings can be aggregated at a meaningful scale to provide flexibility as needed in State and Local Energy Efficiency Action Network. (2020). *Determining Utility System Value of Demand Flexibility from Grid-Interactive Efficient Buildings* Tom Eckman, Lisa Schwartz, and Greg Leventis,

Grid Modernization Plans (GMP): These are plans that should be part of a comprehensive integrated resource plan to incorporate technological innovations to improve safety and reliability as well as reduce costs to customers. Grid Modernization should also facilitate the integration of technologies such as customer-owned generation, Distributed Energy Resources (DERs), storage, smart grid, and demand-side management.

Grid Parity: This is the point of inflection or the cross-over-point where the actual or forecasted cost trajectories of two electric resource technologies are equivalent.

Grid Protection Scheme: Protection equipment for an electric power system, consisting of circuit breakers, certain equipment for measuring electrical quantities (e.g., current and voltage sensors) and devices called relays. Each relay is designed to protect the piece of equipment it has been assigned from damage. The basic philosophy in protection system design is that any equipment that is threatened with damage by a sustained fault is to be automatically taken out of service.

Grid Security Emergency: The occurrence or imminent danger of a malicious act using electronic communication or an electromagnetic pulse, or a geomagnetic storm event, that could disrupt the operation of those electronic devices or communications networks, including hardware, software, and data, that are essential to the reliability of critical electric infrastructure or of defense critical electric infrastructure; and disruption of the operation of such devices or networks, with significant adverse effects on the reliability of critical electric infrastructure or of defense critical electric infrastructure, as a result of such act or event; or a direct physical attack on critical electric infrastructure or on defense critical electric infrastructure; and significant adverse effects on the reliability of critical electric infrastructure or of defense critical electric infrastructure as a result of such physical attack. 16 USC 824 https://www.law.cornell.edu/uscode/text/16/824o%E2%80%931

Gross Cone: *Gross CONE* includes all fixed costs related to the construction and availability of a facility, including those related to capital, financing and fixed Operations, Maintenance, & Ancillary Services but typically not fuel delivery fixed costs. Gross CONE can vary by location.

Gross Domestic Product (GDP): The total value of goods and services produced by labor and property located in the United States. As long as the labor and property are located in the United States, the supplier (that is, the workers and, for property, the owners) may be either U.S. residents or residents of foreign countries. The formula for Gross Domestic Product is GDP = C + I + G + (X – M) or GDP = private consumption + gross investment + government investment + government spending + (exports – imports) [as a note, private consumption is typically in excess of 70%]. Nominal value changes due to shifts in quantity and price. In economics, real value is not influenced by changes in price, it is only impacted by changes in quantity. Real values measure the purchasing power net of any price changes over time. Real GDP accounts for inflation and deflation. It transforms the money-value measure, nominal GDP, into an index for quantity of total output.

Gross Domestic Product Implicit Price Deflator: (see also Implicit Price Deflator, Consumer Price Index or CPI, Producer Price Index or PPI, and the Gross Domestic Product or GDP) The GDP deflator is a measure of price inflation (the rate of change in the price level). A positive IPD shows the rate of inflation. A negative number occurs when there is "deflation." The IPD is calculated by dividing *nominal* (market value of goods and services produced in the economy unadjusted for inflation) GDP by GDP in another year (period) and then multiplying by 100. (Based on the formula). For example, the IPD was 109.729 for 2009 and 110.992 for 2010. Divide 110.992 by109.729 = 1.01151. Subtract the 1 to equal .01151. Convert this number to a percentage by multiplying by 100. The resulting real inflation rate between 2009 and 2010 is 1.151%. This calculation is used to express nominal (or current Gross Domestic Product) into a value in some base year's dollars. The implicit price deflator, published by the U.S. Department of Commerce, Bureau of Economic Analysis, is used to convert nominal figures to real figures.

Gross-Up (Accounting): In ratemaking, the concept that in order to get enough extra revenue to cover higher expenses these expenses must be increased by dividing these expenses by 1 minus the tax rate. **Gross Up Factor**: Used to calculate the pro forma adjustment to income taxes (and other costs that vary in direct proportion to changes in revenues) in determining the overall revenue requirement. Formula = 1 / (1 - Tax Rate). Example: 1 / (1 - 35%)= 1 / .65 = 1.53846

Grounded and Grounding: To complete an electric circuit, there are two wires. One is the "hot" wire and the second is the ground (or neutral) wire. This is referred to as "**grounded** neutral conductor." **Grounding**, in electrical engineering, uses the ground or earth to serve as a reasonably constant reference point in an electric circuit from which voltages are measured. Ideally, since the earth is huge and a good conductor, a ground would absorb an unlimited amount of current without changing its potential. Under normal conditions, the grounding wire does not carry electricity. However, in reality, stray voltages or earth potential rise effects will occur, which may create noise in signals or if large enough will produce an electric shock hazard. The bare wire on the side of a utility pole connects the aerial ground wire directly to the earth (ground). Grounding wires serve as an alternate path for the current to flow back to the source, rather than go through anyone touching a dangerous appliance or electrical box.

INDEX - H

Handy Whitman Index: This Index is commonly used by utilities, regulatory commissions, utility consultants, and insurance companies to estimate cost and valuation trends among different types of utilities, The index is used to calculate estimated reproduction cost at prices prevailing in different regions (e.g., North Atlantic, South Atlantic, North Central, South Central, Plateau, and Pacific) at certain dates, considering inflation, wage rates, cost of living, equipment costs, cost of materials and other relevant factors. The Index number is a percentage ratio between the cost of an item at a specific time and its cost at a base period [Index Number = (Cost at Stated Time / Cost at Base Period) X 100). For electric and natural gas utilities, groups are arranged by the Federal Energy Regulatory Commission's *Uniform System of Accounts*. In 1926, Ezra B. Whitman, a founder of the firm was also the chairman of the Maryland Public Service Commission. In 1934 when W.W. Handy passed away, his estate asked Whitman, Requardt and Associates to assume publication of the Index.

Harmonics: These are frequencies other than 60 Hz and are the result of the imbalances described above, propagated through the system

Harmonization: Coordination of Electric and Natural Gas industries' planning and operations. The differing physics of the natural gas and electric systems make coordination more challenging. That is, natural gas flows at less than 40 miles per hour while electricity flows as speeds approaching the speed of light. The electric industry's need for instantaneous supply of fuel to generate electricity is difficult to reconcile with the natural gas system. This is manifested in the differences between the "Electric Day" for committing and dispatching generation and the "Natural Gas Day" for procuring natural gas. The structures of the two industries and the regulation of the two industries are also very different which may exacerbate the operational and planning coordination.

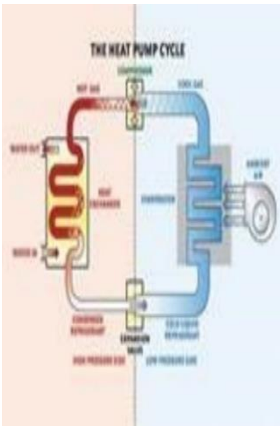
Headroom: The difference between the current operating point of a generator or transmission system and its maximum operating capability. The headroom available at a generator establishes the maximum amount of power that generator theoretically could deliver to oppose a decline in frequency. However, the droop setting for the turbine-governor and the highest set point for UFLS will determine what portion of the available headroom will be able to deliver to contribute to primary frequency control. LBL 2018

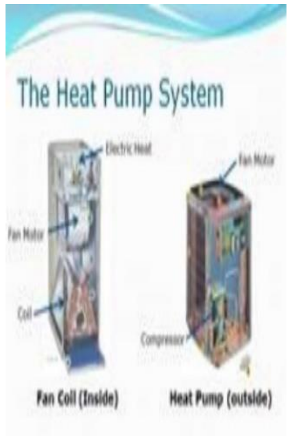
Heat Content: The amount of heat energy available to be released by the transformation or use of a specified physical unit of an energy form (e.g., a ton of coal, a barrel of oil, a kilowatthour of electricity, a cubic foot of natural gas, or a pound of steam). The amount of heat energy is commonly expressed in British thermal units (Btu). Note: Heat content of combustible energy forms can be expressed in terms of either gross heat content (higher or upper heating value) or net heat content (lower heating value), depending upon whether or not the available heat energy includes or excludes the energy used to vaporize water (contained in the original energy form or created during the combustion process). The Energy Information Administration typically uses gross heat content values.

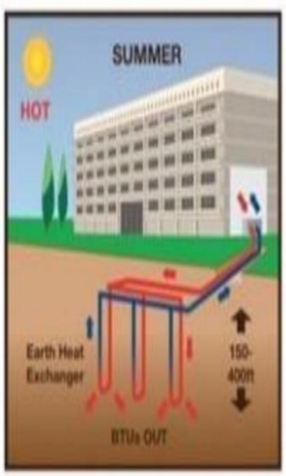
Heat Pump: Heating and/or cooling equipment that, during the heating season, draws heat into a building from outside and, during the cooling season, ejects heat from the building to the outside. Heat pumps are vapor-compression refrigeration systems whose indoor/outdoor coils are used reversibly as condensers or evaporators, depending on the need for heating or cooling.

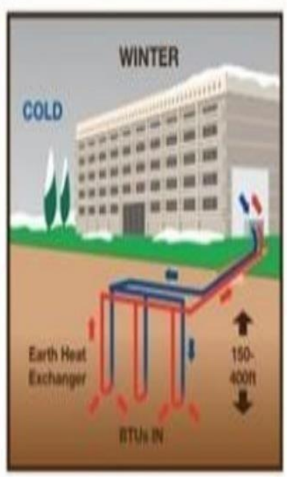
(Air Source) An air-source heat pump is the most common type of heat pump. The heat pump absorbs heat from the outside air and transfers the heat to the space to be heated in the heating mode. In the cooling mode the heat pump absorbs heat from the space to be cooled and rejects the heat to the outside air. In the heating mode when the outside air approaches 32o F or less, air-source heat pumps loose efficiency and generally require a back-up (resistance) heating system.

(Geothermal) A heat pump in which the refrigerant exchanges heat (in a heat exchanger) with a fluid circulating through an earth connection medium (ground or ground water). The fluid is contained in a variety of loop (pipe) configurations depending on the temperature of the ground and the ground area available. Loops may be installed horizontally or vertically in the ground or submersed in a body of water.

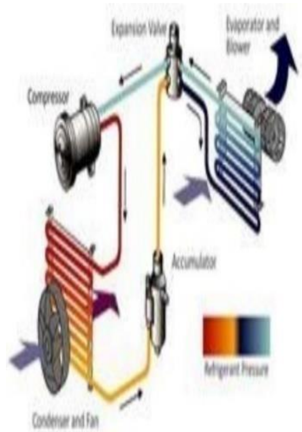


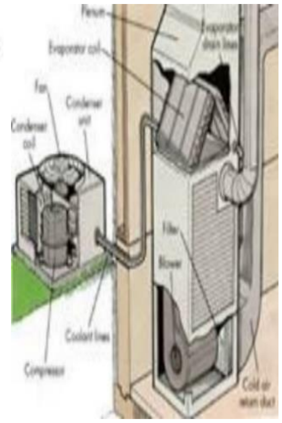




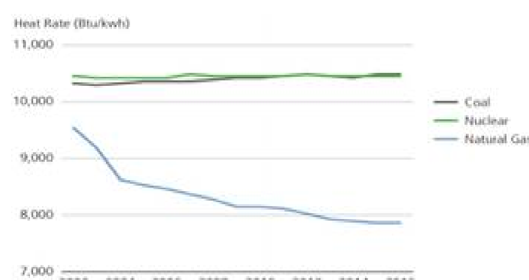


Heat Pump Efficiency: The efficiency of a heat pump, that is, the electrical energy to operate it, is directly related to temperatures between which it operates. Geothermal heat pumps are more efficient than conventional heat pumps or air conditioners that use the outdoor air since the ground or ground water a few feet below the earth's surface remains relatively constant throughout the year. It is more efficient in the winter to draw heat from the relatively warm ground than from the atmosphere where the air temperature is much colder, and in summer transfer waste heat to the relatively cool ground than to hotter air. Geothermal heat pumps are generally more expensive ($2,000-$5,000) to install than outside air heat pumps. However, depending on the location geothermal heat pumps can reduce energy consumption (operating cost) and correspondingly, emissions by more than 20 percent compared to high-efficiency outside air heat pumps. Geothermal heat pumps also use the waste heat from air-conditioning to provide free hot water heating in the summer.





Heat Rate: The heat rate is the amount of energy used by an electrical generator or power plant to generate one kilowatthour (kWh) of electricity so the lower the heat rate the greater the efficiency. According to the Energy Information Administration, in 2015, the average heat rate for a coal-fired power plant was 10,059 (according to a Feb/2015 article in Power Magazine: *Under ideal conditions, an ultra-supercritical turbine cycle system can convert steam into rotational energy at 54% or higher efficiency, supercritical turbine cycles can achieve 50% efficiency, and subcritical turbine cycles can achieve 46% efficiency. However, the turbine cycle system of your power plant is at least as complex as your boiler system, and there are numerous places for efficiency to be lost.* while an average natural gas combined cycle generating unit was 7,655 (newer designs are, purportedly, as low as 5,700). An average natural gas peaking unit had an average heat rate of 11,302. The average nuclear power plant, in 2015, was 10,458. Mathematically, efficiency is "a ratio of the useful energy output by the system to the energy input to the system. *Source: Form EIA-860m: Preliminary Monthly Electric Generator Inventory, Energy Information Administration, March 2017.*



A measure of generating station thermal efficiency commonly stated as Btu per kilowatthour. *Note:* Heat rates can be expressed as either gross or net heat rates, depending whether the electricity output is gross or net generation. Heat rates are typically expressed as net heat rates.

Heating Degree-Days (HDD): A measure of how cold a location is over a period of time relative to a base temperature, most commonly specified as 65 degrees Fahrenheit. The measure is computed for each day by subtracting the average of the day's high and low temperatures from the base temperature (65 degrees), with negative values set equal to zero. Each day's heating degree-days are summed to create a heating degree-day measure for a specified reference period. Heating degree-days are used in energy analysis as an indicator of space heating energy requirements or use.

Heating, Ventilating, and Air Conditioning (HVAC) for large buildings are more complex and varied in engineering. The air conditioning component includes cooling, heating, dehumidification, and humidification. Ventilation includes filtration of recirculated air and exhaust of undesirable air (e.g., toilets, kitchen, laboratories). The two primary types of cooling use either refrigerant (similar to a car AC, the refrigerant evaporates and condenses continuously within a cycle. Since refrigerant has a low boiling point, it makes it ideal for HVAC systems) or evaporative cooling. In addition to rooftop A/C systems, large buildings may employ gas fired chillers, centrifugal chillers, reciprocating chillers, screw chillers, scroll chillers, gas fired engine-driven rooftop ac.

Hedge: The initiation of a transaction in a physical or financial market to reduce risk.

Hedging: The buying and selling of futures contracts so as to protect energy traders from unexpected or adverse price fluctuations.

Hedging Contracts: Contracts which establish future prices and quantities of electricity independent of the short-term market. Derivatives may be used for this purpose.

Heliostat: A mirror that reflects solar rays onto a central receiver. A heliostat automatically adjusts its position to track daily or seasonal changes in the sun's position. The arrangement of heliostats around a central receiver is also called a solar collector field.

Henry Hub (Natural Gas): A pipeline hub on the Louisiana Gulf coast. It is the delivery point for the natural gas futures contract on the New York Mercantile Exchange (NYMEX).

Herfindahl-Hirschman Index (HHI – Used in Antitrust to assess competitiveness of markets): A commonly accepted measure of market concentration. It is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers. For example, for a market consisting of four firms with shares of thirty, thirty, twenty and twenty percent, the HHI is 2600 ($30^2 + 30^2 + 20^2 + 20^2 = 2600$). The HHI takes into account the relative size and distribution of the firms in a market and approaches zero when a market consists of a large number of firms of relatively equal size. The HHI increases both as the number of firms in the market decreases and as the disparity in size between those firms increases. Markets in which the HHI is between 1000 and 1800 points are considered to be moderately concentrated, and those in which the HHI is in excess of 1800 points are considered to be concentrated. Transactions that increase the HHI by more than 100 points in concentrated markets presumptively raise antitrust concerns under the Horizontal Merger Guidelines issued by the U.S. Department of Justice and the Federal Trade Commission. See *Merger Guidelines § 1.51.*

HHI is often used in analyzing the Market Power consequences of a merger. There is evidence, however, that HHI statistics may not provide reliable indications of market power in electricity markets. In part, this is because HHI only examines the Supply (e.g., generation) and not the load side of the equation. Given the dynamic nature of demand and supply in the electricity markets, the over-reliance on HHI is a matter of concern. For a more detailed explanation see Severin Borenstein, James B. Bushnell, and Christopher R. Knittel, “Market Power in Electricity Markets: Beyond Concentration Measures,” *Energy Journal* 20(4), 1999, pp. 65-88.

Heteroskedasticity (Statistics): A statistical term used to describe the behavior of a sample’s variance and standard deviation. If the heteroskedasticity is present, then the variance and standard deviation of the variable are not constant over the entire sample data. If these measures are constant, then the data is said to be *homoskedastic*. There are two varieties of heteroskedasticity: conditional and unconditional. If data is *conditionally heteroskedastic,* analysts cannot predict when data will be more scattered and when it will be less scattered (such as predicting the prices of stocks) and could cause problems making statistical inferences. Unconditional heteroskedasticity is predictable and typically does not cause problems with a regression. Variables that are cyclical by nature commonly exhibit heteroskedasticity.

Heuristic (this may range from rule of thumb, to educated guess, to expert judgement): any approach to problem solving, learning, or discovery that employs a practical method not guaranteed to be optimal or perfect, but sufficient for the immediate goals. Where finding an optimal solution is impossible or impractical, heuristic methods can be used to speed up the process of finding a satisfactory solution.

High Efficiency Ballast: A lighting conservation feature consisting of an energy-efficient version of a conventional electromagnetic ballast. The ballast is the transformer for fluorescent and high-intensity discharge (HID) lamps, which provides the necessary current, voltage, and wave-form conditions to operate the lamp. A high-efficiency ballast requires lower power input than a conventional ballast to operate HID and fluorescent lamps.

High Efficiency Lighting: Lighting provided by high-intensity discharge (HID) lamps and/or fluorescent lamps.

High Efficiency, Low Emissions (HELE): For coal-fired power plants this is a Department of Energy program Two types of advanced coal units would be eligible for loan guarantees under the bill. One is units larger than 300 megawatts (MW); the other is modular units smaller than 300 MW. Loan guarantees for modular units would complement efforts by the Department of Energy (DOE) to develop and demonstrate modular designs for coal units that increase efficiency, lower CO_2 emissions, minimize construction costs, and shorten project development time. To be eligible, both types of HELE units must be designed to achieve an efficiency of at least 40% and be capable of accommodating carbon capture and storage technology in the future.

High Temperature Superconducting (HTS): Cables and wires made of superconducting nitrogen, operated at relatively high temperatures of up to -320 degrees Fahrenheit, in comparison to superconducting materials that operate at near absolute zero, or -457 degrees Fahrenheit.

Mostly used for underground transmission line applications, more transmission line applications are using high-temperature superconducting methods. Although upgrades that use superconductors may be more costly, the method is most useful in areas were new Rights of Ways are not available and existing conduits must be used.

High Voltage Alternating Current (HV AC*)*: As used in transmission. High Voltage AC is typically used for the transmission of electrical energy. After the electricity is generated, the voltage is the *stepped up* in a transformer in a substation for transmission in the *bulk power*

system of one of the three wide area synchronous grids in the continental United States (the Eastern Interconnection, the Electric Reliability Council of Texas, and the Western Interconnection). This is typically three-phase alternating current (AC) ranging from 115 kV to 765 kV (typically 345 kV or 500 kV and above would be regarded as Extra High Voltage (EHV). The High-voltage overhead conductors produce lower *losses lower resistive losses over large distances)* and are not covered by insulation. Rather, ambient air cools the lines. The *conductor* material used in the construction of the lines is typically an aluminum alloy, made into several strands and possibly reinforced with steel strands to form a bundle. Copper was sometimes used for overhead transmission, but aluminum is lighter, yields only marginally reduced performance and costs much less. There are underground HVAC lines that are used to limit Rights of Way and public opposition, and reduce damage caused by bad weather. However, these are typically more expensive.

High Voltage Direct Current (HV DC): Comparing the costs of a thyristor-based HVDC system to an HVAC system, the investment costs for HVDC converter stations are higher than those for HVAC substations, but the costs of transmission lines and land acquisition are lower for HVDC. Furthermore, the operation and maintenance costs are lower in the HVDC case. Loss levels increase with distance on HVDC, but not as much as they do with HVAC. For long distance lines, HVAC has reactive power and voltage drop concerns while HVDC does not. DC converter station costs and system losses are a relatively high part of total cost, while transmission line costs are relatively low, compared to AC systems. Thus, at some transmission line length, costs are even. In estimating the breakeven distance, it is important to compare bipolar HVDC transmission to double-circuit HVAC transmission, especially when reliability is considered. Comparing the costs for an HVAC transmission system with those of a 2,000-MW HVDC system indicates that HVDC becomes cheaper at distances greater than about 435 mi. However, since system prices for both HVAC and HVDC have varied widely even for a given level of power transfer, market conditions at the time a project is built could override these numerical comparisons between the costs of an AC versus a DC system. While technological developments are pushing HVDC system costs downward, and environmental considerations have pushed HVAC costs upward, HVDC and HVAC systems could be considered as equal cost alternatives for the purposes of an early-stage evaluation of transmission system types (Rudervall et al. 2000).

High-Current Transients: Short spikes of high electrical current in a grid, caused by lightning strikes, or rapid switching of electrical devices in the grid, especially capacitors. These transients, or surges, cause cables to overheat, potentially damaging insulation and leading to short circuits. Equipment can be protected from high current transients by using a surge protector.

Higher Heating Value (HHV or Gross Calorific Value - see also Lower Heating Value): The higher heating value (also known gross calorific value or gross energy) of a fuel is defined as the amount of heat released by a specified quantity (initially at 25°C) once it is combusted and the products have returned to a temperature of 25°C, which takes into account the latent heat of vaporization of water in the combustion products. The *higher calorific value* (HCV) is determined by bringing all the products of combustion back to the original pre-combustion temperature, and in particular condensing any vapor produced. Such measurements often use a standard temperature of 15 °C (59 °F; 288 K). This is the same as the thermodynamic heat of combustion since the enthalpy change for the reaction assumes a common temperature of the compounds before and after combustion, in which case the water produced by combustion is condensed to a liquid, hence yielding its latent heat of vaporization. Mechanical systems such as gas-fired boilers used for space heat are suited for the purpose of capturing the HHV as the heat delivered is at temperatures below 150 °C (302 °F; 423 K) yet usable in space heating.

Hinshaw Pipeline: This is a local distribution pipeline or company served by interstate pipelines that **are not** subject to the Federal Energy Regulatory Commission's (FERC's) jurisdiction by reason of section 1(c) of the Natural Gas Act (NGA). That is, it is a regulated company engaged in transportation in interstate commerce, or the sale in interstate commerce for resale, of natural gas received by that company from another person *within a state.* A Hinshaw pipeline may receive a certificate authorizing it to transport natural gas out of the state in which it is located, without giving up its status as a Hinshaw pipeline.

Hope Case - Federal Power Commission v. Hope Natural Gas Co. (1944 – see also Munn v Illinois 1877, Smyth v Ames 1898, and Bluefield 1923): The Supreme Court recognized that regulatory commissions needed to weigh the interests of investors and consumers and should be accorded latitude in the methods used to determine a fair return. The specifics were similar to Bluefield v WVa PSC. In 1938, the Congress enacted the *Natural Gas Act*. Under the provisions of this Act, the FPC was empowered to review and determine the reasonableness of interstate rates. The controversy in *Hope* arose out of an FPC order compelling Hope Natural Gas Company to decrease its rates. Hope Natural Gas (a West Virginia company and a wholly owned subsidiary of Standard Oil Company of New Jersey) distributed gas to several locations in Ohio. In 1938, the FPC received complaints from two Ohio cities charging that the rates collected by Hope through its affiliate were excessive and unreasonable. Another complaint was received in 1939 from the Public Utility Commission of Pennsylvania. The cases were consolidated. The FPC ordered Hope to decrease its interstate rates to a level established by the Commission as "just and reasonable" based on a reasonable return to investors predicated on the "fair value" of the property. By inflating their estimates of the "fair value" of their property the company stood to gain. As a result, when the "fair value" increases so does the return to investors. Hope Natural Gas Company put on evidence of reproduction costs (the cost of reproducing the property at current costs) and "trended original costs" (to account for inflation), arguing that the Commission must consider those as well as the original cost of the property in computing fair value. The Commission refused to place any reliance on these prospective estimates in determining fair value, saying that these computations were "not predicated upon facts" and were "illusory" and "irrational." The FPC based its decision of fair value upon the "actual legitimate cost" of the company's property (i.e., original cost less depreciation) Accordingly, Hope's rates were adjusted downward by the Commission. Hope appealed. Ultimately, the Supreme Court held it is "*the result reached and not the method employed*" which is controlling in determining "just and reasonable" rates. The Court examined certain factors to be considered in arriving at just and reasonable rates. Among those considerations enumerated by the Court were the following: (1) rates should be sufficient to assure confidence in and financial security of the company's enterprise, (2) rates should be sufficient to allow the company to maintain its credit and attract capital, and (3) rates should be sufficient to provide the corporate equity holders with a reasonable return on their investment. General economic conditions were also deemed a legitimate consideration in determining where to set rates. The Court said fixing of just and reasonable rates unquestionably involved "a balancing of investor and consumer interests." The Court also addressed the need for courts to give due deference to the Commission because of its expert judgment.

Horizontal Drilling (Natural Gas): The practice of drilling a horizontal section in a well (used primarily in a shale gas or tight oil well), typically thousands of feet in length.

Horizontal Merger (see also mergers and vertical merger)**:** A merger of two electric (or merger of two natural gas) utilities would be an example of a horizontal merger. These two merging utilities, if they operate in the same geographic market, may constitute a form of *economic concentration* that could substantially diminish competition within *the relevant market*.

Horizontal Merger Guidelines (see also Clayton Act, Federal Trade Commission Act, Herfindahl-Hirschman Index Market Power, Mergers, Sherman Act): Horizontal Merger Guidelines issued by the U.S. Department of Justice (DOJ) and the Federal Trade Commission (FTC). These Guidelines describe how the DOJ and the FTC will determine if horizontal acquisitions and mergers are *likely substantially to lessen competition* pursuant to section 7 of the Clayton Act, section 1 of the Sherman Act, or to section 5 of the FTC Act. The Guidelines attempt to prevent mergers that increase *concentration* that creates or enhances market power (i.e., a seller has the ability to maintain prices above competitive levels for a significant period of time). Market concentration is a function of the number of firms in a market and their respective market shares. As an aid to the interpretation of market data, the Agency will use the Herfindahl-Hirschman Index ("HHI") of market concentration. The HHI is calculated by summing the squares of the individual market shares of all the participants. the HHI into three regions that can be broadly characterized as un-concentrated (HHI below 1000), moderately concentrated (HHI between 1000 and 1800), and highly concentrated (HHI above 1800). (https://www.justice.gov/atr/horizontal-merger-guidelines-0

Hosting Capacity: This is the amount of DER that can be accommodated without adversely affecting power quality and reliability under current conditions and without allowing: *thermal overloads, voltage or flicker* violations, mis-operation of protection equipment, or adverse safety / reliability, or power quality. That is, without requiring infrastructure upgrades to the current system. Hosting capacity is location dependent, feeder specific, time-varying which may or may not be coincident with T&D elements or with the system peak demand. Source: Grid Modernization Laboratory Consortium, U.S. Department of Energy

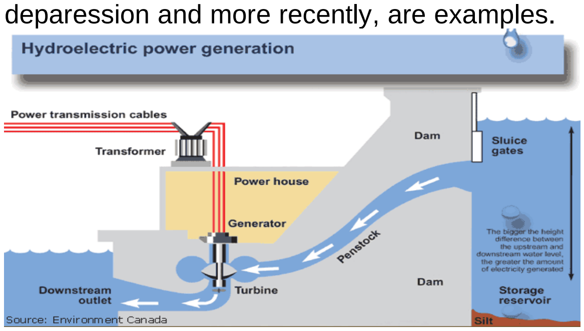
Hub (Electric and Gas): A virtual or physical location for pricing electricity or natural gas. A group of nodes, also called buses, within a predetermined region and at which individual Locational Marginal Prices (LMPs) are calculated, for which the individual LMP values are averaged to create a single pricing reference. See also **Henry Hub**.

Hundred Year Event (probability)**:** A hundred year flood, for example, is not intended to be used to predict the timing of the next major flood. Rather, the term is intended to reflect the probability that such an event will occur. A 100 year event, therefore, has a 1 in 100 chance of occurring every year. Similarly, a 500 year event is a 1 in 500 chance in any given year. Therefore, when designing a facility (e.g., a dam) to withstand a 100 year flood, the designer needs to consider the broader probability. Even though the probability of getting struck by lightning in a given year is 1 in 960,000 the probability of getting struck by lightning in a person's lifetime is 1 in 12,000. The great golfer Lee Trevino was hit by lightning twice (so you shouldn't stand under a tree or Mr. Trevino during a lightning storm).

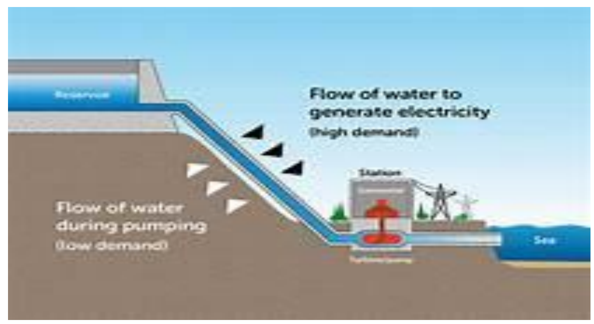
Hurdle Rates (see also Market Friction)**:** For planners and operators of electric utilities, this concept is often used to describe inefficiencies that unduly limit beneficial transactions that must be considered in resource planning and utility operations. Historically, *pancaked transmission rates* or discriminatory tariffs that unreasonably limited transactions have been regarded as hurdle rates. Hurdle rates have also been used to describe appropriate compensation for DSM. For financing in general, hurdle rates refer to the appropriate rate of return to compensate for the level of risk. Higher risks are associated with higher hurdle rates. In capital budgeting, projects are evaluated either by discounting future cash flows to the present by the hurdle rate, so as to ascertain the net present value of the project, or by computing the *internal rate of return* (IRR) on the project and comparing this to the hurdle rate. If the IRR exceeds the hurdle rate, the project would most likely proceed.

Hybrid Energy Systems (HES)**:** May include multiple electricity generation, energy storage, and/or energy conversion technologies that are combined to achieve enhanced capabilities, value, and/or cost savings compared to their standalone alternatives. Office of Energy Efficiency and Renewable Energy (EERE), the Office of Electricity (OE), the Office of Nuclear Energy (NE), the Office of Fossil Energy (FE), and ARPA-E, or the Advanced Research Projects Agency–Energy. 2020

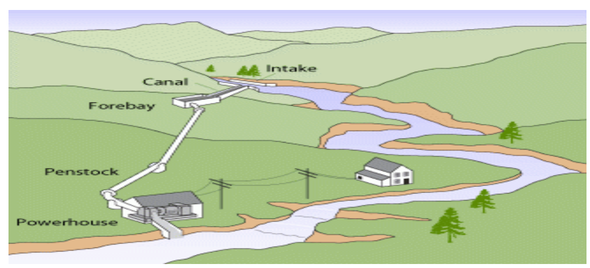
Hydro Power: Electricity generated by water falling across a water turbine. Federal hydro electic dams, many built during the era of great deparession and more recently, are examples.



Pumped hydroelectric dams are designed to provide electricity during peak periods and recharge (like a battery) by storing water during the off-peak periods.



Microhydropower System are run-of-the-river systems.



Hydrogen Fuel Cell Electric Vehicles (FCEV): In fuel cell technology, a process known as reverse electrolysis takes place, in which hydrogen reacts with oxygen in the fuel cell. The hydrogen comes from one or more tanks built into the FCEV, while the oxygen comes from the ambient air. The only results of this reaction are electrical energy, heat and water, which is emitted through the exhaust as water vapor. (BMW)

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Illinois Basin Coal: In April 2013 the United States Geological Service (USGS) assessed the coal resources within the Illinois Basin (bituminous coal with a high sulfur content compared to Appalachian or Powder River Basin coal) and other coal basins. The Illinois Basin is centered in and underlying most of the state of Illinois but extends 400 miles into southwestern Indiana and western Kentucky with production being about roughly equally divided between Illinois, Indiana, and western Kentucky. The basin provided 8% of US coal production in 2008. Over the years until about 2012, the Illinois Basin has produced more than eight billion tons of coal. In the 1970s, the Illinois Basin produced about 140 million tons per year, according to U.S. Energy Department data. Coal production declined in the 1990s but, in 2011, rose to about 116 million tons. Studies indicate that the calorific value of Illinois coals increases from about 11,000 Btu/lb to about 15,000 Btu/lb.

The Peabody Coal Company has a major presence in Indiana and is the largest U.S. coal producer traces its roots back to its first mine in 1895.

Imbalance: A condition where the generation and interchange schedules do not match demand. That is, energy imbalance on an electrical grid is the difference between the real time demand for electricity generation and actual consumption, and what is prearranged through schedules. Mathematically, Energy Imbalance = Actual Production – Scheduled Production.

Imbalance Energy: Power bought or sold by the electric system operator during an operating hour to keep the system supply in balance with demand.

Imbalance Markets (or Energy Imbalance Markets - EIM)**:** EIM is an ancillary service (one of the "services necessary to support the transmission of electric power from seller to purchaser given the obligations of control areas and transmitting utilities within those control areas to maintain reliable operations of the interconnected transmission system."- FERC definition) that provides real-time matching of loads and resources. EIM results in dispatch savings, reduced need for flexibility reserves, and reduced curtailment of renewable energy resources. Individual utilities offer this as part of their Open-Access Transmission Tariff (OATT) but there are significant advantages to operating a regional EIM (California ISO and many western states provide a recent example – October 2014).

Impedance: The opposition to power flow in an AC circuit. Also, any device that introduces such opposition in the form of resistance, reactance, or both. The impedance of a circuit or device is measured as the ratio of voltage to current, where a sinusoidal voltage and current of the same frequency are used for the measurement; it is measured in ohms.

Implicit Price Deflator: The implicit price deflator, published by the U.S. Department of Commerce, Bureau of Economic Analysis, is used to convert nominal figures to real figures.

Implicit Virtual Transactions: A strategy of trading one time period against another without the intent (or perhaps even the ability) to deliver or receive physical power is implemented outside of a transaction system that identifies virtual bids and ensures they will be closed, Virtual positions are included in the same simultaneous feasibility tests and price determination processes as real positions. Thus they can serve to reduce inefficiencies in the market.

Immature Unit: A unit having between zero and five full calendar years of operating experience for reliability calculations.

Implied Heat Rate: A calculation of the day-ahead electric price divided by the day-ahead natural gas price. Implied heat rate is also known as the 'break-even natural gas market heat rate,' because only a natural gas generator with an operating heat rate (measure of unit efficiency) below the implied heat rate value can make money by burning natural gas to generate power. Natural gas plants with a higher operating heat rate cannot make money at the prevailing electricity and natural gas prices.

Imports: The sum of all external transactions where PJM is the Point of Delivery. Capacity imports from external units must be certified as deliverable using firm transmission and non-recallable by any external party.

In Situ Leach Mining (ISL): The recovery, by chemical leaching, of the valuable components of a mineral deposit without physical extraction of the mineralized rock from the ground. Also referred to as "solution mining."

Inadvertent Energy: Each control area as operated by a utility including Regional Transmission Organizations (RTOs/ISOs) has a certain amount of inadvertent interchange, or unexpected energy pass-through, on any given day. Inadvertent energy balancing refers to the accounting and settlement procedures that control areas follow on a daily basis to account for these differences. When one control area is "owed" energy from another due to inadvertent interchange, the difference is usually repaid in energy, rarely in cash. Most transactions are purchased or sales of power through *arranged* or *schedule interchanges.* Inadvertent flows are often the difference Actual Net Interchange or Scheduled Net Interchanges. Inadvertent is inherently created because generation cannot physically follow the electrical demands of the system with absolute precision (e.g., does it include ramping).

Inadvertent Interchange: The difference between the Balancing Authority's Net Actual Interchange and Net Scheduled Interchange. (IA – IS). NERC. This is the difference between net actual energy flow and net scheduled energy flow into or out of a Balancing Area.

Incentive Ratemaking: A form of ratemaking that rewards utility shareholders for achieving goals set by the regulator. For example, bonus rates of return to build transmission or other resources.

Income Statement: The statement of revenues, expenses, gains, and losses for the period ending with net income for the period.

Increment Offers: An hourly offer, expressed in MWh, to sell energy into the Day-Ahead Energy Market if the Day-Ahead LMP is greater than or equal to the specified offer price. This offer must specify hourly quantity, offer price and location (Transmission Zone, Hub, Aggregate, Interface or single bus).

Incremental Auctions: Additional incremental auctions allow for capacity suppliers to purchase replacement capacity or to adjust previously committed capacity levels due to reliability requirement increases or decreases.

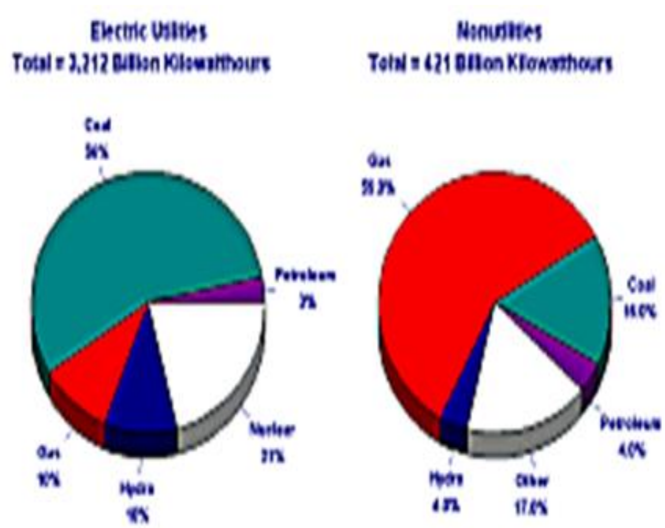
Incremental Auction Revenue Rights (IARR) Both PJM and MISO offer Incremental Auction Revenue Rights created by transmission upgrades that increase the transfer capability of transmission facilities. IARR are awarded for the lesser of the life of the upgrade or 30 years. These are part of the annual transmission rights auctions.

Incremental Capacity Transfer Rights: An allocation of the economic value of transmission import capability into a constrained locational deliverability area (LDA) to eligible transmission facility upgrades.

Incremental Cost (see also marginal cost): A term used in *economic dispatch*. The incremental energy cost is the additional cost per MWh to produce all successive amounts of output. It is calculated by summing the cost of each additional segment of energy in the unit's incremental cost curve up to the generation level. This cost is expressed in dollars per hour ($/MWh). Incremental costs for dispatching electricity tries to capture non-linear step changes or the "lumpiness" in adding new resources to the dispatch stack. Marginal cost is a continuous function. In a large regional market such as an RTO / ISO, because of the amount of and types of resources, the difference between marginal and incremental cost is likely to negligible.

Incremental (vs. rolled-in) Rates (Natural Gas): FERC rate-making policy requiring pipeline expansions to be priced at the higher of actual cost-based rates for the new service or current system rates.

Independent Power Producer: A corporation, person, agency, authority, or other legal entity or instrumentality that owns or operates facilities for the generation of electricity for use primarily by the public, and that is not an electric utility.



Independent Distribution System Operator (IDSO): This is a derivative concept from a DSO. Like a DSO, an IDSO may have similar functions as those off a wholesale market Independent System Operator and would not have a financial interest in the participants.

Independent System Operator (ISO) (see also RTOs – Regional Transmission Organizations): The FERC's Order No. 888 established eleven principles for qualifying for ISO status, including:

1. its governance be fair and nondiscriminatory,
2. the ISO and its employees have no financial interest in any market participant,
3. it provide open access to the transmission system at non-pancaked rates under a single tariff applicable to all users,
4. it has primary responsibility for ensuring short-term reliability of grid operations,
5. it has control over the operation of interconnected transmission facilities within its region,
6. it identifies and takes operational actions to relieve constraints on its system,
7. it has appropriate incentives for efficient management and administration and procures services in an open competitive market,
8. its transmission and ancillary service pricing policies promote efficient use of and investment in generation, transmission and consumption, (9) it makes transmission system information publicly available via an electronic information network such as OAISIS,
9. it develops mechanisms to coordinate with neighboring control areas, and
10. it establishes an Alternative Dispute Resolution process to resolve disputes.

Independent Variable (Statistics): The independent variable is typically the variable being manipulated or changed in contrast to the dependent variable that changes as a result of the independent variable being manipulated. In statistics and mathematics, it is a statement whose value, when specified, determines the value of another variable or other variables. In the equation $y = 3x + 6$, for example, x is the independent variable. Any particular value of x determines a value for y.

Index: A calculated number designed to represent the average price of electricity bought and sold at a specific location during a specified period of time. A published number used as a reference to determine a contractual sales price or use of inflation indicies such as the Consumer Price Index to calculate "real" prices. .

Indicative Analysis: An operational definition of *indicative,* as used in the context of complex DSM and IRP analysis, is analysis that is intended to foster robust risk analysis and serve as a guide but not, necessarily, as the plan. The concept recognizes inherent uncertainties and risks, especially since the DSM and IRP analysis occurs different time periods – perhaps years - resulting in different conclusions over time as more information is brought to bear. The intention is to recognize that professional judgment must be applied to integrating DSM analysis into IRPs which necessarily requires judgment. An indicative analysis is, then, intended to allow flexibility and discretion in establishing DSM programs that are generally consistent with a well-reasoned and credible IRP. In short, an indicative analysis should not be viewed as the *correct* answer to a planning question that would bind the utility to implementing the indicative analysis

Indirect Costs (see also Direct Costs)**:** Indirect Costs include materials and supplies needed for the company's day-to-day operations. These items cannot be assigned to a specific aspect of production. In contrast, direct costs are attributable to specific factors of production such as a generating unit for an electric utility.

Inductance: A property of electric circuits that consumes reactive power.

Inductive Compensation (or reactive power compensation): Since most loads are inductive and consume lagging reactive power, the compensation required is usually supplied by leading reactive power.

Inductive Load: End uses that require both real and reactive power such as motors and fluorescent lights.

Industrial Customer: Every utility will have different definitions for industrial customers but generally, It is a large end user that uses gas or electricity for manufacturing or production of a product. Sometimes defined by utilities simply by size (e.g., MW and MWh).

Inelastic Demand: Demand for a product can be said to be very inelastic if consumers will pay almost any price for the product, and very elastic if consumers will only pay a certain price, or a narrow range of prices, for the product. Inelastic demand means a producer can raise prices without much hurting demand for its product, and elastic demand means that consumers are sensitive to the price at which a product is sold and will not buy it if the price rises by what they consider too much.

Inertia – as Voltage Support (see also *Automatic Generation Control* - AGC, *Area Control Error* (ACE), Frequency, and Kinetic Energy)**:** Baseload coal and nuclear generators, like natural gas generators other rotating machines (motors and generators) including wind turbines provide needed inertia to support *frequency* throughout an entire electric interconnection. At the instant load changes, the system must change generation to match so power into the system must equal power out. Since it is not feasible to change the fuel output or steam input of the generators on a split second basis, the rotating kinetic energy of every machine in the entire interconnection serves to help balance the system. For example, when a light is turned on, the energy needed comes from kinetic energy and the machines slow down and frequency drops. For a single light switch the drop in frequency is imperceptible. However, a rolling mill at a steel plant may cause a perceptible change. The *Automatic Generation Control* (AGC) system, on most large generating units, almost instantaneously recognizes the *Area Control Error* (ACE), which is a combination of the frequency drop and the importation of power from the rest of the interconnection as energy is supplied by their machines, and adjusts the output setting of the generators to restore frequency and *tie-line flow*. Thus, every piece of rotating equipment supplies inertia, including wind turbines (but not solar panels). Of course, large steam-powered turbines have considerably more inertia than a wind turbine (unless there are a few hundred of them) and wind turbines generally do not have the automatic generation control aspect of being able to react to the area control error.

Inertial Response: This is the kinetic energy stored in the rotating mass of all of the synchronized turbine generators and motors on the interconnection. Produced by the slowing of the spinning inertial mass of rotating equipment on the interconnection that both releases the stored kinetic energy and arrests the decline of the interconnection frequency. This happens immediately following a disturbance.

Inferential Statistics (see also Descriptive Statistics): inferential statistics attempts to reach conclusions that extend beyond the data. That is, inferential statistical analysis infers properties about a population: this includes testing hypotheses and deriving estimates. For instance, inferential statistics tries to infer from the sample data information about the entire population. Most of the major inferential statistics come from a general family of statistical models known as the *General Linear Model*. This includes the t-test, Analysis of Variance (ANOVA), Analysis of Covariance (ANCOVA), regression analysis, and many of the multivariate methods like factor analysis, multidimensional scaling, cluster analysis, discriminant function analysis, and so on. Given the importance of the General Linear Model.

Inflation Adjusted: Sometimes referred to as "adjusted for inflation," or "real." The effects of inflation are removed to yield an equivalent *real* amount. This is done by dividing the *nominal* amount for each year by the *price index* for that year (e.g., the *Consumer Price Index* or the *Implicit Price Deflator* and multiply the amount times 100. The result establishes the value for a base year (i.e., To determine how the cost of an item in 2019 would compare to an item in 1990, the nominal 2019 nominal dollars are adjusted to 1990 real or inflation adjusted dollars).

Inflation Rate: The rate of change of an economy's price level as measured by the Consumer Price Index (CPI). To more accurately compare the rate of inflation on costs of goods and services over time, the concept of "real" is employed to adjust the "nominal" (observed rate) to adjust for inflation. This process requires the use of a "deflator."

Inflation Rate History: Average rounded annual percentage: For current inflation information: https://www.usinflationcalculator.com/inflation/historical-inflation-rates/

Year	%	Year	%	Year	%	Year	%
2017	2.3	2016	1.3	2015	0.12	2014	1.6
2013	1.5	2012	2.1	2011	3.2	2010	1.6
2009	-0.3	2008	3.9	2007	2.9	2006	3.2
2005	3.4	2004	2.7	2003	2.3	2002	1.6
2001	2.8	2000	3.4	1999	2.2	1998	1.6
1997	2.3	1996	2.9	1995	2.8	1994	2.6
1993	3.0	1992	3.0	1991	4.3	1990	5.4
1989	4.8	1988	4.1	1987	3.7	1986	1.9
1985	3.5	1984	4.3	1983	3.2	1982	6.2
1981	10.4	1980	13.6	1979	11.2	1978	7.6
1977	6.5	1976	5.8	1975	9.2	1974	11
1973	6.2	1972	3.3	1971	4.3	1970	5.8

U.S. Bureau of Labor Statistics

See also **Prime Interest Rate** for the same periods. In 1979 through 1985, for example, the Prime Interest Rate ranged between 9.5% to 21.5%. Consider also the 1974 and 1978 oil embargoes, recessions, the boom in power plant construction in the 1970s through the1980s, changes in environmental laws, financial crisis such as the Savings & Loan, Junk Bond, "Dot Com bubble," the "Sub-Prime Mortgage Scandal," fracking and the effects on fuel prices, and other events. See also recessions.

Inframarginal Cost: Inside of, as opposed to costs at, the margin. For a firm producing 100 units, the marginal cost is the cost of the 101st unit, while inframarginal cost refers, usually only qualitatively and without a precise definition, to the cost of units 1,...,100.

Inframarginal Revenues: The revenues earned by generators through the electric energy market that are in excess of the generators' short-run variable costs for fuel and other operating expenses, which assists in recovering fixed costs, the largest portion being capital costs.

Infra-Marginal Unit: A unit that is operating, with an accepted offer that is less than the *market clearing price*.

Infrared Thermography: A method used to measure the status of equipment by analyzing the amount of heat it radiates. For example, this is used by some utilities to detect hot spots in underground distribution systems.

Initial Synchronization Date: shall mean the date upon which the Generating Facility is initially synchronized and upon which Trial Operation begins.

In-Service Date: Is the date upon which the generator expects to provide power from the facility. For an interconnection customer, it is the date the interconnection customer can reasonably expect it will be ready to begin use of the Transmission Provider's Interconnection Facilities to obtain back feed power.

Installed Nameplate Capacity (ICAP): A MW value based on the summer net dependable capability of a unit and within the capacity interconnection right limits of the bus to which it is connected. See also Unforced Capacity or UCAP that includes outage rates that is used to reflect more dependable capacity. also see Generator nameplate capacity (installed).

Installed Reserve Margin (see also Reserve Margin and Resource Adequacy): Percentage value used to establish the level of installed capacity resources that provide an acceptable level of reliability.

Instantaneous Peak Demand: The maximum demand at the instant of greatest load.

Instantaneous Reserve Check: Instantaneous Reserve Check (IRC) is a PJM survey to obtain the actual current available reserve on the system. It is an activity performed and recorded daily at morning and evening shifts by dispatch in conjunction with generator owners.

Instantaneous Water Heater (see also Tankless Water Heaters): Also called a "tankless" or "point-of-use" water heater. The water is heated at the point of use as it is needed.

Institute of Electrical and Electronics Engineers (IEEE): Independent organization to develop a variety of standards including electric distribution system reliability indices such as CAIDI, SAIFI, and SAIDI.

Insulator (see also Conductor): A material that does not conduct electric current, such as plastic, some kinds of silicon or glass. The term can also refer to a material that does not conduct heat. For clarity, the terms thermal insulator and electrical insulator may be used.

Integrated Capacity Analysis (also referred to as Housing Capacity Analysis**):** This is used to establish a baseline of the maximum amount of Distributed Energy Resources (DER) an existing distribution system can accommodate safely and reliably without necessitating infrastructure upgrades to the system.

Integrated Demand: The summation of the continuously varying instantaneous demand averaged over a specified interval of time. The information is usually determined by examining a demand meter.

Integrated demand-side management (IDSM): As defined by Lawrence Berkeley National Laboratory, IDSM is a strategic approach to designing and delivering a portfolio of DSM programs by integrating various measures and technologies to improve their collective performance and / or penetration. IDSM includes Energy Efficiency (EE), Demand Response (DR), Distributed Generation (DG), Storage, Electric Vehicles (EV), and time-based rates.

Integrated Gasification - Combined Cycle Technology: Coal, water, and oxygen are fed to gasifier, which produces syngas. This medium-Btu gas is cleaned (particulates and sulfur compounds removed) and is fed to a gas turbine. The hot exhaust of the gas turbine and heat recovered from the gasification process are routed through a heat-recovery routed through a heat-recovery generator to produce steam, which drives a steam turbine to produce electricity.

Integrated Resource Planning (IRP): The engagement in a systematic, comprehensive, and open utility / stakeholder analysis of loads and resources to enable planners and stakeholders to achieve greater optimality in the planning of a robust portfolio of resources including transmission, all forms of generation, demand-side management (including energy efficiency) and distribution planning with the aspiration of providing the lowest delivered cost of electricity. The fundamental building blocks of IRP include load research, load forecasting and a systematic approach to considering all forms of resources needed to satisfy long-term (typically 15 – 30 years) requirements. Many states adopted some form of IRP Rules, often as part of *Certificate of Need* requirements, to lessen the potential for "boom and bust cycles" in the construction of resources that led to periods of excess resources followed by concerns that utilities would have insufficient resources. Increasingly, IRPs include generation, viable alternatives to traditional generating resources, transmission – sometimes as a substitute for generation, and the utility's distribution system plan. Ideally, IRPs would assess various risks in their ramifications. The risk analysis should be robust to include low, moderate, and high risk scenarios (even *Black Swan* events even if the system is not, ultimately, planned to meet such extreme events). While RTOs / ISOs do not formally engage in IRP, the RTOs / ISOs need to have detailed and credible information on the projected loads and resources within their region and information on adjoining regions in order to plan the transmission system and fulfill their reliability functions.

The system for greater optimality in the planning of a robust portfolio of resources including transmission, all forms of generation, demand-side management (including energy efficiency) with the aspiration of providing the lowest delivered cost of electricity. The fundamental building blocks of IRP include load research, load forecasting and a systematic approach to considering all forms of resources needed to satisfy long-term (typically 15 – 30 years) requirements. Many states adopted IRP Rules to lessen the potential for "boom and bust cycles" in the construction of resources that led to periods of excess resources followed by periods of insufficient resources.

Integration of Renewable Resources: With current resource technology, the amount of renewable resources that can be integrated reliability into system dispatch is limited:

Intensity: The amount of a quantity per unit floor space. This method adjusts either the amount of energy consumed or expenditures spent, for the effects of various building characteristics, such as size of the building, number of workers, or number of operating hours, to facilitate comparisons of energy across time, fuels, and buildings.

Intensity Per Hour: Total consumption of a particular fuel(s) divided by the total floor space of buildings that use the fuel(s) divided by total annual hours of operation.

Interchange: Electric power or energy that flows from one entity to another.

Interchange Authority (Electric): The responsible entity that authorizes implementation of valid and balanced Interchange Schedules between Balancing Authority Areas, and ensures communication of Interchange information for reliability assessment purposes. (NERC definition)

Interchange Energy: Kilowatthours delivered to or received by one electric utility or pooling system from another. Settlement may be payment, returned in kind at a later time, or accumulated as energy balances until the end of the stated period.

Interchange Schedule: An agreed-upon interchange transaction that specifies the amount in megawatts, the start and end times, the beginning and ending ramp times and rate, and the arrangements for delivery and receipt of power and energy between the Source and Sink Balancing Authorities involved in the transaction. (NERC)

Interchange Transaction (Electric): An agreement to transfer energy from a seller to a buyer that crosses one or more Balancing Authority Area boundaries. (NERC definition)

Interconnected System: A system consisting of two or more individual electric systems that operates synchroniously and have connecting tielines. In the continental United States, there are three grids. The eastern interconnection that includes Indiana. The Western Interconnection (west of Kansas), and the majority of Texas (Electric Reliability Council of Texas). These three grids are not synchronized to each other and, except for some DC lines, are not interconnected.

Interconnection: The facilities that connect two electric lines. The facilities where a generator connects to the electric grid.

Interconnection Facilities Study: FERC, in their Order No. 845, stated this is a study conducted by the Transmission Provider or a third party consultant for the Interconnection Customer to determine a list of facilities (including Transmission Provider's Interconnection Facilities and Network Upgrades as identified in the Interconnection System Impact Study), the 7 cost of those facilities, and the time required to interconnect the Generating Facility with the Transmission Provider's Transmission System. The scope of the study is defined in Section 8 of the Standard Large Generator Interconnection Procedures.

Interconnection Reliability Operating Limit (IROL): A System Operating Limit that, if violated, could lead to instability, uncontrolled separation, or cascading outages that adversely impact the reliability of the Bulk Electric System.

Interconnection Request: In Order 845 FERC said this shall mean an Interconnection Customer's request, in the form of Appendix 1 to the Standard Large Generator Interconnection Procedures, in accordance with the Tariff, to interconnect a new Generating Facility, or to increase the capacity of, or make a Material Modification to the operating characteristics of, an existing Generating Facility that is interconnected with the Transmission Provider's Transmission System.

Interconnection Service: Service provided by the Transmission Provider associated with interconnecting the Interconnection Customer's Generating Facility to the Transmission Provider's Transmission System and enabling it to receive electric energy and capacity from the Generating Facility at the Point of Interconnection, pursuant to the terms of the Standard Large Generator Interconnection Agreement and, if applicable, the Transmission Provider's Tariff.

Interconnection Standards: These are requirements for initial and on-going testing of the performance, reliability, safety, and maintenance of customer-owned and Distributed Energy Resources (DERs). RTOs / ISOs have requirements for interconnection of certain resources.

Interconnection Study: A type of study that includes the Interconnection Feasibility Study, the Interconnection System Impact Study, and the Interconnection Facilities Study described in the Standard Large Generator Interconnection Procedures.

Interconnection System Impact Study: As defined by the FERC, this means an engineering study that evaluates the impact of the proposed interconnection on the safety and reliability of Transmission Provider's Transmission System and, if applicable, an Affected System. The study shall identify and detail the system impacts that would result if the Generating Facility were interconnected without project modifications or system modifications, focusing on the Adverse System Impacts identified in the Interconnection Feasibility Study, or to study potential impacts, including but not limited to those identified in the Scoping Meeting as described in the Standard Large Generator Interconnection Procedures. Interconnection System Impact Study Agreement shall mean the form.

Inter Control Center Protocol: An industry standard protocol used to communicate real-time data between control centers. Control Centers use this to send and receive operations analog data measurements and digital measurements.

Interface: A group of more than one individual bus into a *proxy pricing node* (*pnode*) developed for transactions into or out of an RTO / ISO in the Energy Market.

Intermittent Resource: Sources of power, such as wind and solar, that cannot operate continuously. These often require “back-up” or supplemental power sources.

Internal Bilateral Transaction (IBT): A physical transfer of energy between two parties in which the path of the energy remains inside the RTO / ISO borders

Internal Control Center Protocol (ICCP): ICCP is an industry standard protocol used to communicate real Time data between Control Centers (e.g., operations data such as MWs, MVar, Voltages, and measurements as well as measurements of circuit breakers and other equipment).

Internal Load: Load that is directly connected to the utility’s transmission and distribution sytems that provides bundled generatin and transmission service. Internal load is a subset of connected load, which also includes directly connected load for which the utility serves only as a transmission provider.

Internal Rate of Return: The internal rate of return (IRR) is frequently used by corporations to compare and decide between capital projects, but it can also help you evaluate items in your own life, like lotteries and investments. The IRR is the interest rate (also known as the discount rate) that will bring a series of cash flows (positive and negative) to a net present value (NPV) of zero (or to the current value of cash invested). Using IRR to obtain net present value is known as the discounted cash flow method of financial analysis. For example, a corporation will evaluate an investment in a new plant versus an extension of an existing plant based on the IRR of each project. In such a case, each new capital project must produce an IRR that is higher than the company's cost of capital. Once this hurdle is surpassed, the project with the highest IRR would be the wiser investment, all other things being equal (including risk).

International Organization for Standardization (ISO) (This is not to be confused with Independent System Operator): The ISO is an independent, non-governmental international organization designed to develop voluntary standards that advance best practices and facilitate international comparisons among similar industries. For electric utilities, for instance, ISO has a variety of standards such as those for Asset Management.

Internet of Things (IoT): The inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to collect and exchange data over a network without requiring human-to-human or human-to-computer interaction. LBL 2018

Interruptible Customer (Natural Gas): A pipeline customer (i.e., shipper) who does not have a firm service contract, and whose service can be interrupted.

Interruptible Load or Interruptible Demand (Electric): Demand that the end-use customer makes available to its Load-Serving Entity via contract or agreement for curtailment. (NERC)

Interruptible or Curtailable Rate: A special electricity or natural gas arrangement under which, in return for lower rates, the customer must either reduce energy demand on short notice or allow the electric or natural gas utility to temporarily cut off the energy supply for the utility to maintain service for higher priority users. This interruption or reduction in demand typically occurs during periods of high demand for the energy (summer for electricity and winter for natural gas).

Interruptible Power: Power and usually the associated energy made available by one utility to another. This transaction is subject to curtailment or cessation of delivery by the supplier in accordance with a prior agreement with the other party or under specified conditions.

Interruptible Service (Natural Gas): A pipeline service contract that allows curtailment or cessation of service at the pipeline's discretion under certain circumstances specified in the service contract.

Interstate Commerce Clause and Act and preferences for in-state resources: - The United States Constitution (Article I, Section 8, Clause 3) states "*the United States Congress shall have power "To regulate Commerce…among the several States…*" The **Interstate Commerce Act of 1887** was designed to regulate the railroad industry, particularly its abusive monopolistic practices. In recent years, the Clause has been the basis for overturning state preference laws involving energy production based on the geographic point of origin of the fuel or energy. Examples of energy-related laws overturned under the Commerce Clause as *per se* invalid include: a New Hampshire law prohibiting hydroelectric plants from selling power out of state before offering it for sale in-state (*New Hampshire v. New England Power*, 455 U.S. 331 -1982) an Oklahoma law requiring in-state plants to burn a mixture of coal containing at least ten percent Oklahoma-mined coal *Oklahoma v. Wyoming*, 502 U.S. 437 (1992); an Illinois law encouraging use of in-state coal for purposes of compliance with the Clean Air Act *Alliance for Clean Coal v. Miller*, 50 F.3d 591 (7th Cir. 1995). Several states have enacted *Renewable Portfolio Standards* that give preference to in-state renewable resources. RPS statutes that express a preference for projects based on geographic location, either within a state or even within a region, are vulnerable to Commerce Clause challenges. To avoid invalidation of a facially discriminatory law, a state must demonstrate a compelling interest unattainable in any other manner. The compelling interest test poses a high bar, however. Even a state's interest in environmental health, diverse supply, safety and energy conservation may not save facially-discriminatory state RPS or renewable incentives laws. The Commerce Clause and Implications for State Renewable Portfolio Standard Programs Clean Energy States Alliance, State RPS Policy Report, by Carolyn Elefant and Edward A. Holt, March 2011.

Interstate Pipeline: A natural gas pipeline company that is engaged in the transportation, by pipeline, of natural gas across state boundaries and is subject to the Federal Energy Regulatory Commission under the Natural Gas Act.

Intertemporal Optimization: A class of optimization problems with an objective to find the optimal time-path of control (i.e., decision) variables subject to a set of constraints, where current decisions affect what decisions are available in the future and vice versa. [EPRI]

Intertie: An electric transmission interconnection permitting passage of current between two or more electric utility systems.

Inverse Elasticity (see also Price Elasticity, Ramsey Pricing, and Cross Price Elasticities)**:** As used in the context of pricing services by a regulated utility monopolist, inverse elasticity may be applicable where there are no significant *cross price elasticities.* The rule is based on the assumption that the demand for each good depends only on its own price (e.g., the demand for electricity does not depend on the price of natural gas). The result is that the rate at which the service is taxed should be inversely proportional to the absolute value of its elasticity of demand. That is, goods with low elasticities of demand (e.g., electric use during peak periods) should be taxed relatively highly and prices should be lower during when the elasticity of demand is higher (e.g., off-peak periods).

Inverted Yield Curve: An inverted yield curve is an interest rate environment in which long-term debt instruments have a lower yield than short-term debt instruments of the same credit quality. This type of yield curve is the rarest of the three main curve types and is considered to be a predictor of economic recession. The flattening curve in U.S. Treasury bonds, a closely monitored signal that a business cycle is ending, has ramped up market speculation that an economic downturn is on the horizon. A negative spread between the short and long-term yields makes banks less willing to lend and further slows down the economy. Longer-term yields in the U.S. (and other nations) have been flattened by the extensive *quantitative easing* programs of Fed and other central banks which created artificially high demand for longer-dated debt. Meanwhile, the Federal Reserve's raising of interest rates is further squeezing the U.S. yield spread by increasing shorter-term borrowing costs.

Inverter (or Power Inverter): An electronic device or circuitry that changes direct current (DC) to alternating current (AC) such as converting the power that comes from a car battery into alternating current. These are often used in conjunction with solar panels and electric vehicles but have wider applications. The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process. A typical power inverter device or circuit requires a relatively stable DC power source capable of supplying enough current for the intended power demands of the system. The input voltage depends on the design and purpose of the inverter. Examples include:

12 Volts direct current (VDC), for smaller consumer and commercial inverters that typically run from a rechargeable 12V lead acid battery.

24 and 48 VDC, which are common standards for home energy systems.

200 to 400 VDC, when power is from photovoltaic solar panels.

300 to 450 VDC, when power is from electric vehicle battery packs in vehicle-to-grid systems.

Hundreds of thousands of volts, where the inverter is part of a high voltage direct current power transmission system.

Larger Photo Voltaic systems require more electrical bussing, fusing and wiring, but the most complex component between the solar array and the customer's load is the inverter.

Inverted Based Resource Performance Task Force (NERC): To address the susceptibility of utility scale inverters tripping during transients generated by faults inf the bulk power system.

Inverter Clipping: A situation that occurs when panels are operating at a capacity that is greater than inverters design which results in converting more DC power to AC than their design suggests. This does not adversely affect the components but could limit production.

Investment Tax Credit (ITC): ITC is a dollar-for-dollar reduction in the income taxes. The ITC for solar, small scale wind, fuel cells, geothermal, micro-turbines, and Combined Heat & Power, and large wind are examples of ITC as a federal policy mechanism to support the deployment of renewable energy. The Consolidated Appropriations Act, signed in December 2015, included several amendments to this credit which apply to solar technologies and PTC-eligible technologies. Notably, the expiration date for these technologies was extended, with a gradual step down of the credits between 2019 and 2022. The ITC is a 30 percent tax credit for solar systems on residential (under Section 25D) and commercial (under Section 48) properties. The intent of the ITC through 2023 is to provide market certainty for companies to develop long-term investments and technological innovation, which in turn, lowers costs for consumers.

Investor-Owned Utility (IOU): A for-profit electric utility owned by stockholders that is regulated by the state and federal governments.

Ionization: The process by which an atom or a molecule acquires a negative or positive charge by gaining or losing electrons to form ions, Ionization can occur through radioactive decay by the internal conversion process, in which an excited nucleus transfers its energy to one of the inner-shell electrons causing it to be ejected.

Island (see also Automatic Islanding or Islanding): A portion of a power system or several power systems that is electrically separated from the interconnection due to the disconnection of transmission system elements.

Islanding: Operating a portion of the transmission or distribution grid while separated from the rest of the grid.

ISO New England — The system operator for multiple states in the U.S. Northeast.

Isochronous Capable: Facilities with the ability to operate independently to regualate voltage and frequency. This may be one of the objectives of a microgrid.

Isotopes: Atoms with the same number of protons, but differing numbers of neutrons and are different forms of the same element. In other words, they have different atomic weights. There are 275 isotopes of the 81 stable elements. There are over 800 radioactive isotopes, some of which are natural and some synthetic. Every element on the periodic table has multiple isotope forms. The most abundant form of hydrogen is protium, which has one proton and no neutrons.

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Joint and Common Costs: For regulated utilities, joint costs is a type of *common costs* that are often defined as the cost to operate joint-product processes including the disposal of waste where the costs cannot be attributed to a single department or user. It is essential to allocate the joint cost for the different joint products for determining individual product costs. Several methods are used to allocate joint cost. These methods are mainly classified onto engineering and non-engineering methods (e.g., market-based).

Joint Control: Automatic Generation Control of jointly owned units by two or more Balancing Authorities.(NERC)

Joint Coordinated System Planning (JCSP): A process established by the Midcontinent ISO, PJM, and the SPP (Southwest Power Pool) to study transmission issues among the three Regional Transmission Organizations (RTOs / ISOs).

Joint Owned Units: A generating unit owned by two or more utilities whose output is dispatched as a pool resource, with each owner receiving a share of output for billing purposes on the percentage of ownership.

Joint Probability (Statistical) (see also Conditional Probability and Bayes' Theorem): The probability of two (or more) independent events occurring together. In a two random variable example, it is expressed as P (X ∩ Y) which is the joint probability of X and Y occurring. For example, the probability that a card is a four and red = p (four and red) = 2/52=1/26. (There are two red fours in a deck of 52, the 4 of hearts and the 4 of diamonds).

In the study of probability, given two random variables X and Y, the **joint distribution** of X and Y defines the probability of events defined in terms of both X and Y. In the case of only two random variables, this is called a bivariate distribution, but the concept generalizes to any number random variables, giving a **multivariate distribution**. An example is drawing three cards and getting all jacks P(JJJ). We can use a tree diagram to figure out this type of probability. This type of probability depends on whether the experiment is done with or without replacement

Joule's Law: The rate of heat production by a steady current in any part of an electrical circuit that is proportional to the resistance and to the square of the current, or, the internal energy of an ideal gas depends only on its temperature. See Line Losses from transmission and distribution of electricity.

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Key Performance Indicators (KPI): These may be worker safety, reliability, service quality, financial, customer satisfaction, customer service, fuel procurement, asset management, regulatory, environmental, corporate citizenship and etc**.** In general, European performance metrics and targets are further ahead than U.S. regulations according to the Council of European Energy Regulators (2008) in their 4th Benchmarking Report on the Quality of Electricity Supply. However, there are cost trade-offs that need to be considered before suggesting that U.S. utilities should achieve comparable levels of reliability. Recently, European regulators have started to require that customers receive a minimum level of service — a requirement not typically found in the U.S.

It should also be recognized that areas with poor reliability can be hidden in system-wide indices. Minimum performance guarantees ensure that every customer receives the minimum as rules are specified in varying degrees of detail. Most countries in Europe include major events in their metrics, but major events tend to have much stricter definitions than in the U.S. For example, a snowstorm in Greece would be considered a major event, while a snowstorm in Sweden would not. In fact, the regulatory philosophy in Europe is that the system should be designed to handle normally expected conditions in its region — high winds, ice storms, snowstorms or high temperatures. Europe has been using outage indices for several years and has been ratcheting up requirements as its grid has improved. Some European regulations also include a component of continuous improvement in their regulations, meaning that the requirements are made stricter over time.

Kilovolt (kV): A unit of potential equal to a thousand volts where the Potential Unit is a measure of the potential energy of a unit charge at a given point in a circuit relative to a reference point (ground) and Volt (V) which is a unit of potential equal to the potential difference between two points on a conductor carrying a current of 1 ampere when the power dissipated between the two points is 1 watt; equivalent to the potential difference across a resistance of 1 ohm when 1 ampere of current flows through it.

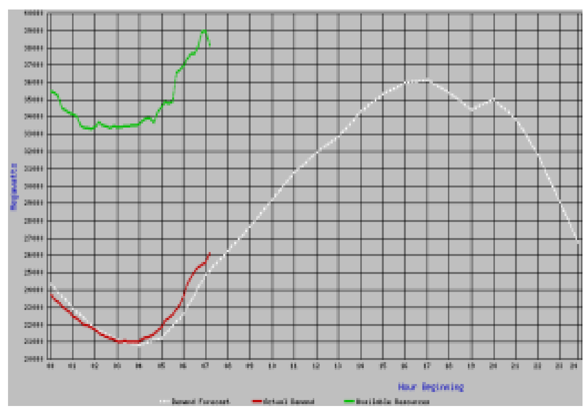
Kilovolt-Ampere (kVA): A unit of apparent power, equal to 1,000 volt-amperes; the mathematical product of the volts and amperes in an electrical circuit.

Kilowatt (kW): One thousand watts.

Kilowatt-Electric (kWe): One thousand watts of electric capacity.

Kilowatt hour (kWh): A measure of electricity defined as a unit of work or energy, measured as 1 kilowatt (1,000 watts) of power expended for 1 hour. One kWh is equivalent to 3,412 Btu.

The following chart depicts the difference between **energy** (kWh, MWh, or GWh) and **demand** (kW, MW, GW)**.** Energy is calculated as the integration of the area under the curve. The curve might be regarded as the resource supply curve. The Y axis Megawatts could be equated to prices at different points in time. At any instance, a demand curve could be drawn to form a traditional supply and demand curve. The intersection of the demand and supply curve would demonstrate the instantaneous cost.



Kinetic Energy (Translational – see also Potential Energy): Kinetic energy is the energy of motion. It is observable as the movement of an object, particle, or set of particles. Any object in motion is using kinetic energy including a charged particle in an electric field. Objects that are not in motion possess potential energy. The amount of kinetic energy depends upon two variables: the mass (m) of the object and the speed (v) of the object. The following equation is used to represent the kinetic energy (KE) of an object.

$$KE = 0.5 \cdot m \cdot v^2$$

Kirchhoff's Law: Electricity flows through a network over the path of least resistance. The second law is based on the conservation of energy around a closed circuit where the algebraic sum of all voltages is equal to zero (algebraic sum accounts for the polarities and signs of the sources and voltage drops around the loop) because no energy is lost in a closed conducting path.

Knife Switch: A type of switch used to control the flow of electricity in a circuit. It is composed of a hinge which allows a metal lever, or knife, to be lifted from or inserted into a slot or jaw. The hinge and jaw are both fixed to an insulated base, and the knife has an insulated handle to grip at one end. Current flows through the switch when the knife is pushed into the jaw. Knife switches can take several forms, including single throw, in which the "knife" engages with only a single slot, and double throw, in which the knife hinge is placed between two slots and can engage with either one. Also, multiple knives may be attached to a single handle and can be used to activate more than one circuit simultaneously.

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Lagging and Leading Power Factor: A **Lagging Power Factor** occurs when the current phase angle is smaller than the voltage phase angle, the current lags the voltage, and the power factor is lagging. A **Leading Power Factor** occurs when the current phase angle is larger than the voltage phase angle, the current leads the voltage, and the power factor is leading.

Lagrange Multiplier: This is a technique to find the maximum or minimum of a multivariable function *f*(*x*,*y*,…) when there is some constraint on the input values you are allowed to use. More specifically, Lagrange multipliers (named after Joseph-Louis Lagrange) is a strategy for finding the local maxima and minima of a function subject to equality constraints.

Lambda: A term commonly given to the incremental (marginal) cost that solves the economic dispatch calculation. It represents the cost of the next kilowatt hour that could be produced from dispatchable units on the system. Assuming no congestion or other constraints, there should be no differences between the hourly system lambdas (marginal cost) of interconnected utilities. In Regional Transmission Organization regions, the prices are set on 5 minute intervals so the use of hourly prices is not as relevant. Still used in non-RTO / ISO regions.

Landfill Gas: Gas that is generated by decomposition of organic material at landfill disposal sites. The average composition of landfill gas is approximately 50 percent methane and 50 percent carbon dioxide and water vapor by volume. The methane percentage, however, can vary from 40 to 60 percent, depending on several factors including waste composition (e.g. carbohydrate and cellulose content). The methane in landfill gas may be vented, flared, combusted to generate electricity or useful thermal energy on-site, or injected into a pipeline for combustion off-site.

Land-Use Restrictions: Constraints placed upon mining by societal policies to protect surface features or entities that could be affected by mining. Because laws and regulations may be modified or repealed, the restrictions, including industrial and environmental restrictions, are subject to change.

Large Generating Facility: According to the FERC, this shall mean a Generating Facility having a Generating Facility Capacity of more than 20 MW.

Large Generator Interconnection Agreement (LGIA): FERC issued a final rule (Order No. 845) in April 2018 revising its *pro forma* Large Generator Interconnection Procedures (LGIP) and the *pro forma* LGIA. These included 10 reforms to address reforms of generator interconnection procedures and agreements for generators of more than 20 megawatts. The reforms: 1) enable an interconnection customer to exercise its option to build, regardless of whether the transmission provider can meet the customers' proposed construction dates; 2) impose a revised dispute resolution requirement on all transmission providers; 3) require all transmission providers to publish a method for identifying contingent facilities; 4) require transmission providers to offer access to the study processes and assumptions used in the interconnection studies; 5) include electric storage resources in the definition; 6) require transmission providers to post interconnection study reporting requirements on a quarterly basis; 7) enable interconnection customers to request interconnection service at a level lower than their generating facility capacity; 8) require transmission providers to allow interconnection agreements for limited operation of a generating facility before completion of the full interconnection process; 9) require transmission providers to develop an expedited process for interconnection customers wanting to use or transfer surplus interconnection service; and 10) require transmission providers to establish a procedure to assess whether changes in an interconnection customer's proposed technology, during the interconnection process, would constitute a material modification. See also *Small Generator Interconnection Agreement* and *Voltage Ride Through*.

Latin Hypercube Sampling (LHS) (see also Monte Carlo (MC) Simulation): LHS was intended to provide greater efficiency than Monte Carlo Simulation without sacrificing accuracy by reducing the number of samples required compared to Monte Carlo simulation. Both MC and LHS are *unbiased estimation techniques.* That is, the computed statistics approach their theoretical values as the sample size increases. MC's inefficiencies can be offset by increasing the sample size. The Latin Hypercube Sampling is intended to make the sampling distribution approximate the *Probability Density Function (PDF).* Latin Hypercube sampling stratifies the input probability distributions. With this sampling type, tools such as @RISK or RISKOptimizer divides the *cumulative curve* into equal intervals on the *cumulative probability scale*, then takes a random value from each interval of the input distribution (The number of intervals equals the number of iterations). Thus there are no longer *pure random samples* and the Central Limit Theorem (CLT) no longer applies. Instead, this produces stratified random samples. The effect is that each sample (the data of each simulation) is constrained to match the input distribution very closely. Therefore, even for modest numbers of iterations, the Latin Hypercube method makes all or nearly all sample means fall within a small fraction of the standard error allowing for a faster *convergence rate* (sometimes referred to as *variance reduction*). This is usually desirable, particularly when just one simulation is performed. For multiple simulations, their means will be much closer together with Latin Hypercube than with Monte Carlo; this is how the Latin Hypercube method makes simulations converge faster than Monte Carlo. However, when there are multiple probabilistic inputs, the convergence rates for LHS start looking more like those in a Monte Carlo simulation. This happens because LHS shuffles each univariate sample so that the pairing of samples across inputs is random. With more variables, this randomness from shuffling becomes the dominant source of randomness. However, there is controversy about whether the improved convergence rate from LHS over MC is significant in real-life multivariate models Analysts may also consider *Median Latin Hypercube* (MLHS) which uses the median value of each equiprobable interval or *Random Latin Hypercube* (RLHS) which selects a random point within each interval.

Law of Conservation of Energy: The law of conservation energy, a basic law of physics, states: *In a closed system, i.e., a system that isolated from its surroundings, the total energy of the system is conserved.* This means that energy can neither be created nor destroyed; rather, it can only be transformed from one form to another. For instance, chemical energy is converted to kinetic energy when a stick of dynamite explodes. If one adds up all the forms of energy that were released in the explosion, such as the kinetic energy of the pieces, as well as heat and sound, one will get the exact decrease of chemical energy in the combustion of the dynamite. *Special Relativity* showed that mass could be converted to energy and vice versa by $E = mc^2$, and science now takes the view that mass–energy is conserved. A consequence of the law of conservation of energy is that a perpetual motion machine of the first kind cannot exist, that is to say, no system without an external energy supply can deliver an unlimited amount of energy to its surroundings.

Lead Cooled Fast Reactor (LFR): According to the World Nuclear Association, the LFR is a flexible fast neutron reactor which can use depleted uranium or thorium fuel matrices, and burn actinides from LWR fuel. Liquid metal (Pb or Pb-Bi eutectic) cooling is at atmospheric pressure by natural convection (at least for decay heat removal). Fuel is metal or nitride, with full actinide recycle from regional or central reprocessing plants. A wide range of unit sizes is envisaged, from factory-built "battery" with 15-20 year life for small grids or developing countries, to modular 300-400 MWe units and large single plants of 1400 MWe. Operating temperature of 550°C is readily achievable but 800°C is envisaged with advanced materials to provide lead corrosion resistance at high temperatures which would enable thermochemical hydrogen production. A two-stage development program leading to industrial deployment is envisaged: by 2025 for reactors operating with relatively low temperature and power density, and by 2040 for more advanced higher-temperature designs. This corresponds with Russia's BREST fast reactor technology which is lead-cooled and builds on 80 reactor-years' experience of lead or lead-bismuth cooling, mostly in submarine reactors. However, these propulsion reactors were small, operated at low capacity factors, featured an epithermal (not fast) neutron spectrum and operated at significantly lower temperatures than those anticipated in Gen-IV LFRs. More immediately the GIF proposal appeared to arise from two experimental designs: the US STAR and Japan's LSPR, these being lead and lead-bismuth cooled respectively.

Least Squares (Statistics): Is a method for fitting a specified model to observed data. For example, it is the most commonly used method of defining a straight line through a set of points on a scatter-plot. Least Squares finds the relationship that minimizes the sum of the squared values of the error (or *residual*) terms. *A **regression line*** is an example because it is a line drawn through the points on a scatter-plot to summarize the relationship between the variables being studied. When it slopes down (from top left to bottom right), this indicates a negative or inverse relationship between the variables (demand for a good decreases when the price of the good increases); when it slopes up (from bottom right to top left such as a business is more willing to produce a good if the price increases), a positive or direct relationship is indicated. The regression line often represents the ***regression equation*** such as the following:

$Y = a + bX + e$

Where:

Y is the dependent variable

a is the intercept

b is the slope or regression coefficient

X is the independent variable (or covariate)

e is the error term – (note the error term represents unexplained (or residual) variation after fitting a regression model. It is the difference - or left over - between the observed value of the variable and the value suggested by the regression model.)

A regression equation indicates the nature of the relationship between two (or more) variables. In particular, it indicates the extent to which you can predict some variables by knowing others, or the extent to which some are associated with others.

LED (Light Emitting Diodes): LEDs are semiconductor devices that produce visible light when an electrical current passed through them. LEDs are used in computers, digital clocks, remote controls, televisions, traffic lights and other applications. LEDs are a type of Solid State Lighting (SSL), as are organic light–emitting diodes (OLEDs) and light–emitting polymers (LEPs). LEDs are longer lasting (they typically don't burn out but the experience lumen depreciation) and use less energy than incandescent (heating a metal filament releasing as much of 90% of their energy as heat) and fluorescent light such as a "compact fluorescent light" – CFL that produces ultaviolet light as a result of current between passing between two electrodes that is turned into visible light when it comes into contact with the phosphor coating on the inside of tube or bulb. The core of every LED is a semiconductor chip made from nitride-based materials. The chip is traditionally positioned on top of the cathode lead. Applying several volts across this device makes the chip emit blue light. Passing the light through a yellow phosphor yields white light. Modern, high-power LEDs are variants of this architecture, featuring more complex packages for superior thermal management.

EDs are "directional" light sources. In contrast, incandescent and compact fluorescent bulbs emit light and heat in all directions. On the far left is a 80W "chip on the board" LED module from an industrial light.

Lerner Index (Economics and Antitrust): The Lerner Index, describes a firm's market power. It is defined by: where P is the market price set by the firm and MC is the firm's marginal cost.

$$L = \frac{P - MC}{P}$$

The index ranges from a high of 1 to a low of 0, with higher numbers implying greater market power. For a perfectly competitive firm (where P=MC), L=0; such a firm has no market power. The main problem with this measure, however, is that it is almost impossible to gather the necessary information on prices and particularly costs for each firms. The Lerner Index is equivalent to the inverse of the formula for elasticity of demand when the price, P, chosen is that which maximizes profits available because of the existence of market power. The measure of market power known now as the L erner Index was formalized by Abba Lerner in "The Concept of Monopoly and the Measurement of Market Power" published in 1934.

Levalized Avoided Cost of Electricity (LACE) (see also Levelized Cost of Electricity LOCE): Used In EIA's Annual Energy Outlook. Since projected utilization rates of existing resources and capacity values can vary dramatically across regions where new generation capacity may be needed, the direct comparison of LCOE across technologies is often problematic and can be misleading as a method to assess the economic competitiveness of various generation alternatives. Conceptually, a better assessment of economic competitiveness can be gained through consideration of avoided cost, a measure of what it would cost the grid to generate the electricity that is otherwise displaced by a new generation project, as well as its levelized cost. Avoided cost, which provides a proxy measure for the annual economic value of a candidate project, may be summed over its financial life and converted to a level annualized value that is divided by average annual output of the project to develop its "levelized" avoided cost of electricity (LACE).5 The LACE value may then be compared with the LCOE value for the candidate project to provide an indication of whether or not the project's value exceeds its cost. If multiple technologies are available to meet load, comparisons of each project's LACE to its LCOE may be used to determine which project provides the best net economic value. Estimating avoided costs is more complex than estimating levelized costs because it requires information about how the system would have operated without the option under evaluation. In this discussion, the calculation of avoided costs is based on the marginal value of energy and capacity that would result from adding a unit of a given technology to the system as it exists or is projected to exist at a specified future date and represents the potential value available to the project owner from the project's contribution to satisfying both energy and capacity requirements. Both the LACE and LCOE estimates are simplifications of modeled decisions, and may not fully capture all decision factors or match modeled results.

Levelized Cost: The present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments. Costs are levelized in real dollars (i.e., adjusted to remove the impact of inflation).

Levelized Cost of Energy (LCOE): The National Renewable Energy Laboratory defines LCOE as: The LCOE is the total cost of installing and operating a project expressed in dollars per kilowatt-hour of electricity generated by the system over its life. It accounts for:

1. Installation costs;
2. Financing costs;
3. Taxes;
4. Operation and maintenance costs;
5. Salvage value;
6. Incentives;
7. Revenue requirements (for utility financing options only); and
8. Quantity of electricity the system generates over its life.

Quantity of electricity the system generates over its life. The LCOE in SAM depends on the following assumptions:

1. The quantity of electricity generated by the system for each year in the analysis period, shown as Energy in the cash flow table. The performance model calculates the annual energy for Year one based on the hourly simulations. SAM adjusts this value by the factors that you specify on the Performance Adjustment page;
2. Installation and operating costs on the System Costs page;
3. Financial assumptions on the Financing page;
4. Incentives on the Incentives page; and
5. Depreciation assumptions on the Depreciation page.

To use the LCOE for evaluating project options, it must be comparable to cost per energy values for alternative options.

Levelized Revenue of Energy (LROE): Captures the revenue available per unit of energy. If sufficient cost data is not available, LROE may be used as a proxy for the Levelized Cost of Energy. Theoretically, in a perfectly competitive market, the LROE should approximate LCOE because the sum of project revenues from the LROE calculation needs to meet total project expenditures over the life time of the project (inclusive of the rate of return.

LIBOR or The London Inter-bank Offered Rate (more officially it is ICE LIBOR or Intercontinental Exchange Libor): Libor is the average of interest rates estimated by each of the leading banks in London that it would be charged if it were to borrow from other banks. more officially to ICE LIBOR (for Intercontinental Exchange Libor).

Life Extension: Restoration or refurbishment of a plant to its original performance without the installation of new combustion technologies. Life extension results in 10 to 20 years of plant life beyond the anticipated retirement date, but usually does not result in larger capacity.

LIFO or **Last in First Out** (see also FIFO or First in First Out): Like FIFO, LIFO is an inventory flow assumption where the cost of goods sold is the cost of the most recently acquired units and the ending inventory cost is determined from costs of the oldest units; contrast with FIFO.

Light Rail: An electric railway with a "light volume" traffic capacity compared to "heavy rail." Light rail may use exclusive or shared rights-of-way, high or low platform loading, and multi-car trains or single cars. Also known as "street car," "trolley car," and "tramway." In the 1920s through the 1940s, electric utilities often owned light rail. This provided an additional source of revenue and justified the extension of electric service in relatively sparsely populated areas.

Light Water: Ordinary water (H_2O), as distinguished from heavy water or deuterium oxide (D_2O).

Light Water Reactor (LWR): A nuclear reactor that uses water as the primary coolant and moderator, with slightly enriched uranium as fuel.

Lighting Demand-Side Management (DSM) Program: A DSM program designed to promote efficient lighting systems in new construction or existing facilities. Lighting DSM programs can include: certain types of high-efficiency fluorescent fixtures including T-8 lamp technology, solid state electronic ballasts, specular reflectors, compact fluorescent fixtures, LED and electro-luminescent Emergency Exist Signs, High Pressure Sodium with switchable ballasts, Compact Metal Halide, occupancy sensors, and daylighting controllers.

Lignite: The lowest rank of coal, often referred to as brown coal, used almost exclusively as fuel for steam-electric power generation. It is brownish-black and has a high inherent moisture content, sometimes as high as 45 percent The heat content of lignite ranges from 9 to 17 million Btu per ton on a moist, mineral-matter-free basis. The heat content of lignite consumed in the United States averages 13 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter).

Limited Demand Resources: Demand Resources which can be called on during weekdays (other than NERC holidays) from noon to 8 p.m. up to 10 times from June through September

Limiting Element: NERC definition - An electrical element that is either:

1. operating at its appropriate maximum rating, or
2. would operate at its maximum rating given a limiting contingency: a limiting element establishes a system limit.

Line Loss: Electric energy lost because of the transmission of electricity on the transmission or distribution systems, particularly over long distances. Much of the loss is thermal in nature because it results from the conversion of electricity to heat and electro-magnetic energy (the Joule effect). From 2011-2015, the Energy Information Administration estimated total T&D losses averaged about 5%. In simple terms, losses are calculated by subtracting out the utility's own use (including electricity consumed by generating stations) from total delivered electricity. A more technical calculation is P = (I ^ 2) R where P = Power, I = current and R = resistence of the conductor (wire). That is, line losses are directly proportional to the square of the current. Thus, the more current throught the conductor, the greater is the line or conductor loss. Losses are mitigated by using higher voltage lines: P = V* I.

Line of Credit (LOC)**:** A line of credit is an arrangement between a bank or other financial institution and a customer that establishes a maximum loan balance that the lender permits the borrower to access or maintain. The primary advantage to the customer is that a LOC is flexible. A borrower can access funds from the line of credit at any time, as long as he does not exceed the maximum amount set in the agreement and as long as he meets any other requirements set by the financial institution, such as making timely minimum payments.

Line Outage Distribution Factor: This is the percentage of power flow on other monitored elements if a contingent facility sustains an outage.

Line Pack (Natural Gas): Is the amount of natural gas in the pipeline and provides a method of storage. Natural gas occupying all pressurized sections of the pipeline network. Introduction of new gas at a receipt point "packs" or adds pressure to the line. Removal of gas at a delivery point lowers the pressure (unpacks the line). More specifically, the compressibility of natural gas allows the use of line pack to compensate for fluctuations of gas demand. Linear-programming models are increasingly used to simulate optimal flow rate of a gas in the pipeline(s).This is similar to Power (or load) Flow Models on the electric system. While the electric system physics are more complex than the natural gas system, natural gas system dynamics are difficult to model due to storage –including line pack - and the highly variable flow rates of the natural gas system.

Line Sensor: Typically sample voltage and / or current and provide various derived quantities, such as RMS volts and / or amps, real and reactive power, power factor, a small number of harmonics of voltage or current, and THD. Transducers may be electrical, magnetic, or optical. PNNL definition.

Line Temperature: Measures temperature distributions on power lines. This is typically done with fiber optics. PNNL definition.

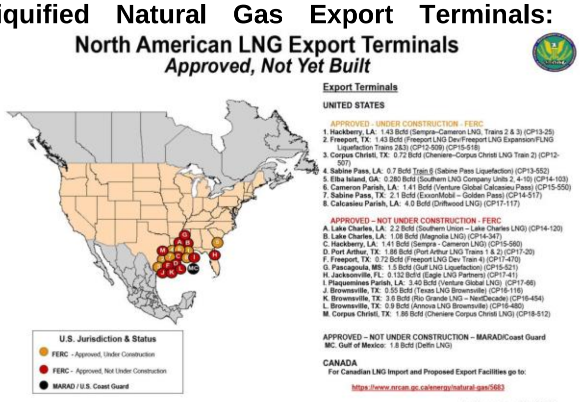
Line Thermal Monitoring (LTM): A process that measures average power-line temperature and detects temperature changes in power lines. Monitoring heat on the power lines is important since heat causes wires to expand and sag, resulting in short circuits, fires and blackouts if they contact treetops etc.

Line Trip: Refers to the automatic opening of the conducting path provided by a transmission line by the circuit breakers. These openings or “trips” are to protect the transmission line during faulted conditions.

Linear Variable Differential Transformer (LVDT also called linear variable displacement transformer, linear variable displacement transducer, or simply differential transformer) is a type of electrical transformer used for measuring linear displacement (position). A counterpart to this device that is used for measuring rotary displacement is called a rotary variable differential transformer (RVDT).

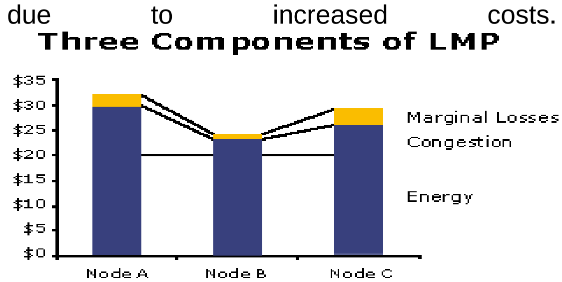
Liquefied Natural Gas (LNG): The process of liquefaction to produce LNG requires reducing the temperature of natural gas to minus 260 degrees F for the purpose of storing the gas.

Liquified Natural Gas Export Terminals:



Liquidity: Liquidity describes the degree to which an asset or security can be quickly bought or sold in the market without affecting the asset's price. Market liquidity refers to the extent to which a market, such as a stock market or real estate market, allows assets to be bought and sold at stable prices. Cash is the most liquid asset, while real estate, fine art and collectibles are all relatively illiquid. Accounting liquidity measures the ease with which an individual or company can meet their financial obligations with the liquid assets available to them. There are several ratios that express accounting liquidity.

LMP Pricing Paradox (See LMP Pricing, Extended LMP, Convex Hull Pricing): There are situations where LMP prices do not increase (or may decrease) and result in inefficient outcomes. This lead RTOs to adopt *extended LMP.* Despite ELMP, there were still costs that were not reflected such as fast starting gas turbines or emergency demand response were not allowed to set the LMP. Another example was the commitment of generating units that are block loaded. To the extent some costs were not reflected in LMP or ELMP, *uplift charges or make whole payments* were required (sometimes very high). To avoid the paradox and to better ensure that the real-time prices capture relevant resource commitment costs not captured by LMP or extended LMP some form of Convex Hull Pricking may be necessary IF fast-start units are not allowed to set the price. Concern has been expressed that Convex-Hull pricing is computationally complex but it also may not encourage fast start resources. Rather, Convex-Hull pricing may also have the effect of inappropriately increasing payments to baseload coal and nuclear units that are not capable of starting and ramping quickly. To the extent that Convex-Hull may provide incentives for relatively inflexible resources that are increasingly not dispatched due to being *out of the money,* the increased benefits to generators *may be* regarded as *subsidies* that diminish *consumer welfare* (consumer surplus) due to increased costs.



Load: Any consumer of electrical energy; also, the amount of power (demand) used by a utility system, electrical device or consumer. Load can be manually or automatically curtailed or shed temporarily during times of high usage (customers have agreed beforehand to such actions) or managed to ensure a reliable electricity supply.

Load Balancing (Natural Gas): Maintaining system integrity through measures which equalize pipeline (shipper) with delivery volumes during periods of high system usage. Withdrawal and injection operations into underground storage facilities are often used to balance load on a short term basis.

Load Bias (a.k.a. Imbalance Conformance)**:** This term is used in the California ISO to describe the last-minute adjustments an operator makes to the load forecast ahead of a market run to account for potential inaccuracies and inconsistencies in the forecast (including load management, variations in schedule interchange, reliability events, etc.

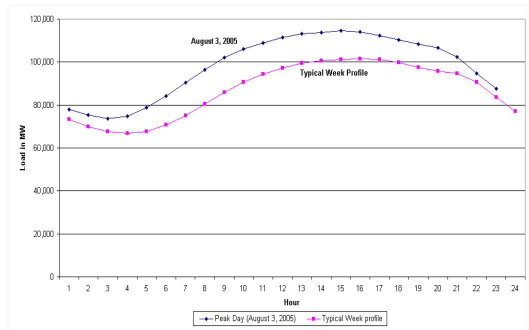
Load Carrying Capability (LCC): Used to express in megawatts, the amount of load that a given resource or resources can serve at a predetermined adequacy standard (typically one day in ten years).

Load Centers: Typically, utilities primarily design their power delivery systems to meet the electrical needs of cities and larger towns that may be regarded as load centers. Because of the amount of power required by load centers, as well as a broad range of appliances and end-uses (inductive motors in particular), utilities devote considerable effort to ensure that adequate resources, voltage, frequency, and power quality (e.g., voltage regulation, limited deviations from system frequency, voltage sags, transient over-voltages, flicker, high frequency noise, phase imbalance, and poor power factor) are maintained. The majority of the load in a typical AC power system is inductive (i.e., the current lags behind the voltage). Since the voltage and current are out-of-phase, this leads to an "imaginary" form of power known as *reactive power* which, unlike *real power,* does no measurable work. *Capacitors*, placed near inductive loads increase the *power factor* and *Static VAR Compensators* and *Static Synchronous Compensators* may be used for voltage support.

Load Curtailment: Complete or partial reduction in consumer electricity consumption. This can be done for reliability or economic reasons.

Load Curve (a/k/a Load Shape): The relationship of power supplied to the time of occurrence. Illustrates the varying magnitude of the load during the period covered. See chart below.

Typical Week Profile

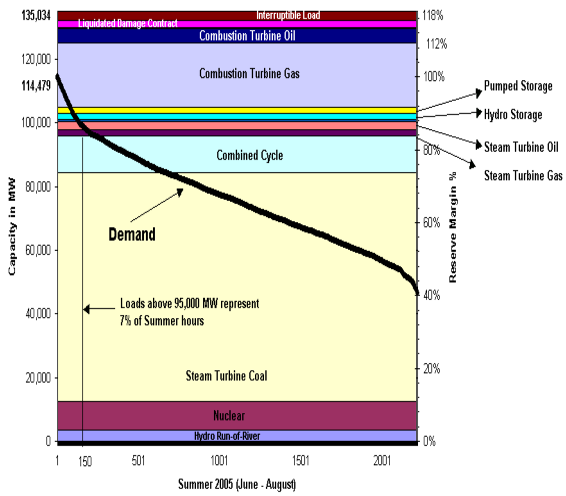


Load Damping (see also load sensitivity): Frequency sensitive loads such as motors have ramifications for *system frequency response* (SFR). The interactions, including oscillations, between dynamic loads and power systems is exemplified by the increasing wind power penetration necessitates frequency regulation to better assure system stability and reliability. Electromagnetic oscillations occur in interconnected power systems because of synchronous generators swinging against each other.

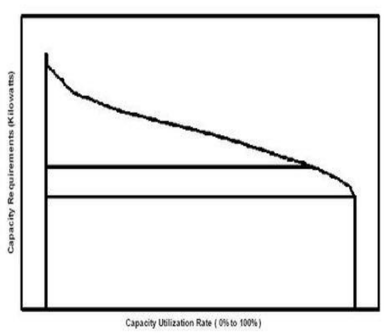
Load Diversity (see also fuel diversity, resource diversity, weather diversity): The difference between the peak of coincident and non-coincident demands of two or more individual loads. From a system planning perspective, diversity is the difference between the individual peak demand of a customer or customer class to the system peak demand of a utility. For members of Regional Transmission Organizations / Independent System Operators, the contribution of each of its load serving members to the RTO's / ISO's maximum system demand (the relevant peak demand for real-time pricing and regional planning) is measure of diversity. Also from a system planning perspective, as with resource and fuel diversity, greater load diversity is regarded as beneficial to the reliable, economically efficient operation, and planning of an individual utility or an RTO / ISO system. In an RTO / ISO system, customers in one region may not peak at the same time as customers in another region. Because of their greater geographic scope, there is much greater weather diversity than for individual utilities. For example, heavily summer peaking utilities are able to import power from predominately winter peaking utilities to meet their summer demand. Correspondingly, during the winter, a winter peaking utility may be able to import power from a predominately summer peaking utility.

Load Duration Curve (LDC): A graphical summary of demand levels with corresponding time durations using a curve, which plots demand magnitude (power) on one axis and percent of time that the magnitude occurs on the other axis. Note how this relates to economic dispatching.

Load Duration Curve with Resource Types



A simplified illustration of a load curve



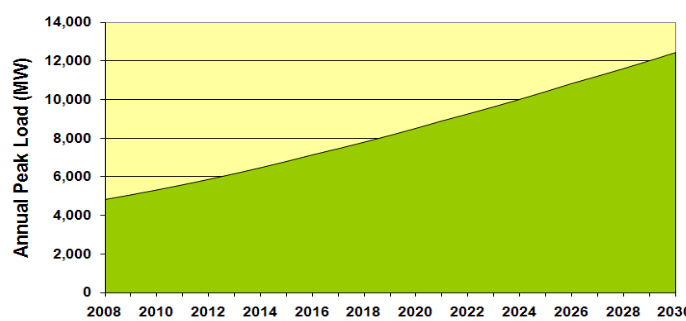
Load Factor (LF): The ratio, expressed as a percentage, of the average load in kilowatts supplied during a designated period to the peak or maximum load in kilowatts occurring in that period. Load factor also may be derived by dividing the kilowatt-hours' in the period by the product of the maximum demand in kilowatts and the number of hours in the period. A 100% Load Factor means constant rate of use.

Load Flow: (see Power Flow for a more accurate characterization and a definition since it is the power – not the load – that flows.)

Load Following: Regulation of the power output of electric generators within a prescribed area in response to changes in system frequency, tie line loading, or the relation of these to each other, so as to maintain the scheduled system frequency and/or established interchange with other areas within predetermined limits.

Load Forecasting: This is the analytical process of estimating customer demand for electricity over a specified period of time (e.g., 1 day – 30 years) and as a basis for determining the resource requirements to satisfy customer requirements in a reliable and economic manner. Typically a utility will want to forecast maximum demand in the amount of Watts usually Megawatts (MW) or Gigawatts (GW) and energy use in Megawatt hours (MWh) or Gigawatt (GWh) hours. Forecasts that are well developed provide a higher degree of believability (confidence) and can, therefore, reduce the financial risks associated with planning resources over the forecast horizon.

Load Forecast



Consequences of Over and Under Forecasting by Application		
Application	**Over Forecasting**	**Under Forecasting**
Financial Forecasting	• Over estimating spending to upgrade infrastructure • Increasing rates more than they should be to maximize the profit • Hiring more people than necessary	• Under estimating spending on upgrading infrastructure • Decreasing more rates than it should be to maximize the profit • Hiring fewer people than necessary
Generation Planning	• Investing in more generators or higher capacity of the new generators • Better reliability but with a higher cost	• Investing less generators or lower capacity of the new generators • Worse reliability but with a lower cost
Transmission Planning	• Investing in more transmission lines or higher capacity of the new lines • Better reliability with higher cost • Less congestion but at a higher cost	• Investing less transmission lines or lower capacity of the new lines • Worse reliability with lower cost. • More congestion in the area which is highly under forecasting

Distribution Planning	• Investing in more distribution substations or higher capacity • Building more distribution lines • Better reliability with higher cost	• Investing in fewer distribution substations or at lower capacities • Building less distribution lines • Worse reliability with lower cost
Cost-of-Service Allocation	• Higher revenue requirement and higher rates due to the expectation of greater electric sales.	• Lower revenue requirement an lower rates due to expectation of lower electric sales.
Demand Response (DR)	• More load to be shifted and less monetary reward for households and commercial consumers participating in grid management under the assumption of over forecasting	• Less load to be shifted and less monetary reward for households and commercial consumers participating in grid management under the assumption of under forecasting
Energy Efficiency (EE)	• Installing more EE than is needed which is likely not to be cost-effective.	• Installing less EE than is cost-effective

Load Forecasting Bias: A forecast bias occurs when there are consistent differences between the actual observations and the forecasts of those quantities. A typical measure of bias of forecasting procedure is the arithmetic mean or expected value of the forecast errors. A forecast bias may result in either over or under-forecasting if actual observations are consistently different. The "NERC Fan" described in the Glossary is an example of over forecasting that, at least in some cases, are likely to have been the result of an over-forecasting bias. A potential example of under-forecasting bias may be undue weighting of the negative effects of an economic downturn longer than is likely. The bias is presumed to be unintentional but it could be intentional. If intentional it may be fraudulent if they are developed to achieve a specific result that is the personal agenda of someone. This may include the use of non-scientific forecasting processes.

Load Forecast Uncertainty (LFU)**:** LFU models the forecast peak load differently from the actual load to provide uncertainty bands around load shapes. Weather, economic variability and forecast modeling errors are key components in establishing these acceptable bands around the 50/50 load shape projections. Each Assessment Area's narrative should address how the load shape is expected to change prospectively. (NERC). Load forecast uncertainty is an important factor in long-range system planning and has been shown to have a significant impact on the calculated reliability indices in generating capacity studies. In general, a higher capacity reserve is required to satisfy a future uncertainty load than to serve a known load, at a specified level of reliability. Load forecast considerations are also important in composite generation and transmission system reliability studies, and their associated probability distributions.

Load Loss: (3 Hours) Any significant incident on an electric utility system that results in a continuous outage of 3 hours or longer to more than 50,000 customers or more than one half of the total customers being served immediately prior to the incident, whichever is less.

Load Management: A resource with a capacity commitment to reduce load when dispatched by the RTO/ ISO or utility. A demand response resource (DR) may be an existing or planned resource. A subset of Disributed Energy Resources (DERs).

Load Management Subzone: A collection of zip codes within a transmission zone where any one location on the demand response registration is located within a zip code. Those within these locations should respond to the PJM dispatch signal, unless otherwise notified by PJM. Registrations based on residential and small commercial direct load control programs not having operational capability to respond to a transmission subzone dispatch signal. These do not need to respond to a transmission subzone dispatch signal, unless instructed by PJM requesting all direct load control related registrations. (PJM definition)

Load Management Technique: Utility demand management practices directed at reducing the maximum kilowatt demand on an electric system and/or modifying the coincident peak demand of one or more classes of service to better meet the utility system capability for a given hour, day, week, season, or year.

Load Modifier: A Disributed Energy Resource (DER) that is not modelled as a separate resource but is simply treated as a device that affects a customer's load curve.

Load Modifying Resource (LMR): LMRs serve an important function in the provision of capacity services by reducing load, thereby reducing the amount of other resources needed during emergencies. Using LMRs to "serve" these loads, rather than building capacity, results in significant savings. LMRs qualify as planning resources to be used to meet a Market Participant's Planning Reserve Margin requirements.

Load on Equipment: One hundred percent load is the maximum continuous net output of the unit at normal operating conditions during the annual peak load month. For example, if the equipment is capable of operating at 5% overpressure continuously, use this condition for 100% load.

Load Pick-Up Factor: The amount of load (expressed in terms of percent of generator rating) that a generator can pick up without incurring dynamic frequency decay below a level at which generators will trip due to under frequency relaying (i.e., usually 57.5 Hz). Used during the system restoration process.

Load Pocket: Geographical area in which electricity demand sometimes exceeds local generation capability and in which there is an electricity import limitation as a result of transmission constraints.

Load Profile Distribution System Studies: Load profiles are commonly utilized by utilities for a wide variety of planning purposes. In a load profile distribution system study, *Time Series Power Flow Analysis* (TSPFA) may be used with daily hourly loads (or more discrete time periods using Advanced Metering Infrastructure - AMI) to determine whether there is a risk of any overloading. Alternatively, time-series analysis can be applied in a time frame of several hours, months, or years with estimated load-duration curves, in order to investigate the possibilities of overloading issues over time. Because most Distributed Energy Resources (DERs) have time-varying power outputs, time series simulations are seen as increasingly important. In distribution systems with larger amounts of DERs, peak and minimum daily load snapshot analyses do not capture the full picture of distribution system operations and requirements. Distribution feeder devices, such as conductors, protective devices, and transformers, may need to be replaced if the load study projects overloads. Some utilities may choose to allow short-term overloads if they are infrequent and only reach 125% or 150% of the device ratings.

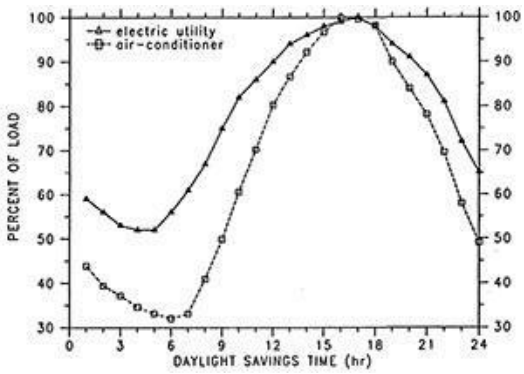
Load Reduction Request: The issuance of any public or private request to any customer or the general public to reduce the use of electricity for the reasons of maintaining the continuity of service of the reporting entity's bulk electric power supply system. Requests to a customer(s) served under provisions of an interruptible contract are not a reportable action unless the request is made for reasons of maintaining the continuity of service of the reporting entity's bulk electric power supply.

Load Research: A term encompassing a random sample of customers from which metered load data, customer end-use or appliance data, demographic information, and other data (e.g., weather) is obtained. For the sample, the metered data measures not only how much electricity is consumed (kWh or energy use) in a specified period but also when the electricity is used (kW or demand). This sample is then used to estimate the use and demand for other customers for purposes of rate design, load forecasting, various system planning purposes, revenue forecasts, and demand-side management (including energy efficiency). The quality of the Load Research is demonstrated by its statistical properties such as Confidence Intervals for conducting specified research. Currently appliance/end-use load research data bases and the resulting load shapes that can be developed is very poor. Ideally, utilities would develop end-use load research for basic customer usage information (e.g., rates, load forecasting) as well as to determine the effectiveness of individual DSM measures (e.g., different types of water heaters are likely to have differing load shapes and impose different demands on the system coincident demand). This granularity of data can also be useful for understanding the implications for customer owned resources and designing appropriate rates. Especially with Advanced Metering Infrastructure, obtaining sub-hourly load information is feasible. This information should be partnered with *Appliance / End-Use Saturation* studies that, ideally, would include demographic data. Because energy efficiency improves over time, these samples and surveys should be refreshed every two to three years. This should set a foundation for additional research into avoided costs and transferability of results to other utilities.

Load Sensitivity (see also Load Damping): Loads that reduce their consumption of electricity in proportion to a decline in interconnection frequency.

Load Serving Entity (LSE): Typically regarded as a distributuion system. An LSE is any entity (or the duly designated agent of such an entity), including a load aggregator or power marketer that (a) serves end-users and (b) is granted the authority or has an obligation pursuant to state or local law, regulation or franchise to sell electric energy to end-users.

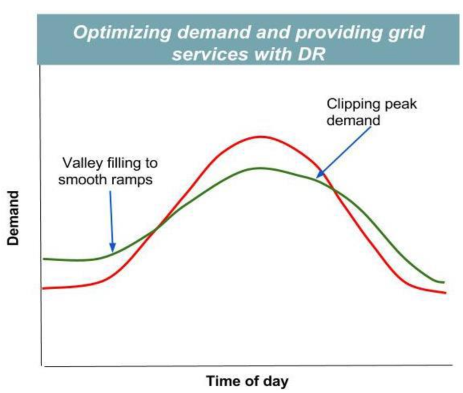
Load Shape: A method of describing peak load demand and the relationship of power supplied to the time of occurrence.



Load Shedding: Intentional action by a utility that results in the reduction of more than 100 megawatts (MW) of firm customer load for reasons of maintaining the continuity of service of the reporting entity's bulk electric power supply system. The routine use of load control equipment that reduces firm customer load is not considered to be a reportable action.

Load Shift Factors: (LSF – see also Generation-to-Load-Distribution Factor, Generation Shift Factor, Total Distribution Factor, and Transmission Loading Relief): A factor to be applied to a load's expected change in demand to determine the amount of flow contribution that change in demand will impose on an identified transmission facility or monitored flowgate.

Load Shifting (DSM term – see also peak shaving and valley filling): Load shifting is an effort to reduce peak demand and / or to increase off-peak consumption of electricity. Load shifting can be done by demand response, energy efficiency, storage technologies, customer-owned resources, and selective incentives.



Load-Serving Entity (LSE) (Electric): Secures energy and transmission service (and related Interconnected Operations Services) to serve the electrical demand and energy requirements of its end-use customers. (NERC definition)

Load Tap Changer (LTC)**:** The purpose of a tap changer is to regulate the output voltage of a transformer (tap changers are not installed on all transformers). The regulation of output voltage is done by altering the number of turns in one winding and thereby changing the turns ratio of the transformer. There are two types of transformer tap changers: an on-load tap changer (OLTC) and a de-energized tap changer (DETC). An OLTC varies the transformer ratio while the transformer is energized and carrying load. An adjacent tap is bridged before breaking contact with the load carrying tap for the purpose of transferring load from one tap to the other without interrupting or appreciably changing the load current. While in a bridging position (i.e., contact is made with two taps), some form of impedance (resistive or reactive) is present to limit circulating current. A high speed resistive type OLTC uses a resistor pair to absorb energy and does not use the bridging position as a service position. A reactive type OLTC uses a reactor that is designed for continuous loading, e.g., a preventative auto-transformer, and therefore uses the bridging position as a service position.

Loading Ratio (ILR)**:** The DC to AC ratio (also known as the Inverter Load Ratio, or "ILR") is an important parameter when designing a solar project

Local Distribution Company (LDC) (Natural Gas): A legal entity engaged primarily in the retail sale and/or delivery of natural gas through a distribution system that includes mainlines (that is, pipelines designed to carry large volumes of gas, usually located under roads or other major right-of-ways) and laterals (that is, pipelines of smaller diameter that connect the end user to the mainline). Since the restructuring of the gas industry, the sale of gas and/or delivery arrangements may be handled by other agents, such as producers, brokers, and marketers that are referred to as "non-LDC."

Locational Constraints (see also Locational Marginal Cost Pricing): Localized capacity import capability limitations that are caused by transmission facility limitations or voltage.

Locational Deliverability Areas in PJM (LDAs) The process of determining the *Installed Reserve Margin* (IRM) that meets the PJM reliability criterion assumes that the internal RTO transmission is adequate and any generation can be delivered to any load without transmission constraints. This process helps in determining the minimum possible IRM for the RTO. However, since transmission may have limitations, after IRM is determined a Load Deliverability analysis is conducted. The RTO is divided into different sub-regions for this analysis. These sub-regions are referred to as Locational Deliverability Areas (LDAs) in the Reliability Pricing Model. The first step in the Load Deliverability analysis is to determine the transmission import capability required for each LDA to meet the area reliability criterion of Loss of Load Expectation of one occurrence in 25 years. This import capability requirement is called Capacity Emergency Transfer Objective (CETO), expressed in megawatts and valued as unforced capacity. The standard generation reliability evaluation model is used to determine CETO. The Updated FPR that is posted for the Third Incremental Auction for the Delivery Year is the final FPR for the Delivery Year. The following parameters are values used in the determination of Forecast Pool Requirement:

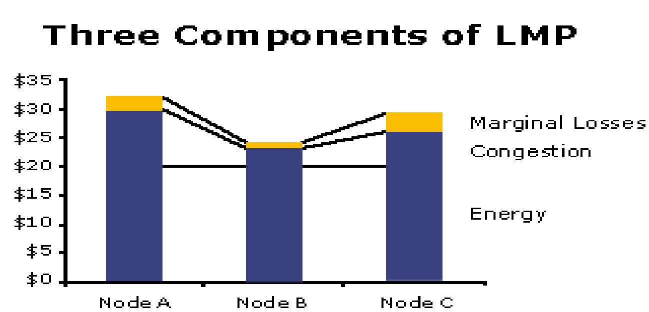
- Installed Reserve Margin (IRM)
- Pool-wide Average EFORd
- The Forecast Pool Requirement (FPR) for the Delivery Year is calculated by PJM and is equal to (1 + Installed Reserve Margin) times (1-Pool-wide Average EFORd).

  Forecast Pool Requirement (FPR) = (1 + Installed Reserve Margin) *(1 – Pool Wide Average EFORd)

The second step in Load Deliverability analysis is to determine the transmission import capability limit for each LDA using the transmission analysis models. For this analysis, a Transmission Upgrade including transmission facilities at voltages of 500 kV or higher that is in an approved Regional Transmission Expansion Plan ("Backbone Transmission") will be included in the system model only if it satisfies the project development milestones set forth in the tariff. This import capability limit is called Capacity Emergency Transfer Limit (CETL), expressed in megawatts and valued as unforced capacity. If CETL value is less than CETO value, transmission upgrades are planned under the Regional Transmission Expansion Planning Process (RTEPP). However, higher than anticipated load growth and unanticipated retirements may result in the CETL value being less than CETO value with no lead time to build transmission upgrades to increase CETL value. These conditions could result in locational constraints in the RTO. Effective with the 2017/2018 Delivery, the Reliability Pricing Model recognizes locational constraints that limit the delivery of generation capacity to PJM from areas outside of PJM (i.e., Capacity Import Limits). The Capacity Import Limit Calculation Procedure is performed by PJM to establish the amount of power that can be reliably transferred to PJM from defined regions external to PJM.

Locational Marginal Cost Pricing (LMP): Determining the cost of power at any one point on the grid (including the opportunity costs created by congestion) is called *location-based marginal costing*. A Locational Marginal Price (LMP) is the market clearing price at a specific Commercial Pricing Node (CPNode) and is equal to the cost of supplying the next increment of Load at that location. LMP values have three components for Settlement purposes: marginal energy component, marginal congestion component, and marginal loss component. The value of an LMP is the same whether a purchase or sale is made at that node.

Because prices based on location-based marginal costing reflect the costs of *transmitted* power at different nodes, they act as signals that allow system users to allocate such costs among themselves efficiently. In the jargon of economics, the network externalities of pricing delivered power are internalized in location-based marginal costing. For this reason, *location-based marginal pricing* has been called the "most accurate pricing method" for transmission.



Locational Net Benefits Analysis: A systematic quantification of benefits and costs associated with the integration of customer-owned, Distributed Energy Resources (DER), DSM, battery storage, microgrids for various elements on a distribution system (e.g., substation, feeder, lines, congestion, voltage support, reliability). The benefits and costs might include avoided or incremental cost of new infrastructure.

Locational Price Adder: A component of the Resource Clearing Price that represents the additional price value of capacity resources located in a constrained Locational Delivery Area (LDA).

Locational Reliability Charge: A PJM term. This is a fee applied to each LSE that serves load in PJM during the delivery year. Equal to the LSEs Daily Unforced Capacity Obligation multiplied by the applicable Final Zonal Capacity Price.

Lockout: A state of a transmission line following breaker operations where the condition detected by the protective relaying was not eliminated by temporarily opening and reclosing the line, possibly several times. In this state, the circuit breakers cannot generally be reclosed without resetting a lockout device.

Long Term Debt: Debt securities or borrowings having a maturity of more than one year.

Long Term Firm Point to Point Transmission Service: Firm Point-to-Point Transmission Service with a term of one year or more.

Long Term Transmission Planning Horizon: Transmission planning period that covers years six through ten or beyond when required to accommodate any known longer lead time projects that may take longer than ten years to complete.(NERC)

Loop Flow: The movement of electric power from generator to load by dividing along multiple parallel paths; it especially refers to power flow along an unintended path that loops away from the most direct geographic path or contract path. Sometimes referred to as parallel path flows. For regions served by Regional Transmission Organizations / Independent System Operator, this is a matter dealt with in "Seams Agreements."

Looping (Natural Gas): The addition of pipe segments to add capacity to an existing pipeline.

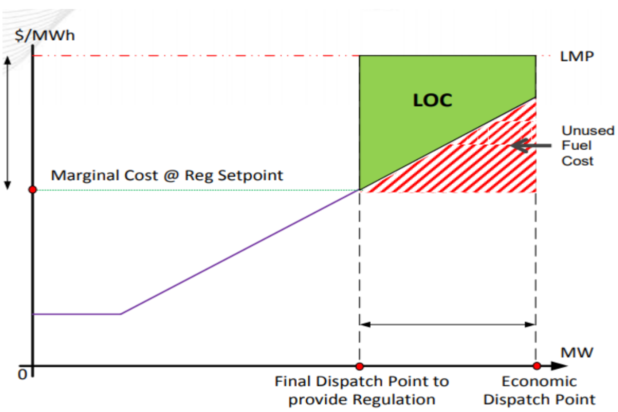
Loss of Load Events: The number of events in which some system load is not served in a given year. A LOLEV can last for one hour or for several continuous hours and can involve the loss of one or several hundred megawatts of load. Note that this is not a probability index, but a frequency of occurrence index.

Loss of Load Expectation (LOLE): LOLE defines the adequacy of capacity for the entire system. based on load exceeding available capacity, on average, only once in 10 years.Used to set "Planning Reserve Margins." LOLE is normally expressed as the number of days/year that generation resources will be insufficient to meet load. Most widely accepted level: 1 Day (or event) in 10 Years. This, like the "Loss of the Single Largest Generator" or a fixed percentage above forecasted peak demand (e.g., 15%) are all arbitrary measures for attempting to quantify the amount of capacity in excess of peak demand required to reliably serve customers.

Loss of Load Probability (LOLP): The probability of system load exceeding available capacity over a defined period of time.A LOLP or a *Loss of Load Expectation* (LOLE) analysis is typically performed on a system to determine the amount of capacity that needs to be installed to meet the desired reliability target e.g., Resource Adequacy, Reserve Margin), commonly expressed as an expected value, or LOLP of 0.1 days/year (or hours per day or as a percent of time). For calculating the total capacity needed – including a reserve margin - LOLP is an arbitrary calculation but it is regarded as being superior to the *rules of thumb* of using the loss of the single largest contingency or a fixed percentage above the forecasted peak demand (e.g., 15% to 20%) to determine the required reserve margins. LOLP (or LOLE) is a measure of scarcity by calculating the probability that the system cannot supply the load peak during a given interval of time, has been used interchangeably with LOLE for most, if not all utilities. LOLE would be the more accurate term if expressed as days per year. LOLP is more properly reserved for the dimensionless probability values. LOLP must have a value between 0 and 1.0. There are two types of LOLP values - indicative and final and these can be based on static or dynamic analysis. An indicative LOLP is calculated from data available at defined times (at midday the day before and 8, 4 and 2 hours).

Losses (see also Electric Energy Losses or Line Losses): Transmitting electricity at high voltage reduces the fraction of energy lost to Joule heating. For a given amount of power, a higher voltage reduces the current and thus the resistive losses in the conductor. For example, raising the voltage by a factor of 10 reduces the current by a corresponding factor of 10 and therefore the I^2R losses (where I represents current flow and R represents resistance of the conductor) by a factor of 100, provided the same sized conductors are used in both cases.

Lost Opportunity Costs (LOC see also Avoided Costs): The foregone revenue or increase in costs relative to the energy market. LOC can also be used for providing regulation in the energy market which is part of the Regulation Market Clearing Price. Accurate and reliable quantification of even approximate marginal costs is very difficult which adds complexity to offers by generators. Operational decisions by energy-limited resources, such as the large storage hydro systems or combustion turbines, are driven largely by opportunity costs. Below is a PJM illustration.



Low Frequency Ride Through (LFRT see Frequency Ride Through, Low Voltage Ride Through, and Voltage Ride Through)**:** In electrical power engineering, fault ride through (FRT), sometimes under-voltage ride through (UVRT), or low voltage ride through (LVRT), is the capability of electric generators to stay connected in short periods of lower electric network voltage or voltage dip.

Low NOx Burners: Impede the formation of NOx by lowering the temperature of the boiler flame to control coal combustion.

Low Voltage Ride Through (LVRT see also Voltage Ride Through, Low Frequency Ride Through and Frequency Ride Through): LVRT is a grid connection requirement for Wind Energy Conversion Systems (WECS). In the event of a voltage dip, a mismatch is produced between the generated active power and the active power delivered to the grid. Low voltage ride through requirement is intended to address this mismatch. NERC addressed the concern that distributed energy resources (DER) that have sensitive voltage and frequency trip points with short delay times, as mandated by the current version of IEEE Standard 1547, pose a risk to bulk power system security. This issue is described in the NERC Integration of Variable Generation Task Force Task 1-7 report.1 This NERC report recommends that IEEE 1547 be modified to incorporate voltage and frequency ride-through requirements (VRT and FRT, or collectively V/FRT). IEEE Standard 1547 is presently being amended to provide more flexibility in the "must trip" requirements, which allow V/FRT to be implemented by utilities or other local entities, but do not mandate these ride-through capabilities. The base IEEE 1547 standard, however, is required by recently-changed IEEE Standards Association rules to undergo full review and potential revision. A clear example of an inherent technical limitation to LVRT performance is the issue of synchronous generator DR loss of synchronism (transient instability) as a result of very low voltage persisting beyond a certain duration. Bulk generators also have this limitation. DR synchronous generators and prime movers, however, tend to have lower per-unit inertias than large generators, making it sometimes difficult for the DR to remain stable for a transmission fault case where nearby large generators are capable of maintaining stability. Sandia National Laboratories April 2014.

Lower Heating Value (LHV) (see also Higher Heating Value): Natural gas-fired plants have the highest thermal efficiency (about 55-56%) of the plants without capture of CO_2. The capture of CO_2 reduces the thermal efficiency of the generating units. The efficiency is calculated on a lower heating value basis. In comparison, LHV for pulverized coal ranges from 44% without capturing CO_2 and as low as 35.3% post combustion or Oxy combustion. Integrated Gas Combined Cycle has a 41% LHV without carbon capture. The LHV is calculated using a formula to account for the moisture in the fuel (i.e., subtract the energy required to vaporize the water in the coal and is thus not available to produce steam). Regardless of whether LHV or HHV are used to compare relative efficiencies, it is important to use consistent measures.

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Machine Learning: Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it learn for themselves. The process entails the machine to utilize observations or data, such as examples, direct experience, or instruction, in order to look for patterns in data and make better decisions in the future based on the examples that we provide. The primary aim is to allow the computers learn automatically without human intervention or assistance and adjust actions accordingly.

Maintenance Derating (D4): The removal of a component for scheduled repairs that can be deferred beyond the end of the next weekend, but requires a reduction of capacity before the next planned outage.

Maintenance Expenses: That portion of operating expenses consisting of labor, materials, and other direct and indirect expenses incurred for preserving the operating efficiency and/or physical condition of utility plants used for power production, transmission, and distribution of energy.

Maintenance of Boiler Plant (Expenses): The cost of labor, material, and expenses incurred in the maintenance of a steam plant. Includes furnaces; boilers; coal, ash-handling, and coal-preparation equipment; steam and feed water piping; and boiler apparatus and accessories used in the production of steam, mercury, or other vapor to be used primarily for generating electricity. The point at which an electric steam plant is distinguished from an electric plant is defined as follows:

Inlet flange of throttle valve on prime mover.

Flange of all steam extraction lines on prime mover.

Hotwell pump outlet on condensate lines.

Inlet flange of all turbine-room auxiliaries.

Connection to line side of motor starter for all boiler-plant equipment.

Maintenance Outage (MO): The removal of a unit from service to perform work on specific components that can be deferred beyond the end of the next weekend, but requires the unit be removed from service before the next planned outage. Typically, a MO may occur anytime during the year, have flexible start dates, and may or may not have a predetermined duration.

Maintenance Outage Hours (MOH) = Sum of all hours experienced during Maintenance Outages (MO) **+** Maintenance Outage Extensions (ME) of any Maintenance Outages (MO).

Major Event Days (MED): Used in electric utility performance indices such as System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI) and Customer Average Interruption Duration Index (CAIDI which is = SAIDI divided by SAIFI), and the information is often reported both with and without Major Events. Historically, there hasn't been universal agreement on what constitutes a Major Event so, unless normalization or some other weighting factor (e.g., using 2.5 beta to estimate a threshold daily SAIDI TMed where TMed = exp(α+2.5β), Beta = log-normal standard deviation, Alpha = log-normal statistical mean. Multiplying beta – the Standard Deviation – by 2.5 encompasses 99.379% of the expected observations. This translates to a 2.3 Major Event Days per year) is applied, including Major Events may be a more useful metric. According to the Institute for Electrical and Electronics Engineers (IEEE Std.1366 last amended 2012)), events that may be included in unadjusted information are major weather events, major substation events, or unexpected catastrophic events such as earthquakes. Major events are events that are beyond the design and/or operational limits of a utility. It is anticipated that both executives and regulators will scrutinize those events that cause MEDs and take appropriate action to mitigate their future impact on reliability. There could be cases where no additional action is required, as would be the case when an event was beyond control and beyond the design and/or operation limits of the utility (e.g., Class 4 hurricane).

Manual Load Dump (see also Load Shedding): The removal of electric load from a system by manually opening circuit breakers. Also known as load shedding.

Manual Load Dump Warning: Primary Reserve capacity is less than the largest operating generator (or a transmission tripping jeopardizes reliable operations).

Manufactured Gas: A gas obtained by destructive distillation of coal or by the thermal decomposition of oil, or by the reaction of steam passing through a bed of heated coal or coke. Examples are coal gases, coke oven gases, producer gas, blast furnace gas, blue (water) gas, carbureted water gas. Btu content varies widely.

Margin: The difference between net capacity (a system's total capacity resources) and net internal demand that is generally expressed in MW for operating reserves and as a percentage of either system load or installed generating capacity for planning reserves.

Margin of Error: is an approximate 95 percent confidence interval for the sampling proportion. It is calculated for a sample proportion:

$$\hat{p} \pm \sqrt{(1 + CV^2)} / n$$

Where:

p̂ = sample proportion is symbolized as **p̂** (remember a population proportion is symbolized as *p*).

CV = coefficient of variation of the sample weights

n = sample size used to compute the proportion.

If P is unknown, p (hat) is an estimate. This is a measure of sampling error (the average of all estimates obtained using the same sample selection and weighting procedures repeatedly should, in principle, be within the margin of error in 95 percent of such samples). It does not reflect non-sampling errors, including potential selection bias. The validity of the margin of error for total survey error (including non-sampling error) requires that, after controlling for the sample selection and weighting variables, survey measurements be independent of sample selection.

Marginal Cost (MC) (Typically used interchangeably with Incremental Cost – see also Avoided Costs): In economics, marginal cost is the change in the total cost that arises when the quantity produced is incremented by one unit. That is, MC is the cost of producing one more (or less) unit of a good. In general terms, marginal cost at each level of production includes any additional costs required to produce the next unit. Unlike *fixed costs* which do not vary with the level of output.

For electricity, the marginal cost is typically regarded as the cost of producing an additional (kWh) of electricity or building an additional facility (e.g., a generating unit). For the economic dispatch of electricity, dispatchers seek to select the combination of resources that minimize the total operating cost required to produce each kWh of electric energy at any instant. Changes in dispatch reflect the changes in marginal cost. Operating costs for power plants include fuel, labor and maintenance costs where fuel costs dominate for fossil fuel power plants. For renewables, fuel is generally free so labor and maintenance costs might constitute the primary total operating costs. Fuel costs for nuclear power plants are very low so they are a high priority in economic dispatch. With *hydraulic fracking,* beginning around 2015, natural gas was increasingly less expensive than coal so natural gas was increasingly dispatched relative to coal. In sum, the change in marginal cost of generating electricity rises (or declines) as more (or less) electricity is produced. Marginal Cost may also be used for planning new resources.

Marginal Loss Component: The component of the nodal price that reflects the marginal loss at a node.

Marginal Losses Cost (see also Locational Marginal Cost Pricing): The price that represents the power lost when power moves across a transmission system. Marginal Losses Cost is one of the three components of Locational Marginal Pricing (LMP).

Marginal Probabilities (statistical – see also Conditional Probability, Joint Probabilities, Bayes' Theorem) When there is interest in a single event, irrespective of any other event (i.e. "marginalizing the other event"), then it is a marginal probability. For instance, the probability of a coin flip giving a head is considered a marginal probability because there is no consideration of any other events.

Marginal Resources: The generators that set the price in the Real-Time Energy Markets and the projected prices in the Day-Ahead Markets.

Market Based Pricing: Prices of electric power or other forms of energy determined in an open market system of supply and demand under which prices are set solely by agreement as to what buyers will pay and sellers will accept.

Such prices could recover less or more than full costs, depending upon what the buyers and sellers see as their relevant opportunities and risks.

Market Based Rate Authority: {Section 203 of the FPA). Market-based rate authority requires a power seller to demonstrates they and their affiliates lack or have adequately mitigated horizontal and vertical market power.

Market Center: A physical location where buyers and sellers make transactions (this may or may not also be a hub).

Market Clearing Price: The price at which supply equals demand for the Day-Ahead or Hour-Ahead markets. Alternatively it is the price at which the market is able to match the last unit of energy a specific seller is willing to sell with the last unit of energy a specific purchaser is willing to buy. That is, it is the price paid by customers to all suppliers for the resources provided to serve load requirements.

At the extreme such as a blackout, it is possible that demand will exceed supply (an inelastic demand curve) and their will not be a market clearing price. That is, it is the price paid by to all suppliers for the resources provided to serve load requirements.

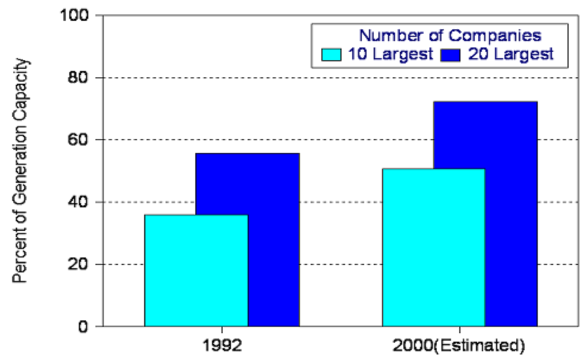
Market Failure: A principle under-pinning of the justification of regulation. Market failure is the unwillingness or inability of a firm to provide goods or services.

Market Friction: Inefficiencies among utilities or regions that hinder the exchange of power resources. These can be technical, regulatory, or attitudinal. Differences in assessing capabilities of transmission elements, for instance, may constitute a Market Friction. Reducing Market Friction is a primary objective of *seams agreements* among RTOs / ISOs and individual utilities.

Market Out Clause (see also Force Majeure)**:** Permits a party to escape from the terms of a gas purchase contract upon certain conditions such as the contract price renders it unmarketable. This is generally an economic type escape clause and should not be confused with the *force majeure clause.*

Market Potential (or "**Achievable**" **Potential**): Refers to the subset of economic potential that reflects the estimated amount of energy savings that can realistically be achieve taking into account factors such as technology adoption process, market failures or barriers that inhibit technology adoption, transaction costs, consumer preferences, social and institutional constraints, and possibly the capability of programs and administrators to ramp up program activity over time.

Market Power: The ability to alter the price of wholesale or retail electricity or services to one's advantage -- and away from competitive levels -- in a competitive market (also called market manipulation). Note the increased "concentration" of economic power in the chart below and in the attachment that details the mergers of electric utilities since 1995.



Market Based Pricing: Prices of electric power or other forms of energy determined in an open market system of supply and demand under which prices are set solely by agreement as to what buyers will pay and sellers will accept. Such prices could recover less or more than full costs, depending upon what the buyers and sellers see as their relevant opportunities and risks.

Market Risk Premium: Additional compensation beyond Risk-Free rate.

Marketer (Electric): An entity that has the authority to take title to electrical power generated by itself or another entity and re-market that power at market-based price.

Marketer (Natural Gas): A company other than a pipeline or LDC that purchases and resells natural gas or brokers the gas transactions for a profit. Marketers also arrange transportation and monitor deliveries and balancing. An independent marketer is not affiliated with a pipeline, producer, or LDC.

Mark-Up Index: This index summarizes the offers made by market participants for *marginal resources.*

Markov Chain: A stochastic process that differs from a general stochastic process in that a Markov chain must be memory-less. That is, the probability of future actions are not dependent upon the steps that led up to the present state. The Markov property.

Mass-Based Compliance with the Clean Power Plan (CPP) published on June 18, 2014: In its simplest form, a mass-based outcome is the product of an emissions rate and generation level: Mass = CO_2 Emissions Rate X Generation. Seemingly, most state regulators, utility officials and representatives of grid operators such as the PJM Interconnection and the Midcontinent Independent System Operator, based on detailed long-term resource planning, concluded a mass-based approach is simpler, easier to administer, better facilitates trading for ERCs, and has the added benefit of being more familiar to state air regulators who have established similar emissions caps for other pollutants such as California and the Northeastern and mid-Atlantic members of the Regional Greenhouse Gas Initiative (RGGI) which use a Mass-Based approach. Coal-dependent states, especially, are likely to see mass-based approaches as being most favorable because retirements of older, inefficient plants that are occurring regardless of the Clean Power Plant can be counted toward compliance. Mass-Based is an alternative to a *Rate-Based* approach.

Mature Unit: A unit that has at least five years of operating experience for NERC reliability calculations.

Maximum Continuious Discharge Current: Maximum Continuous Discharge Current – The maximum current at which the battery can be discharged continuously. This limit is usually defined by the battery manufacturer in order to prevent excessive discharge rates that would damage the battery or reduce its capacity. For automobiles, along with the maximum continuous power of the motor, this defines the top sustainable speed and acceleration of the vehicle.

Maximum Dependable Capacity, Net (MDC): The gross electrical output measured at the output terminals of the turbine generator(s) during the most restrictive seasonal conditions, less the station service load.

Maximum Generation Emergency (MaxGen): The RTO / ISO, other utility, Planning Authority issues a warning that generation may not be sufficient. A MaxGen is invoked if enough generation is not made available to meet projected requirements beyond the Economic Maximum MW energy level of all resources. That is, generating units may be dispatched to Emergency Max MW limits. Emergency Energy bids are requested.

Maximum Generator Nameplate Capacity: The maximum rated output of a generator, prime mover, or other electric power production equipment under specific conditions designated by the manufacturer.

Maximum Hourly Load: This is determined by the interval in which the 60-minute integrated demand is the greatest.

Maxium Internal Resistance: The resistance within the battery, generally different for charging and discharging.

Maxiumum 30 Second Discharge Pulse Current: The maximum current at which the battery can be discharged for pulses of up to 30 seconds. This limit is usually defined by the battery manufacturer in order to prevent excessive discharge rates that would damage the battery or reduce its capacity. For automobiles, along with the peak power of the electric motor, this defines the acceleration performance (0-60 mph time) of the vehicle.

Mean (Statistics – is also the “Average” – see also Expected Value): An estimator for estimating the population mean often symbolized as $\bar{x}$ (X bar). Its value depends equally on all of the data which may include outliers. As a result it may not appear representative for skewed data sets. It is especially useful as being representative of the whole sample. *Example:* a data set of: 5 3 54 93 83 22 17 19 has a sample mean that is calculated by taking the sum of all the data values and dividing by the total number of data values:

$$\bar{x} = \frac{5+3+54+93+83+22+17+19}{8} = 37$$

The Mean, Mode, and Median are all “Measures of Central Tendency.” In statistics, **mean** has two related meanings: the arithmetic mean (and is distinguished from the geometric mean or harmonic mean) or the expected value of a random variable, which is also called the *population mean*. It is sometimes stated that the 'mean' means average. This is incorrect if "mean" is taken in the specific sense of "arithmetic mean" as there are different types of averages: the mean, median, and mode.

Mean Absolute Percentage Error (MAPE): (Also known as mean absolute percentage deviation MAPD. MAPE is a measure of prediction accuracy of a forecasting method in statistics; for example in trend estimation. It usually expresses accuracy as a percentage, and is defined by the formula:

$$\mathrm{M} = \frac{100}{n} \sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right|,$$

M = 100 n ∑ t = 1 n | A t − F t A t | , {\displaystyle {\mbox{M}}={\frac {100}{n}}\sum _{t=1}^{n}\left|{\frac {A_{t}-F_{t}}{A_{t}}}\right|,}

Where:

A_t is the actual value and F_t is the forecast value.

The difference between A_t and F_t is divided by the Actual value A_t again. The absolute value in this calculation is summed for every forecasted point in time and divided by the number of fitted points *n*. Multiplying by 100 makes it a percentage error. Although the concept of MAPE sounds very simple and convincing, it has major drawbacks in practical application

It cannot be used if there are zero values (which sometimes happens for example in demand data) because there would be a division by zero.

For forecasts which are too low the percentage error cannot exceed 100%, but for forecasts which are too high there is no upper limit to the percentage error.

When MAPE is used to compare the accuracy of prediction methods it is biased in that it will systematically select a method whose forecasts are too low. This little-known but serious issue can be overcome by using an accuracy measure based on the ratio of the predicted to actual value (called the *Accuracy Ratio*), this approach leads to superior statistical properties and leads to predictions which can be interpreted in terms of the geometric mean.

Mean Percent Error (MPE) (Statistical): The mean percentage error is the computed average of percentage errors by which forecasts of a model differ from actual values of the quantity being forecast. The formula for the mean percentage error is:

$$\mathrm{MPE} = \frac{100\%}{n} \sum_{t=1}^{n} \frac{a_t - f_t}{a_t}$$

Where a_t is the actual value of the quantity being forecast, f_t is the forecast, and n is the number of different times for which the variable is forecast. Because actual rather than absolute values of the forecast errors are used in the formula, positive and negative forecast errors can offset each other; as a result the formula can be used as a measure of the bias in the forecasts. A disadvantage of this measure is that it is undefined whenever a single actual value is zero.

Mean Reverting Jump Diffusion (MRJD): This is a method of calculating the futures prices under uncertainty for risk management purposes. Because the price of electricity can vary significantly, especially during periods of high demand when less efficient (more costly) resources are dispatched, the MRJD tries to capture the potential *jump* in prices (where λ is the average number of jumps in a year). This is a mathematical technique that utilizes historical electricity prices that are calibrated using probability (stochastic) analysis to estimate market risk. A risk neutral Monte Carlo simulation is used to price a *Bermudan option.* MRJD has been used for forward markets. The general equation is: *d*Si = a(St,t)*d*t + b (St, t)*d*Zt where: *d*Zt ~ N(0, *d*t. Geometric Brownian Motion and Geometric Mean Reversion are also used.

Median (Statistical): The middle value in a set of numbers arranged in increasing order. If there is an even number of values, then median is the average of the middle two values. For example: The median of the set {10, 12, 14, 19, 20} is 14. The median of the set {2, 3, 4, 6, 8, 9} is 5, which is the average of 4 and 6.

Megavar (MVAr): One million VAr (volt-ampere reactive) and **Megavoltampere (MVA):** is one million VA (volt-ampere).

Megawatt (MW): A unit of power equaling one million watts (1 MW = 1,000,000 watts) or one thousand kilowatts (1 MW = 1,000 KW). To put it in perspective, under non-severe weather conditions, one MW could power roughly 800 to 1,000 average-sized American homes.

Megawatthour (MWh): A megawatt-hour is a unit of measurement used to describe the amount of electricity produced or consumed. One megawatthour equals one million watthours and is approximately enough to serve 750 homes for one hour.

Merchant Generation: Power sold by a for-profit entity (marketer, broker or generator) at unregulated prices.

Merchant Transmission: Transmission not owned and operated by an electric utility and that sells its transmission capacity to wholesales customers.

Mercury and Air Toxic Standard (MATS): On December 16, 2011, the Environmental Protection Agency (EPA) finalized national standards to reduce mercury and other toxic air pollution from coal and oil-fired power plants. At the time the Rule was finalized, there were about 1,400 coal and oil-fired electric generating units (EGUs) at 600 power plants covered by these standards. To reduce mercury emissions, the Rule requires Selective Catalytic Reduction (SCR) with Flue-gas Desulfurization (FGD), Activated - Carbon Injection (ACI), ACI with Fabric Filter (FF) or Electrostatic Precipitators (ESP).

Mercury Control: Uses calcium bromide; to further reduce mercury, activated carbon can be injected.

Mergers and Acquisitions (see also Federal Power Act, Horizontal Mergers, Horizontal Merger Guidelines, Market Power, and Vertical Mergers)**:** Utility mergers are generally viewed as a combination of two utilities (a *Horizontal Merger*) that believe that a single utility would produce economies of scale and / or scope that were not available to the utilities operating separately and shareholder and customer value is expected to be enhanced. These are often called *merger of equals.* In this instance, both companies relinquish their stock and new stock is issued by the merged companies.

For electric and natural gas utilities, a *Vertical Merger* or *acquisition* involves firms that provide products or services to the utility (e.g., fuel companies). An acquisition is generally regarded as one utility buying another (sometimes referred to as the *target company)* and can be horizontal or vertical.

By definition, since horizontal mergers within a *relevant market area* (e.g., a RTO region) result in less competition, antitrust experts are generally are more concerned with horizontal mergers that *substantially reduce competition*. Horizontal mergers, in particular, would seem at odds with the FERC's objective of increasing competition in the wholesale power markets. Over the last three decades, most gas and electric industry mergers have been horizontal mergers where one utility merges or acquires another utility. Since 1995, FERC has approved 101 utility mergers while 7 have been withdrawn. In 1995, there was one merger involving Delmarva Power & Light. In 2000, there were 16 mergers which is was the most in the last 22 years. There were no mergers approved or withdrawn in 2003. On average, there has been an average of just over 5 mergers per year.

Especially, after the repeal of the Public Utility Holding Company Act (PUHCA due to the enactment of the Energy Policy Act of 2005, the Securities & Exchange Commission (SEC) was no longer required to consider state perspectives in merger review. As a result, many states had little authority to influence mergers and acquisitions, particularly those that were interstate. The FERC became the forum of last resort for states. While the Federal Power Act (FPA) treats states as any other party, in practice the FERC may recognize there are few bright lines separating state and federal jurisdiction and may give weight to state perspectives in areas where there is a shared objective that achieves the purposes of the FPA.

It is difficult to project the potential benefits and costs of a merger or acquisition and there have been more instances where the prospective benefits have been exaggerated than those instances where the merger benefits were understated. Business schools often use the example of the Hewlett-Packard / COMPAQ merger of 2001-2 to illustrate the irrational exuberance of mergers. Fortune Magazine in 2005, said *HP's shareholders paid $24 billion in stock to buy Compaq and in exchange got relatively little in value*. After the FERC ordered non-discriminatory open-access transmission tariffs (OATT) and, certainly, after RTOs started operating their security constrained economic dispatch over large geographic regions with much greater *resource diversity* and *load diversity,* utilities in regions served by RTOs could no longer make the argument that merging companies could save customers money or enhance shareholder value by joint dispatch of their respective systems. Merging companies were left with making the argument that there are compelling economies of scale (e.g., staff reductions, purchasing power, acquiring new expensive technologies that would have severely burdened one utility). However, if state policymakers and regulatory commissions insist on the merging companies demonstrating positive net benefits from the merger, the merging companies have to demonstrate that there are not off-setting economies of size. See: https://www.ferc.gov/industries/electric/gen-info/mergers/mergers-1997.asp

For FERC approved mergers involving Indiana utilities: Duke Energy and Progress Energy (2012 after being rejected in 2011), AES and DPL et.al. (2011), Duke Energy and Cinergy (2005), Duke Energy and Engage Energy, Fredericksen Power (2002), AES and IPL (2001), NiSource and Columbia Energy Group (2000), AEP and Central & Southwest (2000), and Southern Indiana Gas & Electric and Indiana Gas (1999), Duke Energy and Nantahala Power & Light (1998). El Paso Electric and Sun Jupiter Holdings and Infrastructure Investments Fund (IIF) US Holding 2 (2019).

Meta Data: Descriptive information about data files necessary for the reuse of data. Metadata should thoroughly describe the data. (LBNL)

Meter: A device such as Advanced Metering Infrastructure (AMI) or Demand Meter that is used to measure the amount of gas or electricity flowing through a point on the system.

Metric Cubic Foot (MCF): A MCF is equivalent to 1,000 cubic feet (of gas).

Metric Ton (MT): A metric ton is 2,204.62 pounds or 1.1 ton and is usually rounded to 2040 pounds.

Metropolitan Statistical Area (MSA): A county or group of contiguous counties (towns and cities in New England) that has (1) at least one city with 50,000 or more in habitants; or (2) an urbanized area of 50,000 inhabitants and a total population of 100,000 or more inhabitants (75,000 in New England). These areas are defined by the U.S. Office of Management and Budget. The contiguous counties or other jurisdictions to be included in an MSA are those that, according to certain criteria, are essentially metropolitan in character and are socially and economically integrated with the central city or urbanized area.

MicroGrids: Microgrids can provide lower cost of operations, greater reliability during storms or other events, reduced reliance on the utility especially during peak periods, and improved power quality, A localized group of electricity sources and loads that normally operates connected to and synchronous with the traditional centralized electrical grid (macrogrid), but can also disconnect to "island mode" — and function autonomously as physical and/or economic conditions dictate.The following graphic is from GTM Research showing 1,600 operational microgrids in the U.S, as of 2017.

Microturbine A gas turbine generator with a nameplate rating of 500 kW or smaller.

Midcontinent Independent System Operator (MISO): The nation's first FERC certified Regional Transmission Organization. MISO serves portions of the Midwest, Southeast, and the Canadian province of Manitoba.

Midstream Oil and Gas Activities (Natural Gas): Consist of activities and expenditures downstream of the wellhead, including gathering, gas and liquids processing, and pipeline transportation.

Mill: Equal to 1/1000 of a dollar or 1/10 of a cent. Used in utility rates and often used in property tax where a mill represents the amount per $1,000 of assessed value of a property.

Mine Spoils: Coal mining generates waste, including overburden, which is discarded in spoil heaps. Acid mine drainage is the acidic metal-rich water resulting from the oxidation of sulfide-containing minerals that form in spoil heaps.

Minimum Acceptable Rate of Return (MARR see also Hurdle Rate): This is the lowest acceptable rate of return for a project to be considered for approval (a.k.a. hurdle rate, expected rate of return).

Minimum Generation Emergency (MinGen): An emergency declared by the RTO/ ISO. other utility, Planning Authority in which it anticipates requesting one or more generating resources to operate at or below its economic minimum limit so that it can manage, alleviate, or end the emergency.

Minimum Offer Price Rule (MOPR): Provision that imposes a minimum offer screening process to determine whether an offer from a new resource is competitive and prevents market participants from submitting uncompetitive, low new entry offers in Reliabilty Pricing Model (RPM) Auctions to depress auction clearing prices artificially. FERC's June 29, 2018 order directed PJM to expand its current Minimum Offer Price Rule (MOPR) to address state-subsidized electric generation resources that distort prices in PJM's capacity market. FERC allowed certain exemptions (i.e., existing renewable resources participating in state RPS programs, existing DR/EE/ storage, existing self-supply, and competitive resources that do not received states subsidies. MOPR intended to address out-of-market payments provided, or required to be provided, by PJM states to support operation of certain generation resources. In FERC's opinion these resources threaten the competitiveness of PJM's capacity market. MOPR failed to address the price-distorting impact of resources receiving out-of-market support.

Minimum Plant Method (cost allocation – see also Zero Intercept Method): Some cost of service methods rely on trying to create a minimum-plant. For example, the minimum amount of distribution lines (smallest conductor or wire size) and transformers needed to serve different types or sized customer needs.

Minimum Run Level: Minimum level of output that can be provided from a generator. Different generators have different minimum run levels based in part on fuel source and plant design.

Minimum System Studies (Cost-of-Service Method): Classifying distribution plant with the minimum-size method assumes that a minimum size distribution system can be built to serve the minimum loading requirements of the customer. The minimum-size method involves determining the minimum size pole, conductor, cable, transformer, and service that is currently installed by the utility. Normally, the average book cost for each piece of equipment determines the price of all installed units. Once determined for each primary plant account, the minimum size distribution system is classified as customer-related costs. The demand-related costs for each account are the difference between the total investment in the account and customer-related costs. Comparative studies between the minimum-size and other methods show that it generally produces a larger customer component than the *zero-intercept method*. Accounts 364 (poles towers and fixtures), 365 (over-head conductor and devices), 366 – 367 (underground conduits, conductors, and devices), 368 (line transformers), and 369 (Services). For each, multiply the average book cost by each of the assets to determine the customer component. <u>Electric Utility Cost Allocation Manual</u> National Association of Regulatory Utility Commissioners (NARUC), January 1992.

Minimum Vegetation Clearance Distance: The calculated minimum distance stated in feet (meters) to prevent flash-over between conductors and vegetation, for various altitudes and operating voltages. (NERC)

Missing Money: Generators primarily rely on the highest priced hours to recover most of their fixed costs (e.g., the cost of generating units). Missing money problems may arise if there is no opportunity to recover *shortage costs* (*scarcity pricing*) when demand threatens to exceed supply or economically available resources. Price caps on offers by generators, where there is no evidence that any generator(s) is exercising market power, could result in reduced investment in generating units and may affect short-term economic dispatch. The need to ensure adequate short and long-term resources is a primary justification for *capacity markets* like the "Installed Capacity" in ISO New England and "Resource Planning Model" in PJM.

Misoperation: The failure of a Composite Protection System to operate as intended for protection purposes. Any of the following is a Misoperation: 1. Failure to Trip – During Fault – A failure of a Composite Protection System to operate for a Fault condition for which it is designed. The failure of a Protection System component is not a Misoperation as long as the performance of the Composite Protection System is correct. 2. Failure to Trip – Other Than Fault – A failure of a Composite Protection System to operate for a non-Fault condition for which it is designed, such as a power swing, undervoltage, overexcitation, or loss of excitation. The failure of a Protection System component is not a Misoperation as long as the performance of the Composite Protection System is correct. 3. Slow Trip – During Fault – A Composite Protection System operation that is slower than required for a Fault condition if the duration of its operating time resulted in the operation of at least one other Element's Composite Protection System. 4. Slow Trip – Other Than Fault – A Composite Protection System operation that is slower than required for a non-Fault condition, such as a power swing, undervoltage, overexcitation, or loss of excitation, if the duration of its operating time resulted in the operation of at least one other Element's Composite Protection System. 5. Unnecessary Trip – During Fault – An unnecessary Composite Protection System operation for a Fault condition on another Element. 6. Unnecessary Trip – Other Than Fault – An unnecessary Composite Protection System operation for a non-Fault condition. A Composite Protection System operation that is caused by personnel during on-site maintenance, testing, inspection, construction, or commissioning activities is not a Misoperation. (NERC)

Mixed Integer Linear Programing (MILP): Is an optimization method combining *continuous* and *discrete* variables to model complex dynamic planning problems; often in a more efficient manner than other mathematical tools. Some of the decision variables are constrained to be integer values (i.e. whole numbers such as -1, 0, 1, 2, etc.) at the optimal solution. The use of integer variables greatly expands the scope of useful optimization problems that you can define and solve. An important special case is a decision variable X_1 that must be either 0 or 1 at the solution. Such variables are called 0-1 or binary integer variables and can be used to model yes/no decisions, such as whether to build a plant or buy a piece of equipment. However, integer variables make an optimization problem *non-convex*, and therefore far more difficult to solve. Memory and solution time may rise exponentially as you add more integer variables. A classic example of a constraint programming problem is the traveling salesman problem: A salesman plans to visit N cities and must drive varying distances between them. In what order should he/she visit the cities to minimize the total distance traveled, while visiting each city exactly once? In the electric utility industry, for example, MILP can be used to find optimal solutions for a utility's resource mix under varying assumptions.

Mobile Sierra Doctrine (Federal Power Commission v. Sierra Pacific Power Co): The Supreme Court held the Federal Power Act permits the FPC to modify a rate specified in a contract between an electric utility and distribution company only upon a finding that the contract rate is unlawful because it adversely affects the public interest. *Sierra Pacific* and its companion case *United Gas Pipe Line Co. v. Mobile Gas Service Corp.* established the *Mobile-Sierra* doctrine, which holds that an electricity or natural gas supply rate, established resulting from a freely negotiated contract, is presumed to be "just and reasonable" and thus acceptable under the FPA or Natural Gas Act (NGA).

Mode (Statistical): The **mode** is the value that occurs the most frequently in a data set or a probability distribution. In some fields, notably education, sample data are often called **scores**, and the sample mode is known as the **modal score**. Like the statistical mean and the median, the mode is a way of capturing important information about a random variable or a population in a single quantity. The mode is in general different from the mean and median, and may be very different for strongly skewed distributions.

Moderator (Nuclear): The purpose of the moderator is to slow down high energy neutrons created during the fission process in order to increase the probability of fission within a thermal reactor. Water is the most common moderator used in modern U.S. reactors. Other moderators used in reactors include heavy water (deuterium) and graphite.

Modified Accelerated Cost Recovery System (MACRS): Used to recover the basis of most business and investment property placed in service after 1986. MACRS consists of two depreciation systems, the General Depreciation System (GDS) and the Alternative Depreciation System (ADS). Generally, these systems provide different methods and recovery periods to use in figuring depreciation deductions.

Depreciation in 1st Year =

$$\text{Cost} \times \frac{1}{\text{Useful Life}} \times A \times \text{Depreciation Convention}$$

Depreciation in Subsequent Years =

$$(\text{Cost} - \text{Depreciation in Previous Years}) \times \frac{1}{\text{Recovery Period}} \times A$$

Where,

A is 100 or 150% or 200%.

Modified Fixed Variable (natural gas - see also Fixed Variable and Straight Fixed Variable)**:** Places a natural gas pipeline's equity in the commodity portion of the rate, generally in the 25% to 35% range, and the remainder in demand. The original purpose of this rate design was to unload cost from the commodity portion of the rate to make interruptible natural gas sales competitive with oil.

Mole: Mole is equal to 6.02×10^{23} the amount of a substance of a system that contains as many elemental entities (e.g., atoms, molecules, ions, electrons) as there are atoms in 12 g (grams) of carbon 12 (^{12}C). I gram = 1 mole of amu. Moles help translates between atoms and grams (g) that are more common in measurements. [sometimes referred to as Avogadro's number]

Molten Salt: In a Molten Salt Reactor (MSR), the fuel is dissolved in a fluoride salt or other salt coolant.

The second descriptor refers to the neutron moderator used to decelerate the neutrons. The presence of a moderator indicates that it is a thermal (slow) neutron reactor. Typical moderators include:

- ***Light Water.*** (Most widely used moderator.)
- ***Heavy Water.*** (Predominant in Canadian CANDU reactors, allows use of natural un-enriched uranium)
- **Graphite.** (United Kingdom, Russia)

If there is only one descriptor such as light water, it implies that it is both the coolant and the moderator. For example, in the U.S., pressurized light water reactors (PWR) and boiling light water reactors (BWR) use light water both as the coolant and the moderator. The basic difference between these two types of reactors is that PWRs have an intermediate heat exchanger between the radioactive primary coolant and the steam turbine. In a boiling water reactor, the primary coolant is heated to boiling by nuclear fission and the steam is sent directly to the steam turbine.

Should the term "**fast**" appear in the name of the reactor, it implies that high energy neutrons are used to split uranium and plutonium isotopes that would not normally fission with slow neutrons. Fast reactors do not have moderators, only coolants.

If the term "**small**" appears in the name of the reactor it is understood to be less than 300 MWe unless noted otherwise.

Momentary Average Interruption Frequency Index (MAIFI): From the instant of interruption to the restoration, no more than 1 minute. Measures the average number of momentary interruptions that a customer experiences during a given time period. Most distribution systems only track momentary interruptions at the substation, which does not account for pole-mounted devices that might momentarily interrupt a customer. MAIFI is rarely used in reporting distribution indices because of the difficulty in knowing when a momentary interruption has occurred. MAIFI is calculated by summing the number of device operations (opening and reclosing is counted as one event), multiplying the operations by the number of customers affected and dividing by the total number of customers.

$$MAIFI = \Sigma(IDi * Ni) / NT$$

Where:

IDi = Number of interrupting device operations,

Ni = Total number of customers interrupted, and

NT = Total number of customers served.

MAIFI, improves the overall understanding of reliability. Unfortunately, many utilities do not have the capability (SCADA, Smart Meters under Smart Grid) to measure MAIFI and MAIFI only counts events when the line voltage drops to zero for three to five minutes which may not be able to assess **Power Quality** events.

Also see the following distribution system reliability indicies:

- Average Service Availability Index (ASAI),
- System Average Interruption Duration Index (SAIDI),
- System Average Interruption Frequency Index (SAIFI),
- Customer Average Interruption Duration Index (CAIDI),
- Customer Average Interruption Frequency Index (CAIFI),

- Worst CKAIDI (Circuits with the worst circuit-level Average Interruption Duration Index),
- Worst CKAIFI (Circuits with the worst circuit–level Average Interruption Frequency Index),
- CELID-X — customers experiencing longest interruption durations;
- CELID-8 is the percentage of customers who experienced outages exceeding 8 hours,
- CEMI-X — customers experiencing multiple interruptions; a measure of the percentage of customers who experienced X interruptions,
- CEMMI-X — customers experiencing multiple momentary interruptions; a measure of the percentage of customers who experienced X momentary interruptions. See also Major Event Days.

Money Pool: Provides an efficient means for meeting short-term capital needs for individual companies within a utility (or other) holding company. Each company within the holding company structure may be called upon to contribute surplus funds and will be allowed to make short-term borrowings from the money pool; at the discretion of holding company

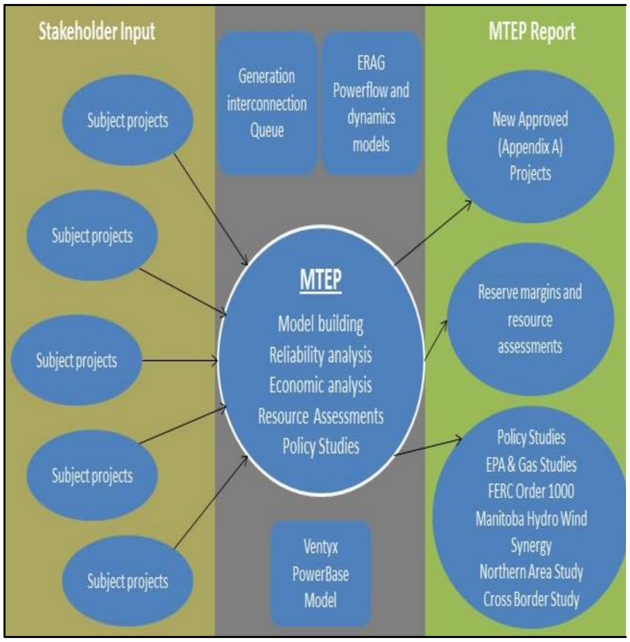
Monopoly: The only seller with control over market sales. It is not illegal to be a monopoly but it may be illegal (**violation** of antitrust laws such as the Sherman Act) depending on how the monopoly is gained or retained. At the extreme, it may be necessary to break-up the monopoly.

Monte Carlo Simulation (See also Latin Hypercube Sampling or LHS): A risk analysis method to assess a broad range of possible outcomes using a probability distribution (e.g., a normal *Bell-Shaped Curve, a Log Normal to account for skewed distributions, Triangular to assess minimum – most likely – and maximum values, Discrete which define specific probabilities for each outcome, or other)* for factors that are uncertain. Monte Carlo simulation is a computerized technique that allows people to account for risk and uncertainty. The technique was named for the casinos in Monte Carlo, Monaco and was first used by scientists working on the atomic bomb project.

Most Severe Single Contingency: The Balancing Contingency Event, due to a single contingency identified using system models maintained within the Reserve Sharing Group (RSG) or a Balancing Authority's area that is not part of a Reserve Sharing Group, that would result in the greatest loss (measured in MW) of resource output used by the RSG or a Balancing Authority that is not participating as a member of a RSG at the time of the event to meet Firm Demand and export obligation (excluding export obligation for which Contingency Reserve obligations are being met by the Sink Balancing Authority). (NERC)

Mothballed Unit: A mothballed unit is a generating unit placed on inactive status for a defined amount of time (ex. one-to-two years). This unit would be deactivated but not retired.

MTEP (Midcontinent ISO Transmission Expansion Planning) (see also RTEP for PJM): MTEP is the long-term (10 to as many as 15 years) transmission planning process needed to better assure the reliabile and economic operation of the transmission system. Because transmission systems can not be planned in isolation – without consideration of available resources and public policy – MTEP involves the participation of utilities other stakeholders, and state commissions. The plans multi-value plans (economic, reliability and public policy facilitation), generation interconnection, market efficiency to reduce congestion, baseline reliability to meet NERC requirements,and participant funded projects.



Multi-Attribute Utility Theory (MAUT) is a structured methodology designed to guide analysts in selecting, defining, and scaling metrics by handling the tradeoffs among multiple objectives such as cost, reliability requirements, environmental objectives, renewable goals, and etc. For electric utility integrated resource planning, MAUT might be useful in developing narratives to structure the analysis of the metrics used to evaluate different objectives. Utility theory is a systematic approach for quantifying an individual's preferences. It is used to rescale a numerical value on some measure of interest onto a 0-1 scale with 0 representing the worst preference and 1 the best. This allows the direct comparison of many diverse measures. The end result is a rank ordered evaluation of alternatives that reflects the decision makers' preferences. MAUT is one methodology in the broader field of Multi-Criteria Decision Making (MCDM). The Analytic Hierarchy Process (AHP) is an alternative to MAUT.

Multicollinearity (Statistics) (or Colinearity): Is the undesirable situation where the correlations among the independent variables are strong. In some cases, multiple regression results may seem paradoxical. For instance, the model may fit the data well (high F-Test), even though none of the X variables has a statistically significant impact on explaining Y. This occurs when two X variables are highly correlated, they both convey essentially the same information. When this happens, the X variables are *collinear* and the results show *multicollinearity*. Multicollinearity increases the standard errors of the coefficients. Increased standard errors in turn means that coefficients for some independent variables may be found not to be significantly different from 0, whereas without multicollinearity and with lower standard errors, these same coefficients might have been found to be significant and the researcher may not have come to null findings in the first place. In other words, multicollinearity misleadingly inflates the standard errors. Thus, it makes some variables statistically insignificant while they should be otherwise significant. It should be stressed that the presence of multicollinearity cannot make an insignificant variable appear to be significant.

Multi-Value Projects (MVPs): A MISO regional transmission planning process to satisfy one or more of the following three goals: 1) Reliably and economically enable regional public policy needs; 2) Provide multiple types of regional economic value; 3) Provide a combination of regional reliability and economic value.

Multi-Year Rate Plan: MRPs are a price mechanism that sets a utility's base rates and revenue requirements for longer than a single 12-month period. MRPs specify rates beyond the rate effective year of a rate case by applying a formula or index, or detailed forecasts for allowable rate changes over the duration of the plan. For example, instead of a utility filing a new general rate case when conditions change, an MRP may forecast what these conditions are and adjust rates within a single rate case. Utilities advance the argument that MRPs facilitate recovery of capital costs between general rate cases. While this may result in reduced risk and allow for lower returns, and greater predictability of rates which would benefit customers, MRPs may be viewed as shifting the risks from the utility to customers. Arguably, having rate cases on a predictable schedule may, over time, be mutually beneficial to utilities and customers (sometimes benefiting the utility and other times benefiting customers). MRPs may also be an opportunity to reduce the number of automatic adjustment clauses (a/k/a trackers or riders). From a public policy perspective, especially when MRPs are based on quantifiable performance metrics (perhaps as part of *Performance-Based Rates* and Regulation), may provide incentives for enhanced performance by the utilities.

Multiple Contingencies: For transmission and resource planning, assessing the implications of multiple contingencies on the reliable operations of the electric system is essential. Any combination of losing a generating unit, a transmission circuit, a transformer, or a shunt device would constitute a multiple contingency under NERC Standard TPL-004-4. There are other situations that would result in a multiple contingency such as a failure of an element that prevents clearing a fault.

Muni: A municipal or city-owned utility. See also municipalization.

Municipal Solid Waste: Most commonly thought of as trash and garbage. In 2013, Americans generated about 254 million tons of trash and recycled and composted about 87 million tons of this material, equivalent to a 34.3 percent recycling rate. On average, we recycled and composted 1.51 pounds of our individual waste generation of 4.40 pounds per person per day In 2014, 84 waste-to-energy facilities were in operation in the U.S., with a combined capacity to generate 2,769 megawatt-hours of electricity.

Municipalization: Almost from the beginning of the electric industry, some communities built their own systems. Generally, this decision was in response to market failure for investor-owned utilities to extend service. Despite the ubigutiousness of electric service in the U.S., every year, several communities investigate their options such as San Francisco considering buying Pacific Gas & Electric in 2019 after several fires resulted in blackouts. Cities often consider reliability, cost, and local control as reasons to municipalize their electric systems. Following the acquistion of El Paso Electric In 2019-20, El Paso is considering city ownership. Beginning in 2015, the City of Boulder began its municipalization effort. In October 2019, the Colorado Public Utilities Commission approved the city's request to condemn certain XCEL facilities. In November 2019, Boulder Colorado offered Xcel Energy $94 million to takeover the system serving Boulder. A final vote will be held in November 2021. As of 2020, Pueblo Colorado and Pittisburg Kansas are exploring municipal ownership. Even New York City is considering buying assets from Consolidated Edison due to a power outage in Manhattan on July 13, 2019.

In 2018, American Public Power Association had a membership in excess of 2000 not-for-profit utilities serving 49 states. This includes over 100 Joint Action Agencies that generate or buy power for their city members.In 2016, the 15 largest municipal utilities by population served include: The Puerto Rico Power Authority, Los Angeles Department of Water and Power, Long Island Power Authority, Salt River Project (AZ), CPS Energy, Sacramento Municipal Utility District, Austin Energy, Jacksonville Electric Authority, Seattle City Light, Memphis Light, Gas, and Water Division, Nashville Electric Service, Omaha Public Power District, Public Utility District No 1 of Snohomish County, Orlando Utilities Commission, Colorado Springs Utilities.

Munn v Illinois 94 U.S. 113 (1877 – (see also Smyth v Ames 1898, Bluefield 1923, and Hope 1944). The Supreme Court upheld the authority of states to regulate private enterprise. Chief Justice Waite wrote for the majority, that state power to regulate extends to private industries that *affect the public interest*. Because grain storage facilities were devoted to public use, their rates were subject to public regulation. Moreover, Waite declared that even if Congress alone is granted control over interstate commerce, a state could take action in the public interest without impairing that federal control. In 1871, the legislature of Illinois, under pressure from the National Grange, set maximum rates for private companies to charge for the storage and transport of agricultural products. The Chicago grain warehouse firm of Munn and Scott was found guilty of violating the law but appealed the conviction on the grounds that the law was an unconstitutional deprivation of property without due process of law that violated the Fourteenth Amendment.

Must Run Generation see also Reliability Must Run (RMR): Generation designated to operate at a specific level and not available for economical dispatch. Also referred to as *fixed generation*. From an RTO's perspective, some units are regarded as essential to meet reliability requirements, needed to meet load requirements in a constrained area, or needed for voltage support. Often these are units that the owner intends to retire (deactivate) that are not economically viable in the wholesale market but serve a reliabillty purpose. The RTOs / ISOs provide compensation for such units in their FERC approved tariffs. These units may retain this status until there are new transmission or other resources that address the reliabilty concerns.

A generation owner might offer-in generation with the specification that a certain minimum amount of capacity would be made avaiable at a specific price but that the RTO / ISO must accept that amount if the RTO / ISO dispatches the unit. In some instances, a generator may regard a unit as must run because it is operationally too costly to take the unit off-line and restart it in a relatively short period of time (e.g., a nuclear generating unit). In this instance, a low offer price – perhaps as low as "0," might be made to ensure the unit is included in the RTO's / ISO's dispatch.

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N-1: A first contingency; the largest impact on the system when a first power element (generation or transmission facility) of a system is lost.

N-1-1, N-2: A second contingency; the loss of the facility that would have the largest impact on the system after the first facility is lost.

NAICS (North American Industry Classification System): A coding system developed jointly by the United States, Canada, and Mexico to classify businesses and industries according to the type of economic activity in which they are engaged. NAICS replaces the Standard Industrial Classification (SIC) codes.

Name Plate Capacity (see also Generator Nameplate Capacity (installed)): The full-load continuous rating of a generator, prime mover, or other electrical equipment under specified conditions as designated by the manufacturers.

Name Plate Rating (a/k/a the **Rated Capacity**, N**ominal Capacity**, or I**nstalled Capacity**), is the intended full-load sustained output of a power plant. Nameplate capacity is the number registered with NERC, state, and other authorities for classifying the electric power output of a generating station; usually expressed in megawatts (MW). Power plants with an output consistently near their nameplate capacity have high capacity and availability factors.

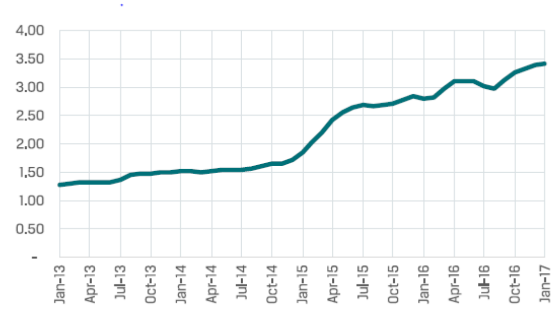
Narrowly Constrained Area (NCA): A geographic area that is served by few (e.g., 1-3 "Pivotal Suppliers" which could enable these suppliers to exercise market power in providing electrical service to those within the Narrowly Constrained Area.

Native Load (Electric): The end-use customers that the Load-Serving Entity is obligated to serve. (NERC definition). The wholesale and retail power customers of the Transmission Provider on whose behalf the Transmission Provider, by statute, franchise, regulatory requirement, or contract, has undertaken an obligation to construct and operate the Transmission Provider's system to meet the reliable electric needs of such customers (FERC definition).

Native Load Customers: The wholesale and retail power customers of the Transmission Provider on whose behalf the Transmission Provider, by statute, franchise, regulatory requirement, or contract, has undertaken an obligation to construct and operate the Transmission Provider's system to meet the reliable electric needs of such customers (FERC definition).

Natural Gas: Natural gas may be dry *or wet.* Typically, the media refers to dry gas because of its use dominant use for heating, cooling, and electrical power generation. Compressed dry gas is used for natural gas vehicles. Natural gas consists of several hydrocarbons. These hydrocarbons include ethane, butane, pentane etc. Methane is the most prevalent constituent. The higher the concentration of methane the *drier* the natural gas is and it is what remains after the liquefied hydrocarbons such as hexane, octane, etc. and non-hydrocarbons (helium, nitrogen etc.) impurities are removed. The largest dry gas producing states include Texas, New Mexico, Louisiana, Oklahoma, and Wyoming. Wet natural gas contains less than 85% methane. Pennsylvania, Texas, Louisiana, Oklahoma, and Colorado have the largest yields of wet gas.

Natural Gas and Oil Drilling Techniques: NEW-WELL GAS PRODUCTION PER RIG (MMCFD) 2016



Source: Energy Information Administration (EIA), Drilling Productivity Report

Significant improvements in drilling efficiency, well completion techniques, fracturing technologies, and multi-well drill sites (8 to 10 horizontal wells from a single well pad) have substantially increased gas supply.. From 2012 – 2016, well productivity has increased by roughly 300 percent. As a result, natural gas prices are likely to be steadier and less volatile than in the past. As oil and gas producers continue to improve well completion technologies, each well will become more productive and impactful on overall supply. The cost variations across the studied areas arise primarily from differences in geology, well depth, and water disposal options. For example, Bakken wells are the most costly because of long well lengths and use of higher-cost manufactured and resin coated proppants. In contrast, Marcellus wells are the least costly because the wells are shallower and use less expensive natural sand proppant. The Bakken play has consistently had the lowest average drilling and completion costs of the basins. [see "*Trends in U.S. Oil and Natural Gas Upstream Costs*," EIA, March 2016].

Natural Gas Liquids (NGL or Condensates): Components of natural gas that are in gaseous form in the reservoir, but can be separated from the natural gas at the wellhead or in a gas processing plant in liquid form. NGLs include ethane, propane, butanes, pentanes, and heavier hydrocarbons. The higher the percentage of NGLs. The *wetter* or *hotter* the natural gas is. The NGLs must be stripped out of the gas before it can be transported in the pipeline system.

Natural Gas Plant Liquids (NGPL): Those hydrocarbons in natural gas that are separated as liquids at natural gas processing, fractionating, and cycling plants. Products obtained include ethane, liquefied petroleum gases (propane, normal butane, and isobutane), and natural gasoline. Component products may be fractionated or mixed. Lease condensate and plant condensate are excluded.

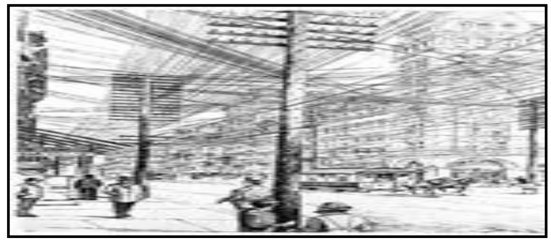
Natural Gas Specification: The following table was from a Report by Science Applications International Corporation (SAIC) prepared for the Energy Information Administration Office of Energy Analysis, February 2013

Component		Volume Percentage	
Methane	CH_4	93.9	
Ethane	C_2H_6	3.2	
Propane	C_3H_8	0.7	
n-Butane	C_4H_{10}	0.4	
Carbon Dioxide	CO_2	1.0	
Nitrogen	N_2	0.8	
Total		100.0	
		LHV	HHV
kJ/kg MJ/scm (1)		47.764 35	52,970 39
Btu/lb Btu/scf (2)		20,552 939	22,792 1,040

(1) Mega joules per standard cubic meter ("MJ/scm").
(2) Standard cubic feet ("scf").

Natural Monopoly: A situation where one firm can produce a given level of output at a lower total cost than can any combination of multiple firms. Natural monopolies occur in industries which exhibit decreasing average long-run costs due to size (economies of scale). The development of *retail competition, merchant generation* and *merchant transmission* has challenged the natural monopoly paradigm.

According to economic theory, a public



monopoly governed by regulation is justified when an industry exhibits natural monopoly characteristics such as: economies of scale, an essential service, significant barriers to entry such as cost, and where competition would result in wasteful and expensive duplication of services.

Naturally Occurring Efficiency: The amount of savings that can be expected to result from the adoption of energy-efficient measures by consumers in response to normal market dynamics such as product features and electricity price. (LBL)

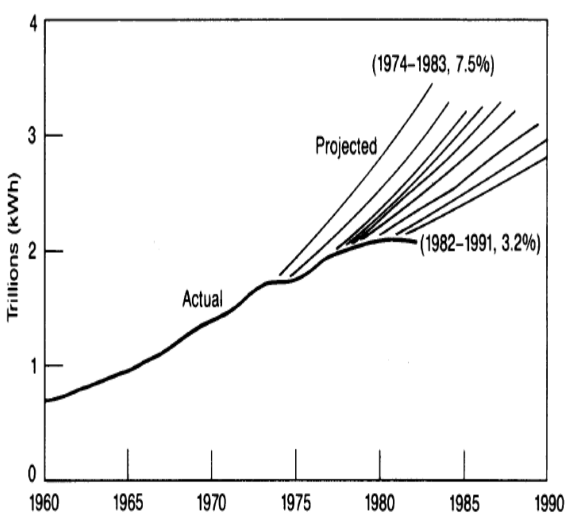
Near Term Transmission Planning Horizon: The transmission planning period that covers Year One through five. (NERC)

NEEM: NEEM & MRN model – from Charles River and Associates - combines the North American Electricity and Environment Model (***NEEM***) and the Multi-Region National (***MRN***) model. This integrated modeling approach is a general equilibrium solution, meaning that all markets in the economy are at equilibrium. The NEEM model uses the "pipe and bubble approach" as a proxy for interregional transfers of power. That is, a single "pipe" might be used to represent the transfer capability between two regions (bubbles).

NERC (North American Electric Reliability Corporation – formerly **"Council"*)***: The non-profit entity (ten regional councils and one affiliate) established in 1968 following the blackout in 1965 to promote the reliability of North America's electric supply. Now under FERC authority as a result of the Energy Policy Act of 2005. See also Electric Reliability Organizations (EROs).

National Environmental Policy Act (NEPA): 1970 law requires environmental impact statements (EAs) for major infrastructure. NEPA was a model for more than 100 nations.

NERC FAN: The NERC fan shows successive declines in utilities' ten year load forecasts. Beginning in1974 as utilities embarked on a boom cycle to build new electric generators to meet anticipated demand for electricity, the North American Electric Reliability Council (NERC – now North American Electric Reliability Corporation) combined and published utilities'10-year electric load forecasts. The figure below shows the rate of growth between 1951 and to 1973 was 7.8% compounded. The forecasts for 1974-1983 projected a growth rate of 7.5%. However, actual growth after 1973 fell sharply (recall during the 1970s there were two oil embargoes and significant public policy changes). Through 1982, the actual growth rate was only 2.2%. From 1983-1992, the forecasts showed continual declines to 3.2%. The shortfall of actual electricity sales relative to forecasts and persistent downward revisions of projected growth rates raised several questions. See chart below:



NESHAPs (National Emissions Standards for Hazardous Air Pollutants): Under the Mercury and Air Toxics Rule (MATS of 2011). The standards are for, in excess of 170 chemicals or chemical compounds that are air pollutants not covered by the National Ambient Air Quality Standards –NAAQS. These pollutants may cause an increase in serious illnesses.

Net Avoidable Cost Rate (NACR): These are the avoidable costs associated with the incremental costs of a capacity resource minus projected revenues where the avoidable cost rate (ACR) is the total annual Avoided Cost / MW ICAP / 365 days ($/MW day). This is used in context with the Minimum Offer Price Rule.

Net Book Value: NBV is the recorded cost of an asset or group of assets minus the accumulated provision for depreciation of these assets.

Net Capability: Net Summer Capability and Net Winter Capability:

Net Summer Capability. The steady hourly output which generating equipment is expected to supply to system load (exclusive of auxiliary) power as demonstrated by test at the time of summer peak demand.

Net Winter Capability. The steady hourly output which generating equipment is expected to supply to system load (exclusive of auxiliary) power as demonstrated by test at the time of winter peak demand.

Net Capacity Factor (NCF): NCF measures the actual amount of electricity generated as a fraction of the maximum possible energy that could be generated if the unit or station were operated at maximum capacity. NCF shows the output over a period of time. A higher NCF means greater utilization of the unit in a given period.

NCF = 100% X (Net Actual Generation) / [Period Hours X (Net Maximum Capacity)]

Net CONE (see also Cost of New Entry or CONE, and Gross Cone) is determined as the estimated nominal levelized fixed costs of new entry (Gross CONE) based on a 20 year asset life of a combustion turbine net of estimated energy and ancillary service (E&AS) margins (net revenues).

Net Energy for Load (Electric): Net Balancing Authority Area generation, plus energy received from other Balancing Authority Areas, less energy delivered to Balancing Authority Areas through interchange. It includes Balancing Authority Area losses but excludes energy required for storage at energy storage facilities. (NERC definition)

Net Energy for System: The sum of energy an electric utility needs to satisfy their service areas, including full and partial requirements consumers.

Net Generation: The amount of gross generation less the electrical energy consumed at the generating station(s) for station service or auxiliaries. *Note*: Electricity required for pumping at pumped-storage plants is regarded as electricity for station service and is deducted from gross generation.

Net generation is the amount of electricity a power plant (or generator) supplies to the power transmission line connected to the power plant. Net generation accounts for all the electricity that the power plant consumes to operate the generator(s) and other equipment, such as fuel feeding systems, boiler water pumps, cooling equipment, and pollution control devices. To express the efficiency of a generator or power plant as a percentage, divide the equivalent Btu content of a kWh of electricity (3,412 Btu) by the heat rate. For example, if the heat rate is 10,500 Btu, the efficiency is 33%. If the heat rate is 7,500 Btu, the efficiency is 45%.

Net Interchange: Gross import volume less gross export volume in MWh.

Net Load: System load that is served by traditional generation after all renewable supply has been used, equal to total customer load less renewable generation.

Net Load Curve: This represents load minus wind and solar output.

Net Metering: Measurement of the difference between the electricity that is supplied by the investor-owned electric utility to a net metering customer and the electricity that is supplied back to the investor-owned electric utility by a net metering customer.

Net Operating Income (NOI): Subtracting *Net Operating Expenses* from *Net Operating Revenues* results in Net Operating Income. More generally, NOI is the annual income generated by an income producing property after taking into account all income collected from operations, and deducting all expenses incurred from operations. Subtracting *Net Operating Expenses* from *Net Operating Revenues* results in Net Operating Income.

Net Output Factor (NOF): NOF measures the output of a generating unit as a function of the number of hours it was in-service and synchronized to the bulk power system (grid). Units with higher NOF were dispatched more often.

NOF = 100% x (Net Actual Generation) / [Scheduled Hours x (Net Maximum Capacity)]

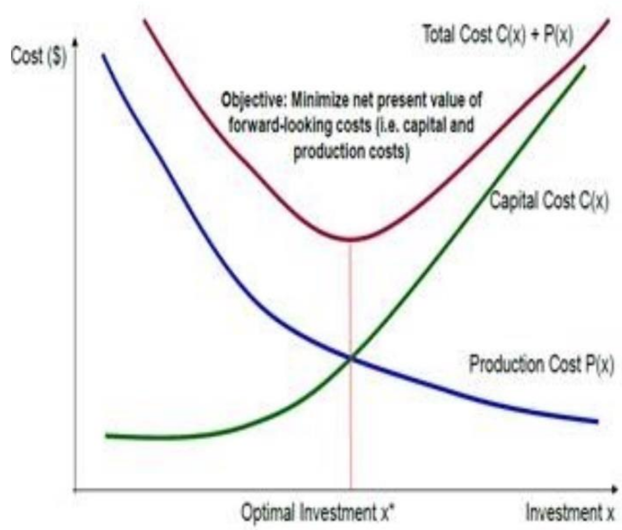
Net Present Value (NPV): Compares the value of a dollar today to the value of that same dollar in the future, taking inflation and returns into account. If the NPV of a prospective project is positive, it should be accepted. However, if NPV is negative, the project should probably be rejected because cash flows will also be negative. Formula:

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_o$$

Where:

C_t = net cash flow in period t
C_o = total initial investment costs
r = discount rate

Net Present Value of Revenue Requirements (NPVRR – see Net Present Value): This term is the Net Present Value applicable to the revenue requirement of regulated utilities. As with the calculation of NPV, the selection of a reasonable *discount rate* is critical to NPVRR. NPVRR is especially useful in the context of evaluating different resource portfolios – including DSM - that emanate from Integrated Resource Planning. Often, the objective function of a scenario is to minimize the long-term revenue requirement for a specific group of resources - or the NPVRR - over a given planning horizon (e.g., 20 years).



Net Scheduled Interchange (NSI): The algebraic sum of all Interchange Schedules across a given path or between Balancing Authorities for a given period or instant in time.

Net Tie Flow: This is telemetered. It is the summation of all the flows on all ties between RTOs.

Network Integration Transmission Service: Service that allows an electric transmission customer to integrate, plan, economically dispatch and regulate its network reserves in a manner comparable to that in which the Transmission Owner serves Native Load customers.

NETL: The National Energy Technology Laboratory (*NETL*), part of DOE's national laboratory system, is owned and operated by the U.S. Department of Energy (*DOE*). NETL supports DOE's mission to advance the national, economic, and energy security of the United States.

Network Integration Transmission Service (NITS): (see also Point-to-Point Transmission Service.) Service that allows an electric transmission customer to integrate, plan, economically dispatch and regulate its network reserves in a manner comparable to that in which the Transmission Owner serves Native Load customers.

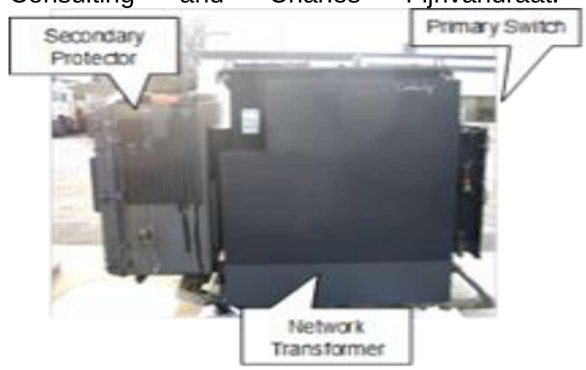
NITS allows Network Customers to more efficiently use their network resources (and non-designated generating resources) to serve their load. NITS is used for the transmission of capacity and energy from generating and other network resources within or deliverable to the Regional Transmission Organization (RTO). The customer purchasing Network Transmission Service must also obtain or provide *Ancillary Services*. Network Transmission Service also may be used by a network customer to deliver economy energy purchases to its network load from non-designated resources. (The Midcontinent ISO also applies *Zonal rate* charges in addition to MISO system-wide rates). For billing purposes, Network Integrated Transmission Service is based on *coincident demand* which differs from Point-to-Point.

Network Model: A mathematical representation of the physical electric grid which includes system topology and equipment parameters.

Network Protector: Is installed on the secondary side of the transformer. The purpose is to be a circuit breaker with automatic open and close capabilities based on various algorithms programmed into the relays associated with the protector.

Network Service Peak: A load's contribution to the zone's annual peak load.

Network Transformers: Take the primary voltage (e.g., 13.2 kV) and step it down to secondary or customer utilization voltage. These are designed to be either submersible or non-submersible, located inside a dry building vault or in an underground street or sidewalk vault. [IEEE C37.12.40 is the standard]. Courtesy of O'Neill Management Consulting and Charles Fijnvandraat.



New Entry Pricing: In PJM, this allows planned generation resources that satisfy the requirement criteria to recover the amount of their initial Base Residual Auction (BRA) cost-of-entry-based offer for up to two additional consecutive delivery years.

New York Independent System Operator (NYISO): Providing service to New York state.

N**ext Generation Nuclear Plant:** The NGNP was envisioned to demonstrate the technical viability *of high temperature gas-cooled reactor* (HTGR) technology that could provide both electricity and high-temperature process heat for a variety of industrial uses. The program has sponsored collaborative efforts with universities, industry, and the U.S. Nuclear Regulatory Commission (NRC) to conduct R&D necessary to license and demonstrate a new generation of gas-cooled, accident-tolerant reactors in the United States. Collaborative efforts have also been conducted with international researchers through the Generation IV International Forum Very High Temperature Reactor System Arrangement and R&D has continued on TRISO coated particle fuels, materials, design methods, and user applications.

Neyman Allocation (Statistical sampling that can be used in DSM, forecasting, cost-of-service,): Neyman allocation is used by utilities (and other researchers) to increase the predictive efficiency of the sample (ideally with increased sample size). The purpose of the method is to maximize survey precision, given a fixed sample size. With Neyman allocation, the "best" sample size for stratum *h* would be: $n_h = n * (N_h * S_h) / [\Sigma (N_i * S_i)]$ where n_h is the sample size for stratum *h*, n is total sample size, N_h is the population size for stratum *h*, and S_h is the standard deviation of stratum *h*. We try to put the population into series of homogeneous groups and by this, the precision will be increased. When the population of interest can be divided into k homogeneous groups and the sample of observation is taken from each group, we have a stratified random sample and each group is called a stratum. The Neyman Allocation has some advanges over proportionate stratification. Strata sample sizes are determined by the following equation: $n_h = (N_h / N) * n$. If the researcher has considerable information about the population, stratification of any type into more homogenous groups can increase the statistical precision.

Nitrogen Oxides (NO_x): Compounds of nitrogen and oxygen produced by the burning of fossil fuels.

Nitrous Oxide (N_2O): A colorless gas, naturally occurring in the atmosphere. Nitrous oxide has a 100-year Global Warming Potential of 310.

No Notice Service: When gas pipeline companies provide gas on short notice.

No Regrets (Nash Equilibrium): People often anticipate regret if they make a wrong choice, The fear of making a wrong choice – being *risk averse* - factors into consideration of making difficult decisions. A no regrets outcome is achieved when the decision maker(s) will have no regrets about the consequences of their decisions. In game theory, it means no player can increase payoff by changing decisions unilaterally. That is, once a decision is made, the player will have no regrets about the consequences.

No Bump Rule (or **Flowing Gas No-Bump Rule**) (Natural Gas): A tariff provision governing interruptible transportation, which dictates that a shipper may temporarily lose its full contract volume rights if shipping a lower volume. Under the no-bump rule, a shipper flowing gas cannot be bumped (i.e., lose capacity) because a shipper with a higher priority in the interruptible transportation schedule increases its gas receipts within its transportation contract.

NOAA: National Oceanic and Atmospheric Administration.

Node or Nodal Pricing (see also LMP or Locational Marginal Cost Pricing): A node is used in simulation modeling to represent an aggregation of significant amounts of electrical demand and/or supply, to simplify the modeling calculations (relative to modeling each power plant or load center individually). Each interconnection is broken down into a set of nodes connected to each other by transmission paths.

Nodal Price: The price for electric energy received or furnished at a node for any given hour. Typically, this is used in a Locational Marginal Cost (LMP) based market.

Nominal Dollars: A measure used to express nominal price.

Nominal Price: The price paid for a product or service at the time of the transaction. Nominal prices are those that have not been adjusted to remove the effect of changes in the purchasing power of the dollar; they reflect buying power in the year in which the transaction occurred.

Nominal Rating: The rating as defined by the equipment owner that specifies the level of electrical loading, usually expressed in megawatts (MW) or other appropriate units that a system, facility, or element can support or withstand through the daily demand cycles without loss of equipment life.

Nominated Demand Response Value: The nominated DR value is the installed capacity load reduction that is committed to respond during a pre-emergency or emergency load management event. The value cannot exceed the customer's Peak Load Contribution.

Nomogram: A graphic representation that depicts operating relationships between generation, load, voltage, or system stability in a defined network. On lines where the relationship between variables does not change, a nomogram can be represented as a single transmission interface limit; in many arenas, the nomogram indicates that an increase in transfers into an area across on line will require a decrease in flows on another line.

Non Attainment Area: Any area that does not meet the national primary or secondary ambient air quality standard established by the Environmental Protection Agency for designated pollutants, such as carbon monoxide and ozone.

Non Coincident Peak Demand (NCP): Sum of two or more demands on individual systems that do not occur in the same demand interval. Non-Coincident demand is typically used by transmission planners to assess the loading on individual elements of the transmission system. In contrast, resource planners typically are concerned with the maximum coincident demand at the time of the system peak demand.

Non Dispatchable Resources (NDR): Any system resource that does not have active power management capability such as *Automatic Generation Control* (AGC) or cannot respond to dispatch signals. These may include some nuclear generating units, geothermal generators, older utility-scale renewable generators,and DERs.

Non Economic Generation: Units producing energy at an offer price greater than the LMP.

Non Firm Transmission Service: Transmission service that is reserved on an as-available basis and is subject to curtailment or interruption. (NERC)

Non Firm Point to Point Transmission Service: Point-to-Point Transmission Service under the Tariff that is reserved and scheduled on an as-available basis and is subject to curtailment or interruption. Non-Firm Point-to-Point Transmission Service is available on a stand-alone basis for periods ranging from one hour to one month.

Non Firm Power: Power or power-producing capacity supplied or available under a commitment having limited or no assured availability.

Non Requirements Consumer: A wholesale consumer (unlike a full or partial requirements consumer) that purchases economic or coordination power to supplement their own or another system's energy needs.

Non Retail Behind the Meter Generation: Used by city and cooperatively owned distribution companies.

Non Spinning Reserve: The generating capacity not currently running but capable of being connected to the bus and load within a specified time. (NERC)

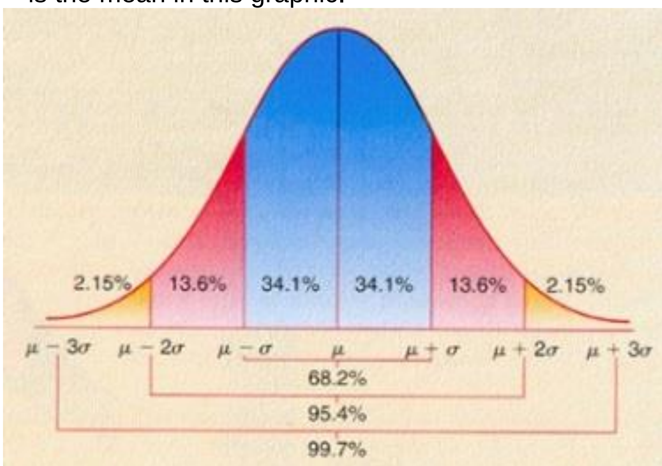
Non Synchronous Generator: This is a generating resource that is not directly connected to the electrical grid because it does not operate at the same frequency as the grid. Examples are wind and solar farms which in some cases generate DC power which is then converted to AC power via a rectification process. These resources are electronically coupled to the grid.

Non Wires Alternatives: These include alternatives to transmission and distribution investments, typically through load reductions or load shifting as a result of investments in distributed generation. These are non-traditional investments or technologies that affect the operations of the utility that defer, mitigate, or eliminate the need for traditional investments in transmission and distribution systems.

There is no consensus for a definition of NWA. However, Navigant defined NWA as "*An electricity grid investment or project that uses non-traditional T&D solutions such as distributed generation, energy storage, energy efficiency, demand response, and gird software and controls, to defer or replace the need for specific equipment upgrades, such as T&D lines or transformers, by reducing load at a substation or circuit level.*" For example, NWA is intended to reduce customer costs by relieving congestion on the distribution system at specific times and locations. NWA, combined with traditional distribution system planning, increasingly affects the wholesale markets. As a result, utilities and state regulatory commissions are considering integration of distribution system planning into their comprehensive Integrated Resource Planning process.

Normal (Pre-Contingency) Operating Procedures: Operating procedures that are normally invoked by the system operator to alleviate potential facility overloads or other potential system problems in anticipation of a contingency.

Normal Distribution (Statistical) **and three standard deviations**: (68.2%, 95.4%, and 99.7%) of observations would be within 1, 2, and 3 SD of the mean**,** respectively. The center is the mean in this graphic.



Normal Rating: The rating as defined by the equipment owner that specifies the level of electrical loading, usually expressed in megawatts (MW) or other appropriate units that a system, facility, or element can support or withstand through the daily demand cycles without loss of equipment life. (NERC)

Normal Voltage Limits: The operating voltage range on the interconnected systems that is acceptable on a sustained basis.

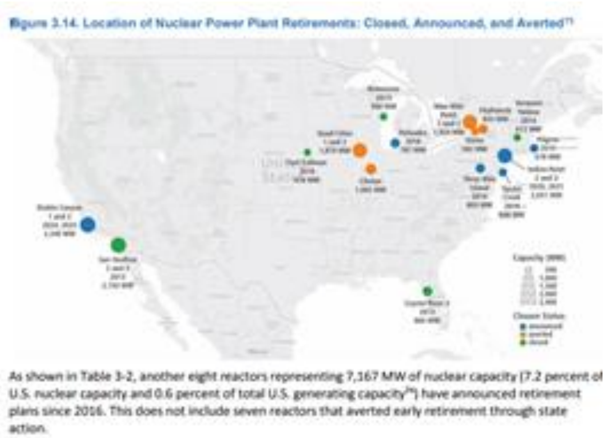
North American Electric Reliability Corporation (NERC)**:** Formerly, the North American Electric Reliability Council. It was changed after EPAct 05 and is now subject to audit by the U.S. Federal Energy Regulatory Commission and governmental authorities in Canada. NERC operates as an electric reliability organization to improve the reliability and security of the bulk power system in North America. To achieve that, NERC develops and enforces reliability standards; monitors the bulk power system; assesses future adequacy; audits owners, operators, and users for preparedness; and educates and trains industry personnel. As the Electric Reliability Organization,

North American Energy Standards Board (NAESB): An industry group of energy companies created to standardize operating and scheduling procedures for natural gas and electricity across North America.

Notice of proposed rulemaking (NOPR) — A document released by a regulatory agency in which the agency sets forth a proposed revision to its rules and gives market participants notice concerning the regulatory proceeding that will consider these revised rules.

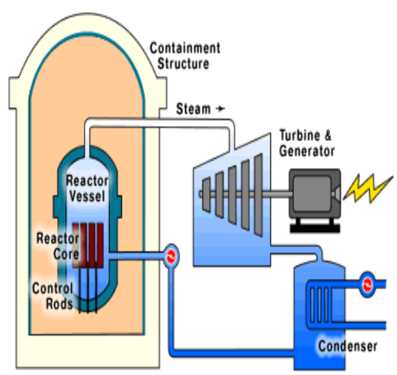
Nuclear Power Plant Accidents: The International Atomic Energy Agency (IAEA) defines a nuclear and radiation accident as "an event that has led to significant consequences to people, the environment or the facility." Examples include lethal effects to individuals, large radioactivity release, or reactor core melt. The prime example of a "major nuclear accident" is one in which a reactor core is damaged and significant amounts of radioactivity are released, such as in the Chernobyl disaster in 1986. Nuclear power plant accidents include the Fukushima Daiichi nuclear disaster (2011), Chernobyl disaster (1986), Three Mile Island accident (1979), and the SL-1 event. The Stationary Low-Power Reactor Number One, was a U.S. Army experimental nuclear unit which underwent a steam explosion and meltdown on January 3, 1961, killing its three operators. The direct cause was the improper withdrawal of the central control rod, responsible for absorbing neutrons in the reactor core. The event is the only reactor incident in the United States which resulted in immediate fatalities.

Nuclear Power Plant Retirements (2016): *Staff Report to the Secretary on Electricity Markets and Reliability*, August 2017, page 30.



Nuclear Reactors Types (Nuclear): The basic nomenclature of nuclear reactors includes several important terms. The first part of the description is the type of coolant used to remove heat from the reactor core. Typical coolants are:

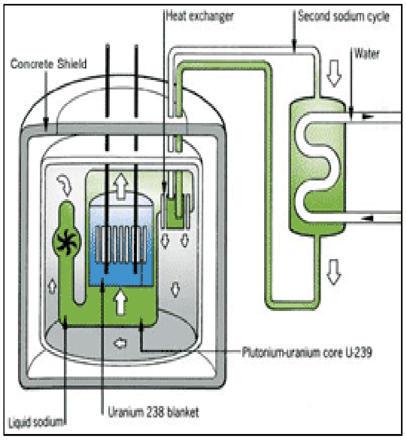
- **Light Water.** This is regular water (H_2O). All operating power reactors in the U.S. employ light water as a coolant. The graphic is of a "*boiling water reactor*."



- **Heavy Water.** This is water in which the hydrogen atom contains a proton and a neutron and is called Deuterium (D_2O). Operating power reactors in Canada employ heavy water as a coolant.

- **Gas.** Carbon dioxide or an inert gas such as helium may be used as a coolant.

- **Liquid Metal.** Liquid metal may be sodium, a combination of sodium and potassium, lead and bismuth, or some other metal(s). Metal-cooled reactors may have a "loop" or "pool" design. The graphic is of a "*liquid metal fast breeder reactor."*



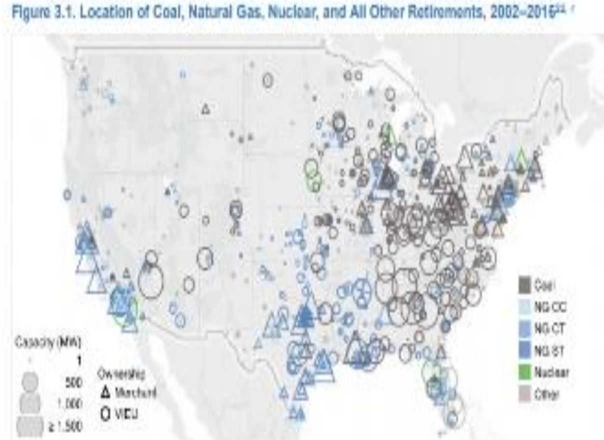
See also Molten Salt:

Nuclear Regulatory Commission Licensing Capability (Nuclear): The NRC is considered the "gold standard" in terms of licensing expertise with light water reactors. However, long lead times for design certification of light water reactors may push reactor developers to build new designs, such as SMRs, in other countries. Additionally, the NRC's lack of experience and current capabilities to license technology other than a light water reactor may push developers of non-light water reactor technology overseas or into Canada to build their prototypes.

Nuclear Uprates (Nuclear): Nuclear power uprates can extend the life of existing plants and create incremental increases in unit output. The overnight cost of extended power uprates is estimated to be half that of new nuclear construction. This cost can still exceed the cost of alternative generation with more dynamic load response than a nuclear power plant. In addition to cost, policy makers should consider attributes such as load following response capabilities in their deliberations as applicable to their local power market characteristics.

Nuclear, Coal, and Natural Gas Power Plant Closures from 2002-2016: _Staff Report to the Secretary on Electricity Markets and Reliability_, Page 15, August 2017. Power plant retirements have accelerated since 2011 and retirement trends vary significantly by generation source. For instance, the current wave of nuclear plant retirements only occurred over the last five years. u Some of the nuclear units now closing are doing so because of state policy pressure (as with California's Diablo Canyon, New Jersey's Oyster Creek, and New York's Indian Point), and some have had maintenance issues that were too costly to fix. However, most plants are closing or threatening closure because–given the economics in some regions—they have become unable to compete against primarily low-cost, gas-fired generation and, to a lesser extent, subsidized and mandated VRE in a low electricity demand environment.

Figure 3.1. Location of Coal, Natural Gas, Nuclear, and All Other Retirements, 2002–2016



Null Hypothesis or H_o (Statistics - see also Alpha, P-Value, T-Value, and Confidence Interval): In *inferential statistics*, the term "null hypothesis" usually refers to a statement or default position that there is no relationship between two measured phenomena, or no difference among groups. The statistician tries to disprove the hypothesis. That is if the statistics obtain a small enough P-Value that it is lower than our *level of significance* **Alpha** and we are justified in rejecting the null hypothesis. If our P-Value is greater than Alpha, then we fail to reject the null hypothesis. A null hypothesis is opposite of an *alternative hypothesis* H_a. The following is an example of a Null Hypothesis: Customers will *not* reduce their use of electricity when the price gets above 75 cents per kWh on the hottest day. An alternative hypothesis would be: Customers will reduce their electric use when prices gets above 75 cents per kWh on the hottest day.

NuScale (nuclear): NuScale is a Small and Modular Reactor that was designed using Integral Pressurized Water Reactor (IPWR) that is a well- established Light Water technology. These units are 50 MW and scalable.

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Obligation to Serve: The obligation of a utility to provide electric service to any customer who seeks that service, and is willing to pay the rates set for that service.

Occam's Razor (see Integrated Resource Planning as a potential application) is a principle attributed to the 14th century logician William of Ockham. The value of Occam's Razor is encapsulated in the following statement: "when you have two competing theories that make exactly the same predictions, the simpler one is the better." Occam's Razor can separate two theories that make the same predictions, but does not rule out other theories that might make a different prediction. Empirical evidence is also required, and Occam himself argued *for* empiricism, not *against* it. Occam's Razor influenced Quantum Mechanics.

Off Balance Sheet Debt (OBS Debt) and Financing: Off-Balance Sheet refers to legal obligations not shown as liabilities on the Balance Sheet. Financing that is not shown as a liability in a company's balance sheet. For example, sometimes a long term lease is treated as an operating lease under Generally Accepted Accounting Principles (GAAP).

Off Cost: Out of merit dispatach operation that may necessitate the need for more expensive resources to decrease their output to relieve a transmission constraint.

Offer Cap: The PJM, for example, established a $1,000 per MWh offer cap, as a market mitigation measure, when the local market structure is not competitive as a means of preventing abusive conduct by market participants that seek to exploit market flaws or temporary market aberrations.

Offer Cap – Reliability: PJM, for example, invokes an offer cap that limits the prices paid for generating units that are committed for reliability reasons such as *black start* or units needed to provide *reactive power.* This can occur in the Day-Ahead or Real-Time Markets.

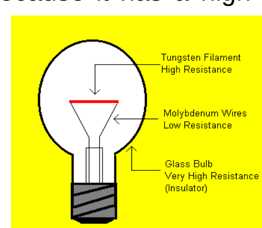
Offer Data: The scheduling, operations planning, dispatch, new resource, and other data and information necessary to schedule and dispatch generation resources and Demand Resource(s) for the provision of energy and other services and the maintenance of the reliability and security of the transmission system.

Offers (see also Bids): Generators submit to the system operator offers to sell electricity – at the sale price at the point of injection into the grid but prior to transmission. The system operator then purchases and dispatches the generation in order of offered price, lowest to highest, basing the locational selling price of power at the nodes on the bid and offer prices it receives.

Off Peak: Period of relatively low system demand. These periods often occur in daily, weekly, and seasonal patterns; these off-peak periods differ for each individual electric utility. Most utilities experience off peak use during weekends, holidays or times of the day when many businesses are not operating, during evenings and early morning (e.g., during the summer when the heat is less intense).

Off Peak Energy: This is energy supplied during periods of relatively low system demands as specified by the supplier *(see also On-Peak Energy).*

Ohm: An Ohm (Ω) is a measure of how much a material resists a flowing current. The filament in this light bulb glows because it has a high resistance and gets hot. The support wires have low resistance - they don't glow. The glass has a resistance so high that the current can't move through it - glass makes a good insulator.



Ohm's Law: In a given electrical circuit, the amount of current in amperes is equal to the pressure in volts divided by the resistance, in ohms. The principle is named after the German scientist Georg Simon Ohm, For Direct Currents voltage equals current multiplied by resistance: for Alternating Currents impedance replaces resistance, such that voltage equals current multiplied by impedance:

$$Voltage\ (V) = Current\ (I) \times Resistance\ (R)$$

Oil Sands: Are a combination of clay, sand, water, and bitumen, a heavy black viscous oil.

Oil sands can be mined and processed to extract the oil-rich bitumen, which is then refined into oil. The bitumen in oil sands cannot be pumped from the ground in its natural state; instead oil sand deposits are mined, usually using strip mining or open pit techniques, or the oil is extracted by underground heating with additional upgrading.

Oil Shale: A kerogen-bearing, finely laminated brown or black sedimentary rock that will yield liquid or gaseous hydrocarbons on distillation. Oil shale, despite the name, does not actually contain oil, but rather a type of organic matter called kerogen, a precursor of oil that is converted to a type of crude oil when heated to about 450 – 500° C.

Old Gas: Gas produced before April l977 or from new wells drilled in old formations were not subject to deregulation under the Natural Gas Policy Act. The price differential between old and new gas was intended to spur production.

On Peak: Periods of relatively high system demand. These periods often occur in daily, weekly, and seasonal patterns; these on-peak periods differ for each individual electric utility.

On Peak Energy: This is energy (kWh or MWh) supplied during periods of relatively high system demands as specified by the supplier.

On the Margin: Power system operators dispatch generators based on cost and physical capabilities. Generators are dispatched sequentially from lowest to highest cost. The last generator to be dispatched at any point in time is referred to as the “marginal generator,” and typically sets the market price for that market period.

Opal (Natural Gas): A natural gas pricing point in Wyoming designated for the Rocky Mountain region.

OPEC – Organization of Oil Producing Countries (see also Cartel)**:** Founded in 1960 in Baghdad by Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela. As of 2016, the 14 countries accounted for an estimated 44 percent of global oil production and 73 percent of the world’s “proven” oil reserves giving OPEC a major influence on global oil prices that were previously determined by American-dominated multinational oil companies. OPEC's stated mission is "to coordinate and unify the petroleum policies of its member countries and ensure the stabilization of oil markets, in order to secure an efficient, economic and regular supply of petroleum to consumers, a steady income to producers, and a fair return on capital for those investing in the petroleum industry." In the 1970s, restrictions on oil production caused dramatic rises in oil prices and OPEC's revenue and wealth, with long-lasting and far-reaching consequences for the global economy (see Recessions in the United States for more discussion). In the 1980s, OPEC started setting production targets for its member nations; and generally when the production targets are reduced, oil prices increase, most recently from the organization's 2008 and 2016 decisions to trim oversupply.

Open Access (Electric): Federal Energy Regulatory Commission Order No. 888 requires public utilities to provide non-discriminatory transmission service over their transmission facilities to third parties to move bulk power from one point to another for a cost-based fee. Order 890 expanded Open Access to cover the methodology for calculating available transmission transfer capability; improvements that opened a coordinated transmission planning processes; standardization of energy and generation imbalance charges; and other reforms regarding the designation and undesignation of transmission network resources. (NERC definition)

Open Access Transmission Tariff (OATT) (Electric): Electronic transmission tariff accepted by the U.S. Federal Energy Regulatory Commission requiring the Transmission Service Provider to furnish to all shippers with non-discriminating service comparable to that provided by Transmission Owners to themselves. (NERC definition) including ancillary services.

Open Automated Demand Response (OpenADR): An open and interoperable information exchange model and communication standard. OpenADR standardizes the message format used for ADR controls, gateways, and energy management systems to enable standardized communication of price and DR signals between customer facilities and utilities, Independent System Operators (ISOs), or Energy Service Providers. LBL 2018

Open Season (Natural Gas): A period (often 1 month) when a pipeline offers to accept bids from shippers and others for potential new transportation capacity. Bidders may or may not have to provide “earnest” money, depending upon the type of open season. If enough interest is shown in the announced new capacity, the pipeline will refine the proposal and prepare an application for construction before the appropriate regulatory body for approval.

Operable Capacity Margin: The amount of resources that must be operational to meet peak demand plus operating-reserve requirements.

Operating Criteria: The fundamental principles of reliable interconnected systems operation, adopted by the North American Electric Reliability Corporation.

Operating Day (Electric and Natural Gas): For many electricity markets, the daily 24-hour period beginning at midnight for which transactions are scheduled. The Operating Day for the electric and natural gas markets are not the same due to operational / physical differences in the commodity (e.g., the flow of electricity approaches the speed of light while natural gas might travel at 30 miles per hour, electricity cannot be stored as economically as natural gas). Efforts to *harmonize* the operating day or find mutually acceptable "work arounds" has proven to be difficult. Since natural gas is an increasingly important fuel source, efforts to coordinate natural gas deliveries with electric operations is imperative.

Operating Expenses: Segment expenses related both to expenses from sales to unaffiliated customers and expenses from intersegment sales or transfers, excluding loss on disposition of property, plant, and equipment; interest expenses and financial charges; foreign currency translation effects; minority interest; and income taxes.

Operating Guides: Operating practices that a Control Area or systems functioning as part of a Control Area may wish to consider. The application of Guides is optional and may vary among Control Areas to accommodate local conditions and individual system requirements.

Operating Income: Operating revenues less operating expenses. Excludes items of other revenue and expense, such as equity in earnings of unconsolidated affiliates, dividends, interest income and expense, income taxes, extraordinary items, and cumulative effects of accounting changes.

Operating Procedures: A set of policies, practices, or system adjustments that may be automatically or manually implemented by the system operator within a specified time frame to maintain the operational integrity of the interconnected electric systems.

Operating Reserve: The generating capability (spinning and non-spinning reserve) above firm system demand needed to provide for regulation, load forecasting errors, scheduled and unplanned equipment outages and local area protection.

Operating Reserves – Spinning: NERC defines this as the portion of Operating Reserve consisting of:

Generation synchronized to the system and fully available to serve load within the Disturbance Recovery Period following the contingency event; or

Load fully removable from the system within the Disturbance Recovery Period following the contingency event.

Operating Reserves – Supplemental: The portion of Operating Reserve consisting of:

Generation (synchronized or capable of being synchronized to the system) that is fully available to serve load within the Disturbance Recovery Period following the contingency event; or

Load fully removable from the system within the Disturbance Recovery Period following the contingency event.

Operating Revenues: Segment revenues both from sales to unaffiliated customers (i.e., revenue from customers outside the enterprise as reported in the company's consolidated income statement) and from intersegment sales or transfers, if any, of product and services similar to those sold to unaffiliated customers, excluding equity in earnings of unconsolidated affiliates; dividend and interest income; gain on disposition of property, plant, and equipment; and foreign currency translation effects.

Operating Security Limit: The value of a system operating parameter (e.g. total power transfer across an interface) that satisfies the most limiting of prescribed pre- and post-contingency operating criteria as determined by equipment loading capability and acceptable stability and voltage conditions. It is the operating limit to be observed so that the transmission system will remain reliable even if the worst contingency occurs.

Operating Standards: The obligations of a Control Area and systems functioning as part of a Control Area that are measurable. An Operating Standard may specify monitoring and surveys for compliance.

Operating Transfer Capability (OTC): The amount of power that can be transferred in a reliable manner, meeting all NERC contingency requirements, considering the current or projected operating state of the system. OTC is sometimes referred to as *Total Transfer Capability* (TTC).

Operating Voltage: The voltage level by which an electrical system is designated and to which certain operating characteristics of the system are related; also, the effective (root-mean-square) potential difference between any two conductors or between a conductor and the ground. The actual voltage of the circuit may vary somewhat above / below this value.NERC

Operational Flow Order (OFO) (Natural Gas): An order issued by a pipeline or Local Distribution Company that restricts service or requires affirmative action by shippers in an effort to ensure the operational integrity of the pipeline or distribution system.

Operational Planning Analysis (OPA): An evaluation of projected system conditions to assess anticipated (pre-Contingency) and potential (post-Contingency) conditions for next-day operations. The evaluation shall reflect applicable inputs including, but not limited to, load forecasts; generation output levels; Interchange; known Protection System and Special Protection System status or degradation; Transmission outages; generator outages; Facility Ratings; and identified phase angle and equipment limitations. (Operational Planning Analysis may be provided through internal systems or through third-party services.) –NERC

Operations Planning: The process of determining how the infrastructure of a power system (e.g., generators, transmission lines, distribution lines, and other equipment) will work together to generate, transmit, and deliver power to users. Operational planning includes determining processes such as generator unit-commitment, startups, ramp rates, and shutdowns, hydro-thermal unit coordination, and more.

Opportunity Costs: Opportunity cost is a tradeoff between two or more options. It is expressed as the relative cost of one alternative in terms of the next-best alternative. That is, opportunity cost is based on the value of the best alternative forgone where, given limited resources and information, a choice needs to be made between several mutually exclusive alternatives. Assuming the best choice is made, it is the cost incurred by not enjoying the benefit that would have been had by taking the second best available choice. Utility Integrated Resource Planning, for example, considers opportunity costs in evaluating resource alternatives.

Options (financial instrument – see also Collars, Derivatives, Hedging Contracts, and Swaps): Options are a type of derivative security. They are a derivative because the price of an option is intrinsically linked to the price of something else. Specifically, options are *contracts* that grant the right, but not the obligation to buy or sell an underlying asset at a set price on or before a certain date. The right to buy is called a call option and the right to sell is a put option. People somewhat familiar with derivatives may not see an obvious difference between this definition and what a future or forward contract does. The answer is that futures or forwards confer *both* the right *and* obligation to buy or sell at some point in the future. For example, somebody short a futures contract for cattle is obliged to deliver physical cows to a buyer unless they close out their positions before expiration. An options contract does not carry the same obligation, which is precisely why it is called an "option."

Ordinary Least Squares (OLS): (Statistics-Forecasting) The simplest form of time series analysis is to regress the dependent variable against a time index. Least squares can be interpreted as a method of fitting data. The best fit, between modeled and observed data, in the least-squares sense is that instance of the model for which the sum of squared residuals has its least value, a residual being the difference between an observed value and the value given by the model.

Organic Waste Biomass: Unlike the dedicated energy crops industry, organic waste biomass is already in widespread use as a source of renewable energy, historically being second only to hydroelectricity as the source of renewable energy consumed in the U.S. Residues from the forestry and wood products industry, including material left from logging, residues from the paper and pulp industry and residues from primary wood milling; Municipal solid waste (MSW), which is the organic portion of the post-consumer waste collected in community garbage collection services; Gas extracted from landfills, which is naturally occurring gas resulting from decomposition of landfill material; Livestock manure, mainly from large swine and dairy farms where it is used to produce gas in bio digesters; and Municipal wastewater, or sewage, which is used to produce gas in bio digesters. Organic waste biomass resources that are not yet in large-scale use as energy sources, but are being considered for future use, include: Agricultural crop residues, such as stalks, leaves and other material left in the fields when conventional crops such as corn are harvested; and Aquatic plants, such as algae that have high oil content that can be converted to biodiesel.

Original Gas-in-Place (Natural Gas): Industry term that specifies the amount of natural gas in a reservoir (including both recoverable and unrecoverable volumes) before any production takes place.

Original Oil-in-Place (Natural Gas): Industry term that specifies the amount of oil in a reservoir (including both recoverable and unrecoverable volumes) before any production takes place.

Oscillation Damping: Low frequency inter-area power oscillations are a common phenomenon arising between groups of rotating power generators, interconnected by weak and/or heavily loaded AC interties. Such oscillations can be excited by several reasons such as line faults, switching of lines or a sudden change of generator output. Inter-area oscillation frequencies typically lie in the range below 2 Hz, and constitute a restraint on power transmission capability over the tie. Damping or alleviating altogether the power oscillations bring the valuable benefit of increased power transmission capability over the existing interconnector. Source ABB

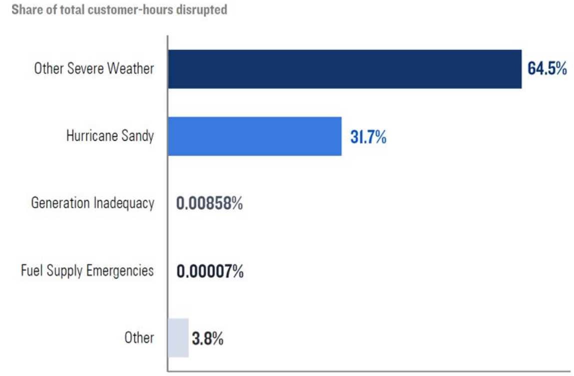
Out of Market Payments: A FERC Order in June 2018 defines “out-of-market payments” as out-of-market revenue that a state either provides, or requires to be provided, to a supplier that participates in the PJM wholesale capacity market. Out-of-market payments include, for example, zero-emissions credits (ZEC) programs and Renewable Portfolio Standards. FERC voted 2-1 December 19 to extend PJM’s minimum offer price rule (MOPR) to all new state-subsidized resources, saying it was needed to combat price suppression in the RTO’s capacity market (EL16-49, EL18-178).

Outage Correlation in Non Peak Months: A combination of reduced generating capacity as well as increased forced and planned outage rates during non-peak periods have led to a phenomenon referred to as outage correlation that raises reliability concerns during shoulder months.

Outage Management System (OMS): A computer system used by operators of electric distribution systems to identify and assist in restoration of power.

Outage Transfer Distribution Factor (OTDF): The electric power transfer distribution factor (PTDF) with a specific system facility removed from service (outage). The OTDF applies only for the post-contingency configuration of the systems under study.

Outages: “Between 2012 and 2016, there were roughly 3.4 billion customer-hours impacted by major electricity disruptions. Of that, 2,382 hours, or 0.00007% of the total, was due to fuel supply problems (below). Interestingly, 2,333 of those customer hours were due to one event in Northern Minnesota in 2014. And it involved a coal-fired power plant.” Data from the EIA and Rhodium Group December 2019.



Out of Market Compensation or Support: Payments to resources outside the electricity market clearing processes, such as Reliability Agreements.

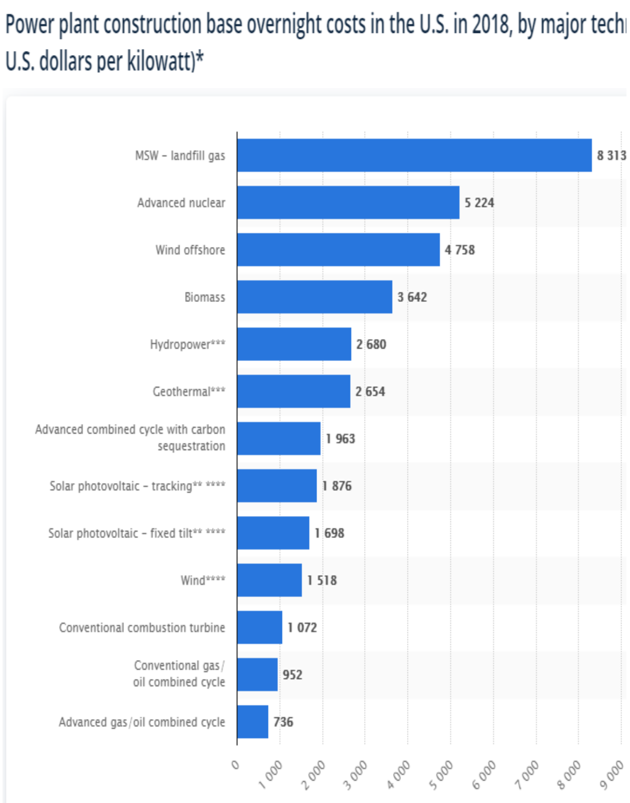
Out of Merit Dispatch: A departure from the most economic dispatch due to operational constraints.

Output: The amount of energy put onto the grid by a power plant over a specific period of time, usually measured in MWh.

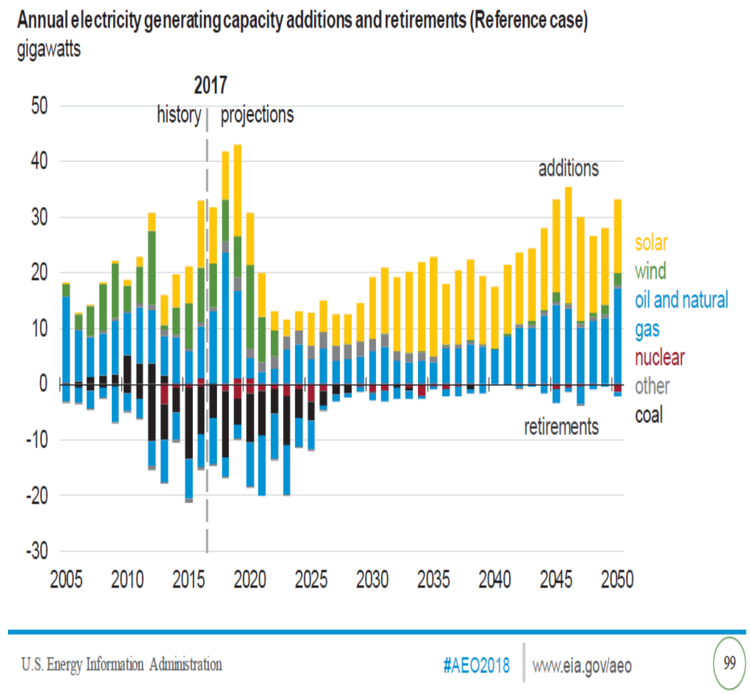
Over Generation: When the supply of non-dispatchable power from renewable resources plus thermal generation exceed the reliability requirements – including net exports.

Overhead facilities: Electrical facilities that are installed on transmission towers or distribution poles.

Over Night Construction Costs (see also Levalized Cost of Energy or LCOE): Is an estimate of the cost of a construction project – such as an electric generator (in $/kW) – if it were possible to construct the facility over-night. That is, there is no interest cost incurred during construction. The overnight cost is frequently used when describing the cost of power plants. Often used as a screening tool. The following graphic is from Energy & Environmental Services Energy & Environmental Technology



A related EIA graphic shows the projected retirements and resource additions.



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Packaged Air Conditioning Units: Usually mounted on the roof or on a slab beside the building. These are self-contained units that contain the equipment that generates cool air and the equipment that distributes the cooled air. These units commonly consume natural gas or electricity. The units are mounted on the rooftop, exposed to the elements. They typically blow cool air into the building through duct work, but other types of distribution systems may exist. The units usually serve more than one room. There are often several units on the roof of a single building. Also known as: Packaged Terminal Air Conditioners (PTAC). These packaged units are often constructed as a single unit for heating and for cooling.

Pancaking: Paying multiple charges to more than one utility to move (wheel) electric power across bulk-power systems (also called pancaked rates). Historically, utilities have charged other utilities for transmitting power over their systems on a contract path basis with little regard to whether the power actually flowed across their lines (see parallel path flow). This pancaking of transmission rates increases the cost of transporting power, and reduces the economic benefits of buying and selling power over any distance. This can be anticompetitive.

Parallel Path Flow: refers to the flow of electric power on an electric system's transmission facilities resulting from scheduled electric power transfers between two other electric systems. (Electric power flows on all interconnected parallel paths in amounts inversely proportional to each path's resistance). (see also "Loop Flow.")

Parameter Limited Schedules: Schedules containing pre-determined limits that could be imposed on the parameters in generation offers when certain operational circumstances exist. Cost based offers are parameter limited. Price based offers can be parameter limited or not.

Parametric Statistics: statistical concept that assumes sample data comes from a population that follows a probability distribution based on a fixed set of parameters. Most commonly used elementary statistical methods are parametric. Conversely a *non-parametric model* differs in that the parameter set (or feature set in machine learning) is not fixed and can increase, or even decrease if new relevant information is collected. Since a parametric model relies on a fixed parameter set, it assumes more about a given population than non-parametric methods do. When the assumptions are correct, parametric methods will produce more accurate and precise estimates than non-parametric methods, i.e. have more statistical power. However, as more is assumed by parametric methods, when the assumptions are not correct they have a greater chance of failing, and for this reason are not robust statistical methods. The normal family of distribution share similar shapes. If the mean and standard deviation is known and if the distribution is normal, the probability of any future observation in a given range is known. For example, if we have a sample of 99 test scores with a mean of 100 and a standard deviation of 1, we assume all 99 test scores are random observations from a normal distribution and we predict there is a 1% chance that the 100th test score will be higher than 102.365 (that is, the mean plus 2.365 standard deviations); assuming that the 100th test score comes from the same distribution as the others. Parametric statistical methods are used to compute the 2.365 value above, given 99 independent observations from the same normal distribution. A non-parametric estimate of the same thing is the maximum of the first 99 scores. We don't need to assume anything about the distribution of test scores to reason that before we gave the test it was equally likely that the highest score would be any of the first 100. Thus there is a 1% chance that the 100th is higher than any of the 99 that preceded it.

Parasitic Load for Generating Units (a component of Station Use)**:** The *gross output* of an electric generator includes an amount of electricity needed to operate the unit. This includes pumps, fans, other electric motors, and pollution control equipment such as Air Separation Units (ASU) that create pure oxygen for the gasification process. This in-facility electrical load is referred to as parasitic load. Parasitic load reduces the amount of power that can be delivered to the grid. Consequently, electric energy output is also expressed in terms of *net output*, which reflects the generator's gross output minus its parasitic load.

Partial Discharge: Detects and counts arcing partial discharges in power transformers.

Partial Requirements Consumer: A wholesale consumer with generating resources insufficient to carry all its load and whose energy seller is a long-term firm power source supplemental to the consumer's own generation or energy received from others. The terms and conditions of sale are similar to those for a full requirements consumer.

Partitioning Around Meldoids (PAM): Statistical clusting methodology. Both the k -means and k -medoids algorithms are partitional (breaking the data set into groups) and both attempt to minimize the distance between points labeled to be in a cluster and a point designated as the center of that cluster.

Passive Solar Heating: A solar heating system that uses no external mechanical power, such as pumps or blowers, to move the collected solar heat.

Peak Capacity Flow Study: Peak Capacity Planning Studies, like Integrated Resource Planning, typically utilize a 20 year planning horizon based on projected load growth. However, unlike IRPs that are primarily focused on meeting system coincident peak demand (CP), the PCP Studies primarily forecast the peak demand on T&D system elements which are likely to be non-coincident (NCP) with the system peak demand. To a lesser extent, PCP studies also consider the system's maximum coincident peak demand because of the desirability to reduce system peak and the resources – like DSM, DER, and batteries – that may be useful to reduce expected peak demand. are performed to determine whether there is a need to upgrade substation transformers, feeder line sections, or other equipment to meet load growth and keep the distribution system operating reliably and safely. It is typical for utilities to run multiple snapshot power flow analyses (often one for each year) to see how the overall distribution system performs, and to plan for system changes and upgrades. The two key building blocks of a peak capacity planning study are power flow analysis and projected load growth. However, current and potential technologies should also be considered.

Peak-Day Demand: The maximum daily natural gas volume used during a specified period (e.g., annual).

Peak Demand: The maximum load during a specified period of time. The electric load corresponding to a maximum level of electric demand in a specified period (also called peak load). Utilities try to forecast their peak load in order to plan for adequate power supplies and demand-response.

Peak Demand Reduction (PDR - see Demand Response, Peak Clipping, Peak Load Pricing): Peak demand reduction methods are typically exercised during a utility's coincident system peak period. PDR conceivably may be used to reduce use on specific transmission and distribution system elements to improve reliability and reduce cost and should be considered in planning.

Peak Load: The maximum load during a specified period of time.

Peak Load Month: The month of greatest plant electrical generation during the winter heating season (Oct-Mar) and summer cooling season (Apr-Sept), respectively.

Peak Load Planning (see also peak load pricing, transmission planning, and integrated resource planning): Resource planners are primarily concerned with having sufficient resources to satisfy their maximum system *coincident peak* demand. Planning resources based on the system coincident peak demand is in contrast to transmission and distribution planning that is primarily concerned with the maximum demand (loadings) on specific transmission and distribution elements which may be *non-coincident* with the system maximum peak coincident peak demand. Strategically, peak load pricing should consider long-term peak load planning.

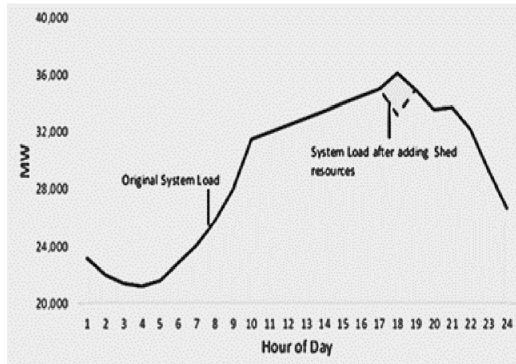
Peak Load Plant: A plant usually housing old, low-efficiency steam units, gas turbines, diesels, or pumped-storage hydroelectric equipment normally used during the peak-load periods.

Peak Load Pricing (see also rate structures, peak load planning, and Ramsey Pricing): Peak load pricing for electric utilities is used to reduce the amount of electric use during the most expensive periods (i.e., to reduce the use of power plants that are most expensive to operate) and when the reliability of the system is of concern. For electric utilities, peak load pricing is a more accurate reflection of the *marginal cost* of producing electricity which requires *dynamic pricing*. A 2010 survey conducted by the Federal Energy Regulatory Commission (FERC 2011, pp. 28, 99) indicated that only about one percent of residential consumers are billed based on time-of-use rates. Accordingly, almost all residential and small commercial consumers in the U.S. buy electricity on rate structures with *flat* rates that do not vary dynamically with changes in overall supply and demand conditions, marginal costs or wholesale market prices from either an ex ante or real time perspective.

Peak load pricing is often used to shift usage to periods when usage is less expensive. Peak load pricing has a long history in other industries to charge more during peak periods and less during low use periods to increase usage (e.g., transportation, matinees, happy hours). For an excellent discussion of peak load pricing, see *The Economics of Regulation: Principles and Institutions* (Alfred E. Kahn, 1970)

Peak Period Equivalent Forced Outage Rate (EFORp): A measure of the probability that a generating unit will not be available due to forced outages or forced deratings when there is a demand on the unit to generate during the defined critical peak hour periods.

Peak Shaving (Electric) (a/k/a Peak Clipping or Peak Response - see also demand response and load management): Peak shaving is typically used to reduce electrical power consumption during periods of high demand on the power system to bolster reliability and / or to reduce the cost of providing electricity at the wholesale and retail level. It could be used to reduce investments and enhance resource adequacy of the generation system, reduce congestion on the transmission system, or enhance reliability of the distribution system by augmenting ancillary services (e.g., voltage support, regulating reserves) which is becoming increasingly important due to the greater reliance on intermittent resources and customer-owned resources. Peak shaving may also utilize energy storage.

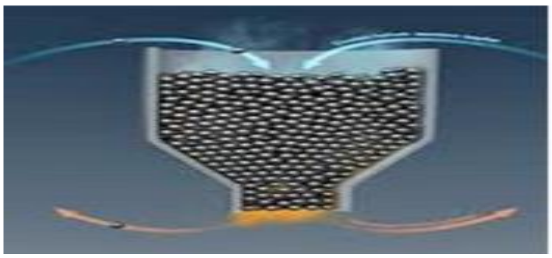


Peak Shaving (Natural Gas): A mechanism to reduce the peak demand for natural gas or electricity, such as high-deliverability natural gas storage or use of LNG.

Peak Splitting: Particularly large customers on demand rates that have large fluctuations in demand may be able split their maximum peak demand and reduce their bill if they know the timing interval (e.g., intervals of 15 minutes) for the meter. That is, the customer may be able to schedule their operations so half of the increase in demand occurs on either side of the interval so that the customer's maximum demand is not fully recorded for billing purposes. This would not occur with well-designed rates and Advanced Metering Infrastructure.

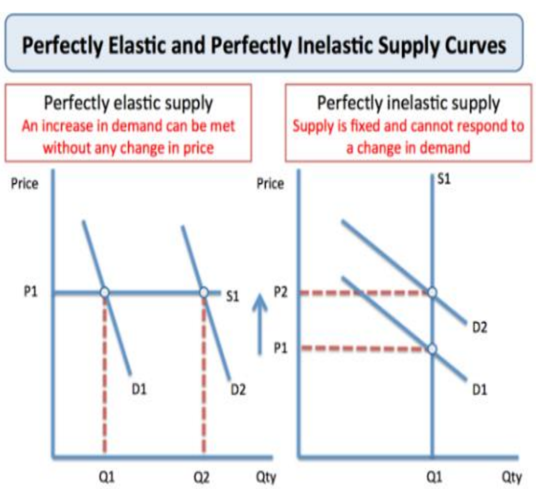
Peaking Capacity (or Peaking Generation): A peaking plant is capacity of generating equipment normally reserved for operation during the hours of highest daily, weekly, or seasonal loads, usually more expensive.

Pebble Bed Reactors (PBR): Are *small modular reactors* that are *helium cooled* that use small tennis ball size fuel balls consisting of only 9 grams of uranium per pebble to provide a low power density reactor. The low power density and large graphite core provide inherent safety features such that the peak temperature reached even under the complete loss of coolant accident without any active emergency core cooling system is significantly below the temperature that the fuel melts. This feature should enhance public confidence in this nuclear technology. With advanced modularity principles, it is expected that this type of design and assembly could lower the cost of new nuclear plants. **Electric Policy** December 7, 2016 -- China plans to repurpose coal-fired generation located near its cities into clean nuclear plants. The first working demonstration unit could begin commercial operation as early as 2018 to curb its growing air pollution problem and boost its nuclear industry and help some large industrialized nations reduce their carbon footprint by converting supercritical coal plants to high-temperature gas cooled reactors (HTGRs) - cost-effectively. The HTGR's heated gas will heat boilers to create steam and turn the turbine traditionally. Lack of need for costly and complex cooling systems of water-cooled reactors will also help make the retrofit plan more affordable.



Percent of Planned Maintenance Completed: Current year-to-date to be reported monthly by type of inspection or test. This is the number of planned maintenance activities completed divided by the total number of planned maintenance activities scheduled.

Perfectly Elastic and Inelastic Supply Curves: Most supply curves are relatively elastic or inelastic compared to the perfectly elastic or inelastic supply curve. Elasticity determines the supplier's willingness to provide a good or or service. A low elasticity indicates that the seller / producer is only willing to sell at high prices (Electric utilities, for example, might charge extremely high prices in an effort to prevent



brownouts or blackouts. Similarly, natural gas utilities might charge extremely high prices to reduce use during an extreme weather event such as the Polar Vortex). In contrast, a high price elasticity of supply implies the seller is willing to charge very low prices for a good or service. This is likely to occur in very competitive markets.

Performance-Based Regulation (PBR) (see also Straight-Fixed Variable Cost and Decoupling): Under Performance-Based Regulation, an energy utility's (electric or gas) revenues are adjusted from a base or test year (probably as a result of a traditional rate case that includes historic and projected costs) predicated on the utility's performance. Incentives are set for utilities to meet or exceed benchmarks that are determined for certain operations, such as reliability and cost and must have, therefore, quality control mechanisms that are verifiable and relatively easy and transparent to monitor. If the utility doesn't achieve the benchmark for a given measurement, the utility must absorb the extra costs. If the utility meets or does slightly better than the benchmark, it keeps the profits and shares them with shareholders; if they exceed the benchmark by determined margins, money is returned to customers**.**

PBR is intended to:

lower the delivered cost of electricity (or gas),

foster improvements in the quality and reliability service,

more accurately assign risks and rewards, and,

improves regulatory efficiency. Especially with the ramifications of increasingly stringent environmental regulations, integration of PBR with long-term resource planning may provide substantial benefits.

A PBR should be compared to the benefits and detriments of the existing regulatory practices and there should be a clear articulation of the rationale for changing the regulatory practice. Whether PBR adopted or traditional regulation is retained, the fundamental regulatory precept is that neither is intended to guarantee a utility's profitability or, even in extreme instances, survivability.

Proponents of PBR argue that traditional cost of service regulation doesn't minimize the cost of providing service. Some assert that it is in the best interest of the utility to "gold plate" investments in facilities since they have an opportunity to recover the cost of the facility and earn a return on that investment. Utilities may also minimize costs by reducing routine maintenance. As a result, traditional regulation may not serve either the interest of the customer or the utility. Often cited from the customers' perspective are examples of utilities postponing rate cases when it is in the utility's financial interest to do so (e.g., instances where the rate-of-return was set during a period when ROR was relatively high). That is, utilities keep 100 percent of any cost savings between rate cases (which can be a very long time). This produces very strong incentives to cut costs which may not always be beneficial to customers. As in the 1970s – 1980s, utilities filed frequent rate cases in response to construction of expensive generating units, high cost of capital, and rapidly escalating fuel costs which lead to the development of *automatic adjustment clauses* (e.g., fuel adjustment clauses, Allowance for Funds Used During Construction - AFUDC). Concern has been expressed that the proliferation of automatic adjustment clauses with, often, limited scrutiny, may – taken as a whole – distort incentives / disincentives for utilities. There is also the perception that PBR is a better vehicle for promoting on-going investment in infrastructure and innovation. That is, under traditional rate-of-return regulation, a utility can increase its profitability by cutting expenses such as investment in infrastructure and postponing investment in new technology; at least until a rate case. From the utility's perspective, PBR recovers costs incurred in a period (perhaps 12 months or longer) so there may be lower financial risk which may, in turn, increase willingness to undertake needed investments and innovation.

There is general recognition, however, that even well designed PBR should not be viewed as a panacea for all perceived or actual short-comings of traditional regulation. Poorly designed PBRs that, by way of examples, do not start with a solid foundation (akin to a traditional rate case), inappropriate or poorly designed benchmarks, failure to construct verifiable metrics for evaluating the prudence of expenditures, or provide incentives that promote a specific resource or technology at the expense of other technologies that are more cost-effective may result in inferior outcomes compared to traditional regulation.

Performance Measure Calculations for Generating Units: Performance Indexes are divided into:

1. Unweighted (time-based) methods for calculating single unit statistics.
2. Unweighted (time-based) methods for calculating pooled (grouping) unit statistics.
3. Weighted (capacity-based) methods for calculating pooling (grouping) unit statistics.
4. Unweighted (time-based) methods for calculating statistics excluding problems outside management control for single unit and pooling unit statistics.
5. Weighted (capacity-based) methods for calculating statistics excluding problems outside management control for pooling unit statistics.

When calculating a single generating unit's performance statistics, it does not matter if you use unweighted- or weighted-based statistics. The answer will generally be the same. The real difference between the unweighted and weighted statistics is in pooling (or grouping) of a set of generating units. In these cases, a group of units of similar size will show only small differences, but a group of units where the MW size is very different (greater than 50 MW), the statistics may be very different. With unweighted statistics, all units are considered equal in outage impact. In the unweighted equations, no MW size is introduced into the equations and the results are based on time, not energy produced or not produced. In such cases, a 50 MW gas turbine and a 1,000 MW nuclear unit have the same impact of the resulting statistics. With weighted statistics, the larger MW size unit in the group has more impact on the final statistics than a smaller generating unit. That is because the MW size of the unit (NMC) is part of the equation. In these cases, a 1,000 MW nuclear unit would have 20 times impact on the final outcome of the calculation than would its 50 MW gas turbine companion.

Period Hours (PH): PH is the number of hours in the period being reported that the unit was in the active state.

Permeability: A measure of the ability of a rock to permit fluids to be transmitted through it; it is controlled by pore size, pore throat geometry, and pore connectivity. Permeability is typically reported in darcies.

Phantom Taxes: This has been a term often used by consumer advocates to characterize deferred taxes which result from the normalization method of accounting for temporary differences.

Phase Angle Regulator (PAR): A power system transformer that has tap changing capability and can change the phase angle across the transformer and thereby increase or decrease power flow.

Phase Imbalance: Phase unbalance of a three-phase system exists when one or more of the line-to-line voltages in a three-phase system are mismatched. While low voltage is always an issue, voltage imbalance is a more subtle problem. It is a condition when the voltage to the major 3-phase components is significantly different between the 3 phases. When voltage imbalance is too different, you can have excessive component temperatures and even burnouts. Three-phase power systems and equipment are intended to operate with phases (Lines) balanced. Line-to-line voltages in a three-phase circuit typically vary by a few volts, but a difference that exceeds 1% can damage motors and equipment. The unbalanced voltages cause unbalanced current in the motor windings; unbalanced currents mean an increase of current to at least one winding raising that winding temperature. Increased temperature reduces motor or equipment life leading to premature failure. A phase imbalance may be caused by unstable utility supply, unbalanced transformer bank, unevenly distributed single-phase loads on the same power system, or unidentified single-phase to ground faults. Single phasing (phase loss) caused by utility supply faults, broken wires, failed fuses, damaged contacts, or malfunctioning overloads can also result in damaging unbalance conditions.

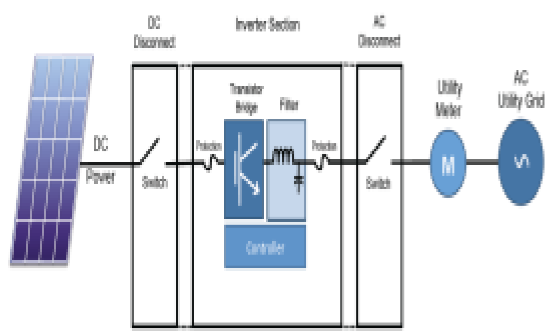
Phase-Shifters: One method to reduce loop flows uses phase-shifting transformers to help direct flows to transmission lines with sufficient transfer capability. As a result, transfers that take place on transmission lines that are not part of the primary flow path are lessened so that transfer limit violations are not attained. Although phase-shifting transformers are costly and consume additional energy, they are widely used in the western United States.

Phasor Measurement Unit (PMU): A PMU measures the electrical waves on an electricity grid to determine the health of the system. In power engineering, these are also commonly referred to as synchrophasors and are considered one of the most important measuring devices in the future of power systems.

Phillips Curve: The Phillips curve depicts the trade-off relationship between unemployment and inflation in an economy. AW Phillips developed the theoretical construct that economic policymakers faced either inflation or unemployment but not together. If the policy goal was to stimulate aggregate demand (AD) the accepted opinion until the latter half of the 20th Century was that it was possible to target either inflation or unemployment but not both without having a negative effect on the other. The stagflation of the 1970s was an example.

Photoelectric Effect: A natural phenomenon where certain materials produce an electric flow when they are struck by sufficient amounts of light.

Photovoltaic and Solar Thermal Energy (As used at electric utilities): Energy radiated by the sun as electromagnetic waves (electromagnetic radiation) that is converted at electric utilities into electricity by means of solar (photovoltaic) cells or concentrating (focusing) collectors. Roof-Top Solar provides an example of how the energy not used by the customer's roof-top solar panels are transmitted to the customer's utility."



Photovoltaic Cell (PVC): An electronic device consisting of layers of semiconductor materials fabricated to form a junction (adjacent layers of materials with different electronic characteristics) and electrical contacts and being capable of converting incident light directly into electricity (direct current).

Pipe and Bubble Transmission Planning: A simplified representation of the transmission system to facilitate computations of power flow over large regions. For example, the Midcontinent ISO or PJM might be represented as a bubble and a single line might be used to represent transfer capability from (or into) MISO or PJM.

Pipeline Capacity (Natural Gas): The maximum allowable throughput of a natural gas pipeline over a specific period of time. The pipeline capacity is specified in the pipeline design, rather than existing service conditions.

Pipeline Nomination (Natural Gas): A request for a physical quantity of natural gas transportation service under a specific sales or transportation contract.

Pipeline Scheduling (Natural Gas): A process through which natural gas nominations are consolidated by receipt point and contract, and verified with upstream and downstream parties. In cases where the verified capacity is larger than or equal to the total nominated volume, all nominate volumes are scheduled. However, if the verified capacity is less than the nominated volume, the nominated volumes are allocated according to the scheduling priorities.

Planned Demand Response: A Demand Resource that does not currently have the capability to provide a reduction in demand or to otherwise control load, but that is scheduled to be capable of providing a reduction or control on or before the start of the Delivery Year for which the resource is to be committed.

Planned Outages: The shutdown of a generating unit, transmission line, or other facility, for inspection or maintenance, in accordance with an advance schedule.

Planned Transmission Outages: Any transmission outage scheduled for the performance of maintenance or repairs or the implementation of a system enhancement which is planned in advance for a pre-determined duration and which meets the notification requirements for such outages as specified by the RTO or Reliability Authority.

Planning Authority (PA) (a/k/a **Planning Coordinators**): The responsible entity that coordinates and integrates transmission facility and service plans, resource plans, and protection systems. The Midcontinent ISO and PJM are Planning Authorities (Coordinators) for their membership.

Planning Coordinator:(See Planning Authority).

Planning Guides: Good planning practices and considerations that Regions, subregions, power pools, or individual systems should follow. The application of Planning Guides may vary to match local conditions and individual system requirements.

Planning Horizon: Long-term planning of 10 to 30 years is essential to electric utilities due to the inherent risks of the capital intensive character of utilities, the long-lived assets, the potentially disruptive implications of new technologies, and environmental regulation. In order for utilities to plan for meeting future energy demand in the most cost-effective way while meeting the reliability needs of its customers, utilities are often required to file integrated resource plans (IRPs) with their state public utility commissions. IRPs first started in the 1980s in response to the desire to better integrate energy efficiency into utility planning, the unexpectedly high costs of developing nuclear plants, and the oil embargoes of the 1970s. Today, new technologies, changing market conditions, and new environmental regulations are making IRPs change with the times. An IRP is merely a roadmap that should have frequent off ramps to ensure optionality in meeting forecasted energy demand. According to AEE's PowerPortal, 33 states - either by state statute or regulation - require utilities to file publicly available IRPs or their equivalent with their commission. IRP requirements and scope vary by state, but most commonly the planning horizon is 20 years, with a detailed implementation plan for the first few years and a required update every two to three years.

Planning Models: The following examples are not exhaustive but include a spectrum of planning tools. Some of these tools are generating capacity expansion models used in formulating Integrated Resource Plans, considering production costing models (economic dispatch and unit commit), power flow models, network reliability models, Demand-Side Management models, load forecasting models, distribution system planning.

AURORAxmp: AURORA produces short, medium, and long-term electric market price forecasts, value and uncertainty analyses, and automated system optimization AURORA is used for generation expansion planning, budgeting, Integrated Resource Planning, budget projections, detailed generator analysis, market assessment / strategy, price forecasting at zonal and nodal level, market design & policy analysis, scenario based and probabilistic treatment of inputs, FTR analysis, ancillary services, and transmission planning. Aurora allows utility planners to analyze system operations to one minute resolution.

Distributed Generation Market Demand model (dGEN):

DSMore: Demand Side Management Option Risk Evaluator (DSMore) is a financial analysis tool designed to evaluate the costs, benefits and risks of demand-side management (DSM) programs, including energy efficiency, demand response and smart grid programs and services.

EGEAS: The Electric Generation Expansion Analysis System is a capacity expansion tool that evaluates possible combinations of resources plans to reach the optimal, least-cost plan considering costs and characteristics of existing and potential resources including DSM, purchase power contracts, and other potential planning options such as Distributed Energy Resources. EGEAS calculates the *present value of revenue requirements* and average system levelized rates.

EnCompass: produces short, medium, and long-term electric market price forecasts, value and uncertainty analyses, and automated system optimization AURORA is used for generation expansion planning, budgeting, Integrated Resource Planning, budget projections, detailed generator analysis, market assessment / strategy, price forecasting at zonal and nodal level, market design & policy analysis, scenario based and probabilistic treatment of inputs, FTR analysis, ancillary services, and transmission planning. Aurora allows utility planners to analyze system operations to one minute resolution..

GE MAPS: The Multi-Area Production Simulation program is capable of simulating detailed (hourly to sub-hourly) operation of a given system; Assess resource adequacy and other aspects of reliability of a system; Analyze the impact of changes in the system (e.g., retirement/addition of capacity) on system operation; Assess transmission congestion and locational marginal prices; Describe the daily pattern of emissions.

GRID VIEW: ABB's GridView simulates detailed (hourly to sub-hourly) operation of a given system; Assess resource adequacy and other aspects of reliability of a system; Analyze the impact of changes in the system (e.g., retirement/addition of capacity) on system operation; Assess transmission congestion and locational marginal prices; Describe the daily pattern of emissions.

MARS: The General Electric Multi-Area Reliability Simulation model is a probabilistic analysis program using sequential Monte Carlo simulation to analyze the resource adequacy for multiple areas. MARS is used by ISOs, RTOs, and other organizations to conduct multi-area reliability simulations.

pcGAR: NERC's personal computer based Generator Availability Report (pcGAR) is a database of all NERC generator data and provides reporting statistics on generators operating in North America. This data and application is distributed by NERC annually, with interested parties paying a set fee for this service.

PLEXOS: Produces short, medium, and long-term electric market price forecasts, value and uncertainty analyses, and automated system optimization PLEXOS is used for generation expansion planning, budgeting, Integrated Resource Planning, budget projections, detailed generator analysis, market assessment / strategy, price forecasting at zonal and nodal level, market design & policy analysis, scenario based and probabilistic treatment of inputs, FTR analysis, and transmission planning. Aurora allows utility planners to analyze system operations to one minute resolution.

PowerWorld: Provides a visualization of power flow under a variety of circumstances and scenarios. Used by transmission planners, power marketers, system operators and trainers, educators, and regulatory commissions. By way of examples, PowerWorld visually demonstrates the interconnectedness of utilities. It can demonstrate cascading blackouts or how power flows along the East Coast can affect power flows in the Midwest, or how the addition of a transmission element affects power flow, or the addition of a generator (or the retirement of a generator) can alter power flow.

PRISM: The Probabilistic Reliability Index Study Model (PRISM) is a planning reliability program. The model is based on statistical measures for both the load model and the generating unit model and is used in the planning process to evaluate the generation adequacy of the bulk electric power system.

PROMOD: An electric market simulation solution that incorporates detailed generating unit operating characteristics, transmission grid topology, and transmission constraints, and market system operations to support economic transmission planning. PROMOD provides nodal locational marginal price (LMP) forecasting and transmission analysis by producing algorithms that align with the decision focus of management. Among other capabilities, PROMOD analyzes nodal features such as forecasting LMP, user-defined hubs, Financial Transmission Rights (FTRs), Congestion Revenue Rights (CRRs), Transmission Congestion Contracts (TCCs), identifying binding constraints, simulating effects of intermittent energy schedules from wind and solar projects, the increase/decrease in reliability metrics associated with transmission expansion and outage scheduling, power market analysis for quantifying the operating risks associated with each facility, and developing a detailed forecast of market prices.

PSS/E (Power System Simulator for Engineering). PSS/E is used as either a steady-state reliability or dynamic stability model used in transmission planning. Provides single hour snapshots representing typical loading in a year and includes substation voltages and thermal loading on circuits under contingent operations. This includes voltage stability analysis of transfers of power among systems at peak demand and transient stability analysis (the ability to reach a steady state condition after a system event such as a fault, loss of a generator, loss of a transmission element) up to 30 seconds. This tool provides a visual depiction of power flow.

SERVM: The Strategic Energy & Risk Valuation Model developed by Astrape is a probabilistic resource adequacy planning model that calculates *Loss of Load Expectation* (LOLE) under different scenarios. This is a 8760 hour view for the next year or in selected future years.

TARA: Transmission Adequacy and Reliability Assessment is a steady-state resource adequacy planning model for transfer analysis used in transmission planning for coordination among RTOs / ISOs and other control areas. TARA identifies the transfer limits.

TSAT: The Transient Security Assessment Tool is a dynamic stability model used in transmission planning to assess transient stability (the ability to reach a steady state condition after a system event such as a fault, loss of a generator, loss of a transmission element) up to 30 seconds.

VSAT: The Voltage Security Assessment Tool is a resource adequacy planning tool to conduct voltage stability analysis of transfers of power among systems at peak demand.

Planning Period: The twelve months beginning june 1 and extending to May 31 of the following planning year. Planning Period may also be referred to as the Planning Year or Delivery Year.

Planning Policies: The framework for the reliability of interconnected bulk electric supply in terms of responsibilities for the development of and conformance to the North American Electric Reliability Corporation (NERC) Planning Principles and Guides and Regional planning criteria or guides, and NERC and Regional issues resolution processes. NERC Planning Procedures, Principles, and Guides emanate from the Planning Policies.

Planning Reserve Margin (PRM): The amount of forecast dependable resource (i.e., generation, demand-response) capacity required to meet the forecast demand for electricity and reasonable contingencies (e.g., loss of a major generating unit). "Dependable" should be used in preference to "Nameplate" because the Nameplate Rating of a resource may not be able to provide dependable capacity at the time of peak. Often established to meet a "Loss of Load Probability" (or Expectation) of one event (or day) in ten years. Typically this construct has resulted in Planning Reserve Margins of around 15% (i.e., 15% greater than the forecast peak demand). While a specified LOLP is arbitrary, it is generally regarded as a reasonable criteria.

Planning Resource Auction (PRA- MISO): MISO's resource adequacy mechanism is used to demonstrate that resources are available to reliably operate the electric grid over the next planning year. Load-serving entities can demonstrate sufficient capacity with owned resources, contracted resources or through participation in MISO's voluntary Planning Resource Auction. The auction provides an additional mechanism for load-serving entities to secure sufficient resources in the right places to maintain reliability across the MISO region. The auction results have been reviewed and certified by MISO's Independent Market Monitor.

Planning Year: The 12 months beginning June 1 and extending through May 31 of the following year. Planning Year may also be referred to as Planning Period or Delivery Year.

Plant-Use Electricity: The electric energy used in the operation of a plant. This energy total is subtracted from the gross energy production of the plant.

Play: A set of known or postulated oil and gas accumulations sharing similar geologic, geographic, and temporal properties, such as source rock, migration pathway, timing, trapping mechanism, and hydrocarbon type. A play differs from an assessment unit; an assessment unit can include one or more plays. A play is often used to refer to a natural gas accumulation, a natural gas shale play.

Plutonium (Nuclear): A non-naturally occurring element produced as fission byproduct in nuclear reactors. Different isotopes have half-lives ranging from less than a second to more than a million years. The shorter the half-life, the more unstable the isotope is and the higher the level of radioactivity. It can be used as nuclear fuel and in making nuclear weapons.

Pnodes: A single pricing node or subset of pricing nodes where a physical injection or withdrawal is modeled and for which a *Locational Marginal Price* is calculated and used for financial settlements.

Point Forecasts (statistics): Often point forecasts are characterized as a "reference scenario" and, in some instances, might be regarded as the best estimate forecast. Narratives that describe a broad range of uncertainty distributions around the point forecast.

Points of Delivery (POD): Point(s) on the Transmission Providers Transmission System where capacity and energy transmitted by the Transmission Provider is made available to the Receiving Party. The Point(s) of Delivery are specified in the Service Agreement for Long-Term Point-to-Point Transmission Service.

Points of Receipt (POR): Point(s) of interconnection on the Transmission Providers transmission system where capacity and energy are made available to the Transmission Provider by the Delivering Party. The Point(s) of Receipt are specified in the Service Agreement for Long-Term Firm Point-to-Point Transmission Service.

Point-to-Point Transmission Service (PtP) (see also Network Integration Transmission Service): Is the use of transmission facilities for the transmission of capacity and energy between a *Point of Receipt* (POR a *source*) and *a Point of Delivery* (POD – a *sink*). In Regional Transmission Organization Open Access Transmission Tariffs (OATTs), *Firm* (highest priority with no planned interruption) and *Non-Firm* Point-to-Point transmission service are offered for terms of various durations. Long-Term Firm Point-To-Point Transmission Service has equal reservation priority with *Native Load Customers* and *Network Customers*. Non-Firm Point-To-Point Transmission Service is available from transmission capability in excess of that needed for reliable service to *Native Load Customers*, *Network Customers*, and other *Transmission Customers* taking Long-Term and Short-Term Firm Point-To-Point Transmission Service. Long-term firm is a year or longer and short-term firm is less than a year. Non-Firm Point-To-Point Transmission Service is available hourly, daily, weekly, monthly. Point-to-Point transmission service can be used for the transmission of capacity and/or energy into an RTO, out of an RTO, through an RTO, or within the RTO.

Polar Vortex: A large area of low pressure and cold air surrounding both of the Earth's poles. The term "vortex" refers to the counter-clockwise flow of air that helps keep the colder air near the Poles. Many times during winter in the northern hemisphere, the polar vortex will expand, sending cold air southward with the jet stream. A Polar Vortex occurred December 2013, January 2014, and December 2016.

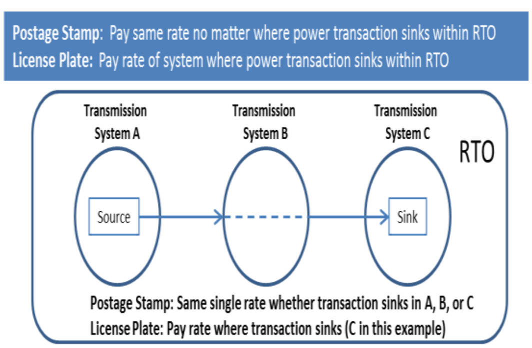
Pole-Mile: A unit of measuring the simple length of an electric transmission/distribution line/ feeder carrying electric conductors, without regard to the number of conductors carried.

Pool Scheduled Resource: A resource that the seller has turned over to PJM for scheduling.

Pool Wide Average EFORd: Average of the forced outage rates based on five years history, weighted for unit capability and expected time in service, attributable to all units that are planned to be in service during the Delivery Year.

Porosity: The part of a rock that is occupied by voids or pores. Pores can be connected by passages called pore throats, which allow for fluid flow, or pores can be isolated and inaccessible to fluid flow.

Postage Stamp Pricing: A transmission pricing method that is not sensitive to distance based on the postage stamp that allows a letter to be sent anywhere within the United States for the same price.



Post Contingency Operating Procedures: Operating procedures that may be invoked by the system operator to mitigate or alleviate system problems after a contingency has occurred.

Posted Path: Any control area to control area interconnection; any path for which service is denied, curtailed or interrupted for more than 24 hours in the past 12 months; and any path for which a customer requests to have ATC or TTC posted (defined in FERC Order 889).

Potential Energy (see also Kinetic Energy): Potential Energy is converted to kinetic energy when some force such as gravity acts upon the object to set it in motion. Elastic potential energy, for example, is stored in a stretched rubber band; when the rubber band is released, the stored energy is converted to kinetic energy.

Potential Peak Reduction: The potential annual peak load reduction (measured in kilowatts) that can be deployed from Direct Load Control, Interruptible Load, Other Load Management, and Other DSM Program activities. (Please note that Energy Efficiency and Load Building are not included in Potential Peak Reduction.) It represents the load that can be reduced either by the direct control of the utility system operator or by the consumer in response to a utility request to curtail load. It reflects the installed load reduction capability, as opposed to the Actual Peak Reduction achieved by participants, during the time of annual system peak load.

Powder River Basin Coal (PRB): In 2015, the United States Geological Service (USGS) prepared its assessment of both coal resources and reserves for all significant coal beds in the entire Powder River Basin, northeastern Wyoming and southeastern Montana. The basin covers about 19,500 square miles, exclusive of the part of the basin within the Crow and Northern Cheyenne Indian Reservations in Montana. The Powder River Basin, which contains the largest resources of low-sulfur, low-ash, subbituminous coal in the United States, is the single most important coal basin in the United States. The U.S. Geological Survey used a geology-based assessment methodology to estimate an original coal resource of about 1.16 trillion short tons for 47 coal beds in the Powder River Basin; in-place (remaining) resources are about 1.15 trillion short tons. This is the first time that all beds were mapped individually over the entire basin. A total of 162 billion short tons of recoverable coal resources (coal reserve base) are estimated at a 10:1 stripping ratio or less. An estimated 25 billion short tons of that coal reserve base met the definition of reserves, which are resources that can be economically produced at or below the current sales price at the time of the evaluation. The total underground coal resource in coal beds 10–20 feet thick is estimated at 304 billion short tons.

Power (Electrical): The rate of producing, transferring, or using energy, most commonly associated with electricity. Power is measured in watts and often expressed in kilowatts (kW) or megawatts (MW). Also known as "real" or "active" power. An electric measurement unit of power called a voltampere is equal to the product of 1 volt and 1 ampere. This is equivalent to 1 watt for a direct current system, and a unit of apparent power is separated into real and reactive power. Real power is the work-producing part of apparent power that measures the rate of supply of energy and is denoted as kilowatts (kW). Reactive power is the portion of apparent power that does no work and is referred to as kilovars; this type of power must be supplied to most types of magnetic equipment, such as motors, and is supplied by generator or by electrostatic equipment. Voltamperes are usually divided by 1,000 and called kilovoltamperes (kVA). Energy is denoted by the product of real power and the length of time utilized; this product is expressed as kilowathours.

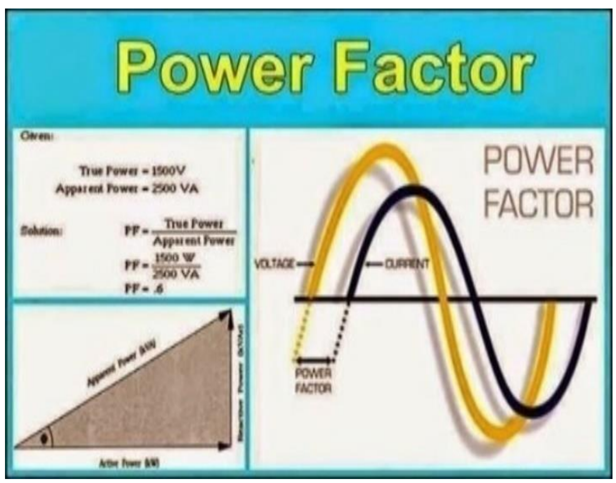
Power Density: As applied to batteries, it is the nominal battery energy per unit volume, sometimes referred to as the volumetric energy density. Specific energy is a characteristic of the battery chemistry and packaging. For batteries used in automobiles, it is a factor, along with the energy consumption of the vehicle, that determines the battery size required to achieve a given electric range. A term also used in nuclear power.

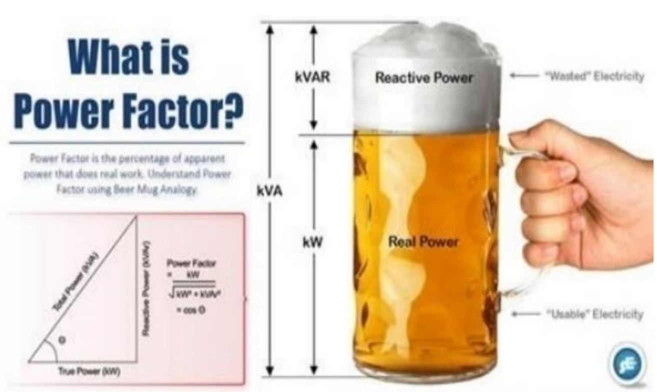
Power/Phase Angle: The angular relationship between an AC (sinusoidal) voltage across a circuit element and the AC (sinusoidal) current through it. The real power that can flow is related to this angle.

Power Factor (PF): The ratio of real power (kilowatt) to apparent power kilovolt-ampere for any given load and time. Power factor can range from 0 (purely *reactive* power) to 1 (purely *active* or *real power).*

Power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit. A power factor of less than one means that the voltage and current waveforms are not in phase. A load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system, and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor. Especially customers that are billed for their peak demand as measured by KVA (apparent power) would reduce their bills by lowering their KVAR. Some utilities penalize customers for a low power factor if it drops below, say, .95. Customers could add capacitors or synchronous motors to improve their power factors.

Inductive loads, such as induction motors (especially inefficient or lightly loaded motors) and transformers, are responsible for KVAR (reactive power) and reductions in a customer's power factor. Especially customers that are billed for their peak demand as measured by KVA (apparent power) would reduce their bills by lowering their KVAR. Some utilities penalize customers for a low power factor if it drops below, say, .95. Customers could add capacitors or synchronous motors to improve their power factors.





Power Flow (see also Load Flow): Estimates of the actual flow of electrons. For planning purposes, Load Flow Studies are used to estimate the flow of electrons under various conditions.

Managing Flow Limits. The flow of electricity on the transmission system must be continually monitored to ensure that the flows through transmission facilities do not exceed pre-established limits established using reliability criteria. These limits include:

Thermal Limits. The capacity of transmission lines, transformers, and other equipment is determined by temperature limits. If these limits are exceeded, the equipment can be damaged or destroyed. For example, when a transmission line heats up, the metal expands and the line sags, potentially coming into contact with surrounding objects, causing a fault. Instead of a single thermal limit, dynamic or seasonal ratings are sometimes used. For example, transmission lines can carry more current on cold, windy days without direct sunlight.

Stability Limits. The stability limit of a transmission line is the maximum amount of flow through the line for which the transmission system will remain stable if a disturbance (e.g., a generating unit outage) occurs.

Power Flow Model: A computerized algorithm that simulates the behavior of the electric system under a given set of conditions and used to compute voltages and flows of real and reactive power through all branches of the system.

Power Loss: The difference between electricity input and output as a result of an energy transfer between two points.

Power Marketing Administrations (PMA): Federal Power Marketing Administrations such as the Bonneville Power Admin. (BPA), Southwestern Power Admin. (SWPA), the Southeastern Power Admin. (SEPA) and the Western Area Power Admin (WAPA) operate hydro-electric facilites in 34 states. The PMAs sell the electricity, under preference clauses, to public power utilities such as cities and rural electric coopearatives.

Power Marketers: Business entities engaged in buying and selling electricity. Power marketers do not usually own generating or transmission facilities. Power marketers, as opposed to brokers, take ownership of the electricity and are involved in interstate trade. These entities file with the Federal Energy Regulatory Commission (FERC) for status as a power marketer.

Power Pool: An association of two or more interconnected electric systems having an agreement to coordinate operations and planning for improved reliability and economic efficiencies for their combined load requirements and maintenance programs; can be **a *tight power pool*** (a group of electric companies that provide reciprocal transmission and/or power generating service for each other, coordinate their planning operations, and generally utilize central dispatch of generating plants) or a **loose power pool** (any multilateral arrangement other than a tight power pool or holding company arrangement).

Power Quality is both a reliability and a customer service metric. Power quality is a measure of the purity of the electric waveform on powerlines. A power quality event, which is not the same as an outage, occurs when one of the waveforms differs from a pure sinusoidal waveform or one or two phases of power are lost. Measurements that can quantify power quality are harmonic distortion and peak-to-peak voltage. Power quality events can last from a few cycles to a few seconds and can be caused by lightning strikes, falling trees, utility operations and operations from other customers such as disturbances from starting a large motor.

Power quality is defined as the electrical system's ability to maintain the sinusoidal waveforms of voltages and currents at rated magnitude and frequency in the system. Marginal or poor power quality contributes to a number of negative effects on both the operation of the transmission and distribution system equipment, and particularly affects the utility customer devices. Electrical disturbances include oscillations, voltage variations, flicker, harmonics, fast disturbances (transients), fault-induced voltage sags, and phase imbalance. Many power quality disturbances are localized, especially voltage and current harmonics and ANSI rating levels. Fewer power quality problems are seen system wide, such as frequency variability, some harmonics, and occasionally high, low, or imbalanced voltage levels. A comprehensive power quality assessment is helpful to detect the operating practices that cause power quality disturbances, in order to determine the devices affected by the power quality disturbances, and to mitigate the effects and eradicate the causes more efficiently. Harmonic level is a commonly investigated attribute in power quality studies. Source: Grid Modernization Laboratory Consortium, U.S. Department of Energy.

Power System Stabilizers (PSS see Damping)**:** PSS are installed to improve synchronous generator's oscillation damping capabilities to improve system situational awareness by having greater knowledge of synchronous generator's oscillation damping capabilities. The enhanced information is used in utility control rooms to better ensure stable and secure operation of interconnected power systems with uncertainties. Poorly damped low frequency oscillations in power systems have caused or contributed to system blackouts.

Power Transfer Distribution Factor (PTDF): A measure of the responsiveness or change in electric loading on system facilities due to a change in electric power transfer from one area to another. Power transfer distribution factor is expressed in percent (up to 100 percent) of the change in power transfer in the pre-contingency configuration of a system under study.

Power Transfer Limit: The maximum power that can be transferred from one electric utility system to another without overloading any facility in either system.

Predetermined Scenario: A planner may wish to "hardwire" (putting a *thumb on the scale* to achieve a specified outcome) an outcome in one scenario to compare it to one or more other scenarios. Especially if the planner does not disclose the rationale for a predetermined scenario, this practice should be avoided. Rather, a planner should allow the modeling programs to solve for the objective function such as the lowest present value of revenue requirements.

Present Value (PV): The current worth of a future sum of money or stream of cash flows given a specified rate of return. Future cash flows are discounted at the discount rate, and the higher the discount rate, the lower the present value of the future cash flows. Determining the appropriate discount rate is the key to properly valuing future cash flows, whether they be earnings or obligations.

Pressurized–Water Reactor (PWR): A nuclear reactor in which heat is transferred from the core to a heat exchanger via water kept under high pressure, so that high temperatures can be maintained in the primary system without boiling the water. Steam is generated in a secondary circuit.

Price Anderson Nuclear Industries Indemnity Act (PAAA)**:** The PAAA was passed in 1957 as an amendment to the Atomic Energy Act (AEA) of 1954 (to eliminate the federal government's monopoly on nuclear energy development). The PAA was renewed several times. The purpose of the PAAA was to provide an incentive for private nuclear energy development by indemnifying non-military nuclear facilities against liability claims resulting from nuclear accidents. Clarifying amendments were made in 1974 to the (Section 234(a) – U.S.C. 2283a) and the June 1996 Nuclear Hazards Indemnity Agreement amendment to provide for indemnification, by the U.S. Department of Energy, against public liability for nuclear incidents under specified circumstances. The Supreme Court upheld the Act in Duke Power v Carolina Environmental Study Group.

Price Elasticity (Ed), is percentage change in quantity demanded by the percentage change in price of the same commodity. In economics and business studies, the **price elasticity of demand** is a measure of the sensitivity of quantity demanded to changes in price. It is measured as elasticity, that is, it measures the relationship as the ratio of percentage changes between quantity demanded of a good and changes in its price. If Ed > 1 a good or service is said to be elastic. If Ed < 1, a good or service is said to be inelastic. If Ed = 1 a good or service is said to be unitary elastic. Furniture has a relatively high elasticity of demand so customers or more likely to postpone purchases of furniture during difficult economic periods. In contrast, cigarettes are relatively inelastic so many smokers will continue to smoke even if there are substantial increases in the cost of cigarettes. Air-conditioning use on a very hot and humid day, is likely to result in electricity having a relatively inelastic demand during this period.

Price Node (Pnodes): A single point or subset of points where a physical injection or withdrawal of energy is modeled and for which a locational marginal price (LMP) is calculated and used for financial settlements.

Price Responsive Demand (PRD): PRD, when successfully implemented, would allow customers to respond to granular rate changes. PRD is complementary to the Advanced Metering Infrastructure and Smart Grid utilization because of the capability of passing the necessary information between supplier and consumer. The Smart Grid technologies ensure greater resource utilization for an increasingly efficient, reliable and safe transmission network. While PRD has been proven difficult to implement, most retail rates do not reflect the hourly or sub-hourly dynamic changes evident at the wholesale level. As a result, customers are insulated (and often unaware) of the true cost of supplying their energy needs. End-use customers commit to only consume a certain amount of electricity when energy prices are high and therefore cap the amount of capacity required to serve the customers. Time of Use rates and interruptible rates are used for this purpose.

Price Sensitive Demand: The willingness of customers to purchase electric energy (natural gas, water or other commodity or service) up to a certain price.

Price Separation: in a locational marginal cost (LMP) market, when different clearing prices exist at different locations. In an energy market, price separation is due to transmission constraints and congestion. In the Forward Capacity Auction, when capacity zones experience a difference in price as a result of the quantity of capacity remaining in each capacity zone as the descending clock drops in price.

Price Taker: A market participant whose buying and selling actions do not affect the market price; a generator that has offered into the market at zero or has self-scheduled, is willing to operate at any price, and is not eligible to set clearing prices.

Price volatility: The movement of market prices over time.

Primary Distribution: A voltage on the distribution system that is lower than transmission voltage and higher than secondary voltage ranging from 600 volts to 50 kV. Common voltages include 4160V, 12.5 kV, 25 kV, 36 kV, and many others.

Primary Energy: Energy form found in nature that has not been subjected to any human engineered conversion process. It is energy contained in raw fuels, and other forms of energy received as input to a system. Primary energy can be non-renewable or renewable.

Primary Frequency Control (PFC): Actions provided by the interconnection to arrest and stabilize frequency in response to frequency deviations. Primary Control comes from automatic generator governor response, load response (typically from motors), and other devices that provide an immediate response based on local (device-level) control systems. (from NERC Frequency response Initiative Report, 10/2012)

Primary Frequency Response (PFR): Primary frequency response control involves the automatic response of a generator, or other resource, to adjust output to dampen large changes in frequency. The secondary frequency response is *automatic generation control* (AGC). AGC is produced from manual or automatic dispatch from a centralized control system. Generally, frequency response is a measure of an Interconnection's ability to stabilize frequency immediately following the sudden loss of generation or load. The *North American Electric Reliability Corporation* filed a Reliability Standard BAL-003-01. The Federal Energy Regulatory Commission issued a notice of proposed ruling (NOPR) on this standard and we are awaiting a final Rule (as of December 1, 2016). This Reliability Standard defines the necessary amount of frequency response needed for reliable operations for each Balancing Authority within an Interconnection.

Primary Reserves: Reserve capability that can be converted fully into energy within 10 minutes from the request of the Planning Authority. The Primary Reserve Requirement is met with Synchronized Reserves and Non-Synchronized Reserves.

Primary Reserve Warning: Primary Reserve capacity is less than the Primary Reserve requirement.

Prime Mover: The part of the generator that moves the rotor, a water, steam or gas turbine for electric power generators.

Prime Rate is the interest rate charged by banks to its most credit worthy customers. See also Inflation Rate and Inflation Rate History for correlations to major events. In the US, the prime rate is typically about 300 basis points (3 percentage points) above the Federal Funds Rate which is the interest rate that banks charge each other for overnight loans. See also recessions.

History of Interest Rates (A sample of Prime Rate) Since 1970					
Date	Prime Rate (%)	Date	Prime Rate (%)	Date	Prime Rate (%)
1970	6.8 - 8.0	1971	5.3 - 6.3	1972	4.8 - 6.5
1973	6.3 - 10.0	1974	8.8 - 11.8	1975	7.0 - 10.0
1976	6.3 - 7.3	1977	6.5 - 7.8	1978	8.0 - 11.5
1979	11.5 - 15.5	1980	11.0 - 21.5	1981	15.8 - 20.5
1982	11.5 - 17.0	1983	10.5 - 11.0	1984	11.3 - 13.0
1985	9.5 - 10.5	1986	7.5 - 8.5	1987	7. - 9.3
1988	8.5 - 10.5	1989	10.5 - 11.5	1990	8.0 - 10.0
1991	6.5 - 9.5	1992	6.0 - 6.5	1994	6.3 - 8.5
1995	8.0 - 9.0	1996	8.3 - 8.9	1997	8.2 - 8.5
1998	7.8 - 8.3	1999	8.0 - 8.5	2000	8.8 - 9.5
2001	4.8 - 9.0	2002	4.0 - 4.3	2003	4.0 - 4.7
2004	4.3 - 5.3	2005	5.5 - 7.3	2006	7.5 - 8.3
2007	7.3 - 7.8	2008	3.3 - 6.5	2009	3.3
2015	3.3 - 3.5	2016	3.7 - 4.0	2017	4.0 - 4.3

PRM$_{ICAP}$: Planning reserve margin based on installed capacity. This is the traditional reserve margin typically referenced by utilities in integrated resource plans.

PRM$_{UCAP}$: Planning reserve margin based on unforced capacity i.e. capacity adjusted for historic unit forced outage history. Because capacity is reduced by forced outage rates, the PRM$_{UCAP}$ is lower than a utility's PRM$_{ICAP}$. Two utilities with the same PRM$_{ICAP}$ could have different PRM$_{UCAP}$ if one system had units with higher forced outage rates.

Pro Forma Statements: Hypothetical financial statements developed to analyze the potential ramifications of some event such as a merger. That is, what the company's financial statements would look like with or without the merger (or other event).

Pro Forma Tariffs: Order 888, for example, required all transmission owners to file pro forma nondiscriminatory open access transmission tariffs (OATTs) that transmission service customers could rely upon to define the terms and conditions of transmission service. Order 888 specified the types of transmission service that must be offered, the maximum price to be charged for these services, the definition for Available Transmission Capacity (ATC) and how it should be allocated when there is excess demand for transmission, and specification for the types of Ancillary Services that must be provided.

Probabilistic Risk Assessment (PRA): This is a risk assessment practice that uses probability distributions to characterize variability or uncertainty in risk estimates. In transmission planning, PRA is used to evaluate various transmission options as well as transmission options in comparison to other resource options as a tool to estimate the most economic and reliable options. PRA is currently viewed as a potential supplement to "deterministic" methods used by transmission planners that evaluate only reliability in the context of traditional NERC contingency such as the loss of a transmission element or generator (e.g. N-1, N-2) (see also NERC contingencies.)

Probability (Statistical): A term sometimes used informally as a synonym for frequency probability, which identifies probability with relative frequency over a long series of events or the proportion of an event in a large population. There are several other interpretations customarily classified as Bayesian probability, which have in common the application of probability to problems which don't necessarily involve repetitive events or populations. Probability lies between 0 and 1 ($0 \leq P \leq 1$).

Probability Density Function (PDF) (see also Continuous Probability Distribution): Most often, the equation used to describe a *continuous probability distribution* is called a probability density function. Sometimes, it is referred to as a density function, a PDF, or a pdf. For a continuous probability distribution, the density function has the following properties:

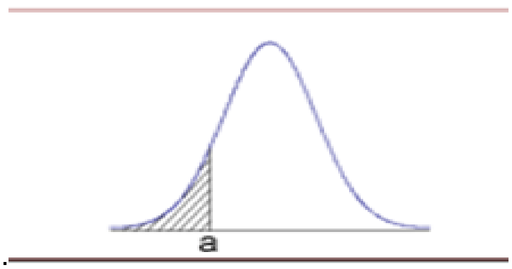
Since the continuous random variable is defined over a continuous range of values (called the domain of the variable), the graph of the density function will also be continuous over that range.

The area bounded by the curve of the density function and the x-axis is equal to 1, when computed over the domain of the variable.

The probability that a random variable assumes a value between *a* and *b* is equal to the area under the density function bounded by *a* and *b*.

For example, consider the probability density function shown in the graph below. Suppose we wanted to know the probability that the random variable *X* was less than or equal to *a*.

The probability that *X* is less than or equal to *a* is equal to the area under the curve bounded by *a* and minus infinity – as indicated by the shaded area



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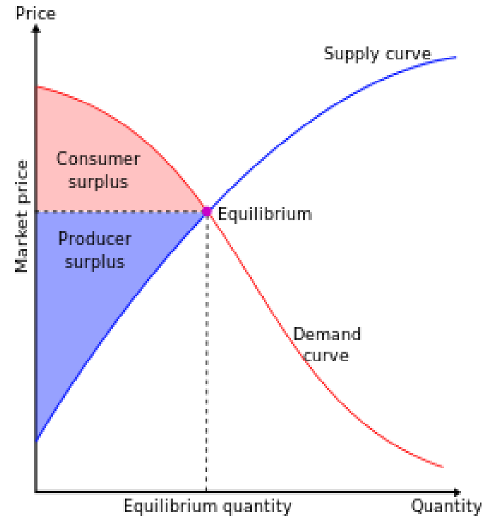
Producer Price Index (PPI, see also Consumer Price Index or CPI and Gross Domestic Product or GDP) The PPI is a weighted index of prices measured at the wholesale, or producer level and is calculated by the Bureau of Labor Statistics. A monthly release from the Bureau of Labor Statistics (BLS), the PPI shows price changes (positive or negative) within the wholesale markets (the PPI was once called the Wholesale Price Index), manufacturing industries and commodities markets. All of the physical goods-producing industries that make up the U.S. economy are included at all stages of production from non-finished goods to finished goods and services, but imports are not.

Producer Surplus: (see also consumer surplus and welfare economics): Producer surplus is the amount of revenue realized by the producer above the cost they were willing to sell the product for which approximates profit. That is, it is above the cost of production. Correspondingly, the consumer surplus is the amount of savings (or benefit or welfare) consumers realize because the amount paid by consumers is less than the amount the consumers were willing to pay. The combination of consumer and producer surplus is *total welfare* (or Marshallian Surplus).



Production Cost Simulation Model: An optimization model used to simulate detailed dispatch, production costs, and operations over a period time (e.g., a year). Multiple years may require the analyst to look at intervals of time over a longer-term planning horizon (e.g., every 4 years over a 20 year planning horizon). Advances in computer capability may enable more granular analysis.

Production Costing: Studies used to estimate the cost of producing electricity under various operating conditions. For example, given forecast estimates of such variables as: fuel prices, heat rates for generating units, energy and demand growth, outage rates, transmission capabilities etc., it is possible to estimate the cost of producing electricity for the forecast period of time.

Production Tax Credit (PTC) (see also Investment Tax Credit): In December 2015, the *Consolidated Appropriations Act, 2016* extended the expiration date for this tax credit to December 31, 2019, for wind facilities commencing construction, with a phase-down beginning for wind projects commencing construction after December 31, 2016. The Act extended the tax credit for other eligible renewable energy technologies commencing construction through December 31, 2016. The Act applies retroactively to January 1, 2015. The federal renewable electricity production tax credit (PTC) is an inflation-adjusted per-kilowatt-hour (kWh) tax credit for electricity generated by qualified energy resources and sold by the taxpayer to an unrelated person during the taxable year. The duration of the credit is 10 years after the date the facility is placed in service for all facilities placed in service after August 8, 2005. Originally enacted in 1992, the PTC has been renewed and expanded numerous times, most recently by the *American Recovery and Reinvestment Act of 2009* (H.R. 1 Div. B, Section 1101 & 1102) in February 2009 (often referred to as "ARRA"), the *American Taxpayer Relief Act of 2012* (H.R. 8, Sec. 407) in January 2013, the *Tax Increase Prevention Act of 2014* (H.R. 5771, Sec. 155) in December 2014, and the Consolidated Appropriations Act, 2016 (H.R. 2029, Sec. 301) in December 2015. The tax credit amount is $0.015 per kWh in 1993 dollars for some technologies and half of that amount for others. The amount is adjusted for inflation by multiplying the tax credit amount by the inflation adjustment factor for the calendar year in which the sale occurs, rounded to the nearest 0.1 cents. The Internal Revenue Service (IRS) publishes the inflation adjustment factor no later than April 1 each year in the Federal Registrar. For 2016, the inflation adjustment factor used by the IRS is 1.5556.

Program Administrator: An entity that maintains primary responsibility and accountability for the design, administration, and delivery of customer-facing demand side management programs that are funded by the public and/or ratepayers. Program administrators can include utilities or independent administrators that are contracted through a state regulatory entity. LBL 2018

Program Potential: Refers to the subset of market potential that can be realized given specific program funding levels and designs. Program potential studies can consider scenarios ranging from a single program to a full portfolio of programs.

Proppant: A solid material, typically sand, treated sand or man-made ceramic materials, designed to keep an induced hydraulic fracture open, during or following a fracturing treatment. It is added to a fracking fluid which may vary in composition depending on the type of fracturing used, and can be gel, foam, or slickwater-based. In addition, there may be unconventional fracking fluids.

Protective Devices: The objective of a protection equipment is to keep the power system stable by isolating the components that are under fault, while leaving as much of the network as possible still in operation. The equipment includes current / voltage transformers, protective relays, circuit breakers, batteries, and – increasingly – communications to remotely control allow tripping of equipment, and fuses for sensing and disconnecting faults. Switchgear is a combination of electrical disconnect switches, fuses, or circuit breakers used to control, protect, and isolate electrical equipment.

Protective Relay: A device designed to detect abnormal system conditions, such as electrical shorts on the electric system or within generating plants, and initiate the operation of circuit breakers or other control equipment.

Proved Reserves (see also Economically Recoverable Resources, Continuous Oil & Gas Accumulations, Technically Recoverable, Unconventional Oil Accumulation): Those quantities of petroleum which, by analysis of geological and engineering data, can be estimated with reasonable certainty to be commercially recoverable, from a given date forward, from known reservoirs and under current economic conditions, operating methods, and government regulations.

Provider of Last Resort: A legal obligation (traditionally given to utilities) to provide service to a customer where competitors have decided they do not want that customer's business.

Prudence: Prudence Standards for utilities considering changes in resources have evolved but, at their core, they are based on who should bear financial responsibilities for *moral hazards* (e.g., unduly shifting risks from the utility to its custimers) by assessing the information available to the utility managements at the time that the decision under consideration was made. Prudence would, then, assess whether reasonable utility managements should have undertaken the investments based on the information they could have and should have known at the time. It is appropriate to ask if the utility management give adequate consideration to other options that might have been more cost-effective, provided greater reliabilty (including diversity), if the decisions provided greater flexibility for future resource decisions, gave due consideration to uncertainty and attendent risks. The regulatory rationale could appropriately be extended to determining if the utility's resource construction program could have – and should have – been reevaluated throughout the construction process (i.e., were there *off ramps?)* if there was a significant change in the primary decision drivers. One indicator for imprudence might be whether the resulting capacity resulted in "excess generating capacity" for an extended period of time. The existence of capacity built or procured in advance of need may violate the *used and useful* concept and, therefore, be inconsistent with appropriate public policy. Imprudence should also weigh the decision-making process and assess if the utility management effectively analyzed changing risks, resource alternatives, and captured the range and potential ramifications of the risks to customers and investors. Well designed state-of-the-art Integrated Resource Plans (IRPs) should provide appropriate planning information but may not be sufficient because IRPs are *snapshots in time* and may not reflect the best current available information. IRPs are almost certain to be enhanced by objective all source Request for Proposals (RFPs) that provide utility managements and policymakers with valuable and timely data.

Prudent Avoidance: This is a precautionary principle in risk management that takes reasonable efforts to minimize potential risks when the actual magnitude of the risks is unknown. The principle was proposed by Prof. Granger Morgan of Carnegie Mellon University in 1989 in the context of electromagnetic radiation safety (in particular, fields produced by power lines). A report for the Office of Technology Assessment of the US Congress described prudent avoidance of power line fields as: "looking systematically for strategies which can keep people out of 60 Hz fields arising from all sources but only adopt those which look to be "prudent" investments given their cost and our current level of scientific understanding about possible risks." While research has not demonstrated a human health concern for electromagnetic fields in power lines, the principle of prudent avoidance has broader applicability.

Pseudo-Tie: A telemetered reading or value that is updated in real-time and used as a "virtual" tie line in the AGC/ACE equation but for which no physical tie or energy metering actually exists. The integrated value is used as a metered MWh value for interchange accounting purposes. Pseudo ties are used to increase liquidity by increasing economic transactions but they may have reliability ramifications.

Public and Private Goods: A public good is not excludable meaning the use by one person does not prevent others from consuming or using the good or service. It is also not depleteable. (National Parks are an example. A private good possesses two properties – *excludability* (consumption by one excludes others from consuming) and it is *finite* as a result it is depleteable.

Public Power: Public power includes municipally owned electric utities, rural electric cooperatives emanating from the Rural Electrification Act, and Power Marketing Administrations (PMAs). City owned utilities do not pay federal taxes and, in some instances, state taxes. City-owned utiliteis often pay "in lieu of taxes" to their cities. Rural electric utilities are able to access capital at lower costs, relative to investor-owned utilities, due to loans from the Rural Utilities' Service (RUS) which is part of the Department of Agriculture.

Public Safety Philosophy (Nuclear): Modern nuclear power plants use several lines of defense to protect the public from the release of radioactive material. The first is conservative operating practices and strict equipment reliability requirements. The second is a robust fuel design that attempts to minimize release of fission products into the coolant during normal plant operations. The third is the reactor coolant system which is designed to remove heat from the fuel rods. Should the primary coolant pumps fail, design criteria require multiple secondary safety system activate to remove decay heat. The final barrier is the containment vessel that surrounds the reactor coolant system. In event of a coolant system rupture the containment and it pressure suppression system are designed to prevent the release of radioactive material.

Public Service or Public Utilities Commission: A state utility regulatory Commission. Each state has its own legislative (or state constitutional authorities). Some states regulate only investor-owned utiliteis. Some states regulate some rural electric cooperatives and / or city-owned electric and natural gas utilities. Some states do not regulate generation in retail access states. Some states have siting authority over new generation and electric transmission. Most states appoint commissioners some states elect commissioners. See NARUC.org for a more complete discussion.

Public Utility: A regulated entity that supplies the general public with an essential service such as electricity, natural gas, water, or telephone.

Public Utility District: A utility run by a local governmental agency or a group of governmental agencies other than a municipality.

PUHCA (**The Public Utility Holding Company Act of 1935**): (It's not the 6' 2 1/2" mythical rabbit – a Pooka - in the movie "Harvey" starring Jimmy Stewart). This act was in response to abuses by rascally holding companies during the 1920s and through much of the 1930s among other things it prohibits acquisition of any wholesale or retail electric business through a holding company unless that business forms part of an integrated public utility system when combined with the utility's other electric business. The legislation also restricts ownership of an electric business by non-utility corporations.

Purchased Power Agreement (PPA): A contract for the sale/purchase of electricity

PURPA (**The Public Utility Regulatory Policy Act of 1978**): PURPA was part of the National Energy Act that was intended to promote conservation, efficiency, and new domestic resources (note the companion Fuel Use Act of 1978 that, among other things, called for the discontinued use of natural gas and oil as electric generating fuels and for industrial use). Context is important. The significant ramifications of the first oil embargo in 1973-1974 (and just before the second energy crisis in 1978). Some of the ramifications included estimates of high fuel prices ($100 per barrel for oil), high inflation, high interest rates, concern that economically recoverable natural gas in the United States was very limited, electric utilities undertaking massive investments in generating capacity at a time when load growth rates were sharply diminishing which, in turn, led to excess capacity, prudence investigations, and some defaults and bankruptcies by utilities.

Among other things, PURPA ushered in a new set of electric suppliers such as "Qualifying Facilities" (QFs), "Electric Wholesale Generators" (EWGs), "Non-Utility Generators" (NUGs), "Co-Gen," and "Independent Power Producers" (IPPs) PURPA required state commissions to compensate these new entrants at an avoided cost rate. This avoided cost rate is intended to be equivalent to what it would have otherwise cost the utility to generate or purchase that power themselves. Utilities must further provide customers who choose to self-generate a reasonably priced back-up supply of electricity. Arguably, the high compensation contributed to interest in retail competition as a means of reducing the price of electricity.

PURPA also required states to order their jurisdictional utilities to undertake load research to provide better information for load forecasting, rate design, demand-side management (i.e., energy efficiency and *load management)* and long-term resource planning. PURPA also required states to discontinue "declining block rates," unless the state commission found them to be cost justified. PURPA encouraged time of use and interruptible rates. *Note with Advanced Metering Infrastructure, there is an opportunity to offer real time pricing that was not possible in 1978.*

The PURPA has been amended with the Energy Policy Act of 2005 (EPAct 05) and the Energy Independence and Security Act of 2007 (EISA). EPAct for the first time gave the FERC explicit authority over reliability. Remember, the definition of reliability includes "security" and "resource adequacy." Of course, states also have statutory obligations and authorities over reliability; particularly making sure there is sufficient generating capacity. EPAct 05 also adds three sections to the PURPA that states must consider (Sec 1251 – Net Metering, Fuel Sources, generation efficiency, Sec 1252 Time-Based Metering and communications, and Sec 1254 that required interconnections). EISA required states to consider Integrated Resource Planning (Sec 532(a), Rate design modifications to promote energy efficiency (Sec. 532(a), Consideration of *Smart Grid* (Sec 1307), and developing Smart Grid information (Sec 1307(a)). Additionally, EPAct 05 also included energy efficiency for appliances, buildings, promotion of renewable resources, development of domestic supplies of oil and natural gas, promotion of nuclear power and coal.

P-Value or P-Statistic (Statistics) (see also T-Test or T-Value, also see "Alpha Hypothesis Test," and Confidence Interval): After selecting the *Alpha* (statistical significance required) the hypothesis test can be calculated. The P-Value is basically the probability of obtaining your sample data If the null hypothesis were true. So if you obtain a P-Value of 0.85, then you have little reason to doubt the null hypothesis. However, if your p-value is say 0.02, there's only a very small chance you would have obtained that data if the null hypothesis was in fact true. Note: The P-Value is a probability just like Alpha and P-Values also range from 0 to 1.

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QUAD: Quadrillion British thermal units (Btu) 10^{15} Btu.

Qualifying Facility (QF): A cogeneration or small power production facility that meets certain ownership, operating, and efficiency criteria established by the Federal Energy Regulatory Commission (FERC) pursuant to the Public Utility Regulatory Policies Act (PURPA).

Qualifying Transmission Upgrade: Genrally, it is a proposed enhancement or addition to the Transmission System. In PJM's region, a transmission upgrade may be offered into the Base Residual Auction (BRA) if such upgrade increases the Capacity Emergency Transfer Limit (CETL) into an Local Delivery Area (LDA) by a megawatt quantity certified by PJM.

Quantitative Easing: An unconventional monetary policy used by the Federal Reserve or other central banks to purchase government securities or other securities from the market in order to lower interest rates and increase the money supply. Quantitative easing increases the money supply by flooding financial institutions with capital in an effort to promote increased lending and liquidity. Quantitative easing is considered when short-term interest rates are at or approaching zero.

Quasi-Judicial: An *Administrative Agency*, such as a regulatory commission, may be created by legislative action and empowered to make decisions concerning the rights of parties. This is an exception to the general rule that only courts of law have the authority to decide controversies that affect individual rights. An administrative agency's power of adjudication falls under the Administrative Procedure Act (60 Stat. 237 [5 U.S.C.A. § 551 et seq.]), With the exception of rule-making, any decision by an agency that has a legal effect is a quasi-judicial action.

Quasi-Legislative: When an administrative agency exercises its rule-making authority, it is said to act in a quasi-legislative manner. Administrative agencies acquire this authority to make rules and regulations that affect legal rights through statutes. This authority is an exception to the general principle that laws affecting rights should be passed only by elected lawmakers. Administrative agencies are creatures of the legislature and administrative rules are made only with the permission of the legislature. In this sense quasi-legislative activity occurs at the discretion of elected officials.

Queue Position: For FERC interconnection requirements, this is the order of a valid Interconnection Requests, relative to all other pending valid Interconnection Requests. This is established based upon the date and time of receipt of the valid Interconnection Request by the Transmission Provider.

Quick Start Units: These are generating units with the ability to synchronize and load quickly, generally within 10 minutes.

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R^2 Value (Statistical): In statistics, the **coefficient of determination, R^2** is used in the context of statistical models whose main purpose is the prediction of future outcomes on the basis of other related information. It is the proportion of variability in a data set that is accounted for by the statistical model. It provides a measure of how well future outcomes are likely to be predicted by the model. There are several different definitions of R^2 which are only sometimes equivalent. One class of such cases includes that of linear regression. In this case, R^2 is simply the square of the sample correlation coefficient between the outcomes and their predicted values, or in the case of simple linear regression, between the outcome and the values being used for prediction. In such cases, the values vary from 0 to 1. Important cases where the computational definition of R^2 can yield negative values, depending on the definition used, arise where the predictions which are being compared to the corresponding outcome have not derived from a model-fitting procedure using those data.

Radial: Type of electrical system configuration where only a single path for power flow exists. Generally thought of as a source of power flowing out to a load center.

Radial Systems (Distribution Systems): Most customers recognize the wires that are typically on poles. The system is arranged like a tree where each customer has one source of supply and is used in less densely populated areas.

Radiation (Nuclear): Unstable materials change into stable materials through the process of radioactive decay. Three types of radiation are of most concern for human health: alpha particles, beta particles, and gamma rays. Each of these forms of energy can interact at the cellular level and cause varying degrees of biological damage. Alpha and beta particles are typically considered only an internal hazard. Therefore, appropriate precautions are taken to prevent ingestion of material that emits them through radioactive decay. Gamma radiation accounts for almost all of the small amounts of radiation nuclear workers receive.

Radiation Measurement (Nuclear): There are two basic types of radiation measures. One is the level of radioactive activity, which is related to the number of radioactive decays per second a material undergoes and is measured in Curies or Becquerel. One Becquerel is defined as the activity of a quantity of radioactive material in which one nucleus decays per second. One Curie is defined as 3.7×10^{10} decays per second, or approximately the activity of 1 gram of radium.

The other measure is an approximation of the biological damage the radiation may cause to the human body. The level of damage is related to the specific organ, level of activity the organ is exposed to, type of radiation particle, energy of the radiation particle, and length of exposure. Two basic measures are the rem and Sievert. One Sievert equals 100 rem.

The average annual radiation exposure from natural sources in the United States is about 310 millirem (3.1 millisieverts or mSv). Another 310 millirem is received through commercial, industrial, and medical processes, so the annual average exposure is 620 millirem in the United States.

The NRC requires that its licensees limit maximum radiation exposure to individual members of the public to 100 millirem (1mSv) per year, and limit occupational radiation exposure to adults working with radioactive material to 5,000 millirem (50 mSv) per year.

Ramp Rate (or Ramping): This is changing the loading level of a generator in a constant manner over a fixed time (e.g., ramping up or ramping down). For scheduling purposes, a generator's ramp rate, is the rate expressed in MW per minute that a generator can change its output or **ramping.**.

Ramsey Pricing (see also Peak Load Pricing): For a *natural monopoly* or any monopoly, the price markup should be inverse to the price elasticity of demand. The greater the elasticity, the smaller the price markup. For customers with a very inelastic demand, unconstrained Ramsey pricing would allow the utility to charge more than the marginal cost of providing electricity. This may adversely affect the poor or those that cannot reduce their use during the most expansive periods and charges greater than the marginal cost might constitute *undue discrimination*.

Random Sample (Statistical): A sample is a subject chosen from a population for investigation. A **random sample** is one chosen by a method involving an unpredictable component. Random sampling can also refer to taking a number of independent observations from the same probability distribution, without involving any real population. A probability sample is one in which each item has a known probability of being in the sample. The sample usually will not be completely representative of the population from which it was drawn — this random variation in the results is known as sampling error. In the case of random samples, mathematical theory is available to assess the sampling error. Thus, estimates obtained from random samples can be accompanied by measures of the uncertainty associated with the estimate. This can take the form of a standard error, or if the sample is large enough for the central limit theorem to take effect, confidence intervals may be calculated.

Random Variable (Statistical): In mathematics, random variables are used in the study of probability. They were developed to assist in the analysis of games of chance, stochastic events, and the results of scientific experiments by capturing only the mathematical properties necessary to answer probabilistic questions. Further formalizations have firmly grounded the entity in the theoretical domains of mathematics by making use of measure theory. There are two types of random variables — discrete and continuous. A discrete random variable takes values from a countable set of specific values, each with some probability greater than zero. A continuous random variable takes values from an uncountable set, and the probability of any one value is zero, but a set of values can have positive probability. Random variables can also be "mixed", having attributes of both discrete and continuous random variables. A random variable has an associated probability distribution and frequently also a probability density function. Probability density functions are commonly used for continuous variables.

Rare Earth Metals from Coal (also Rare Earth Elements – REE): Neodymium and scandium are used in computers, smart phones, rechargeable batteries, electric vehicles, magnets, wind turbines, guided missiles and other defense applications. There are seventeen rare earth metals that also include praseodymium, cerium, lanthanum, samarium, and gadolinium. Rare earths is a misnomer, because they are neither "rare" nor "earths." They are rare in their pure forms, but plentiful as compounds. They are called "earth metals" because that used to be the term for metals that can dissolve in acid. Once coal is burned, the residual ash contains these metals that can be extracted using chemical processes. During the mining of coal, it is also possible to separate out the rocks that have these metals. Past research focused on "*roasting*," a process that is energy intensive and requires exposure to concentrated acids. In contrast, ion exchange is more environmentally friendly and requires less energy. Ion exchange involves rinsing the coal with a solution that releases the REEs that are bound to the coal. The highest concentration of REEs is found in the coal shale which is often discarded due to poor quality for *steam coal.* Demand for these elements are expected to grow by 5% for the next three years. China has been the dominant supplier (85%) due to their low cost of production. The Department of Energy has research projects that may reduce extraction cost to make recovery more effective and, thereby, reduce our dependence on China for these strategically important minerals.

Ratcheted Demand Rate (Demand Ratchet): Typically, based on a customer's maximum demand and the customer, then, is obligated to pay a percentage (e.g., 70%) of that demand the entire year. Historically, these have not been based on a customer's *coincident demand* at the time of the utility's peak or at the time of an RTO / ISO maximum peak demand.

Rate: The authorized charges per unit or level of consumption for a specified time period for any of the classes of utility services provided to a customer.

Rating: The operational limits of a transmission system element under a set of specified conditions. NERC

Rate-Based Compliance with the Clean Power Plant: Generally, the rate-based alternative to using the Mass-Based approach to comply with the Clean Power Plant, would require states to establish enforceable rules that would reduce emissions to a certain level, or rate, per megawatt-hour of electricity generated.

Rate Base: The value of property upon which a utility is permitted to earn a specified rate of return as established by a regulatory authority; generally represents the value of property used by the utility in providing service. A utility's rate base represents what a regulatory commission concludes after hearings is the company's prudent capital investment, net of accumulated depreciation and other specified adjustments, upon which the utility is allowed to earn an approved *rate of return*. For a vertically-integrated electric utility subject to traditional regulation, rate base includes capital costs associated with generation, transmission, and distribution as well as other items such as inventory, working capital, specified *regulatory assets,* pension funds, and offsets for deferred accumulated income taxes. In a *restructured* regulatory environment, typically, generation costs are not included. The rate of return is typically the company's *weighted average cost of capital*. The rate base value is a primary determinant of a utility's *revenue requirement* (the size of the pie that has to be divided among the different *rate classes* in a *cost-of-service* study and rate design). and may be calculated by any one or a combination of the following accounting methods: fair value, prudent investment, reproduction cost, or original cost.

Rate Class: A group of customers identified as a class and subject to a rate different from the rates of other groups. There is no uniform definition for what constitutes a "rate class" which makes comparisons among utilities difficult.

Rate Structures or Rate Design: The design and organization of billing charges by customer class to distribute the revenue requirement among customer classes and rating periods. At the retail level, these may include flat rates, declining block rates, inverted block rates, economic development rates, and time-differentiated rates such as seasonal rates, interruptible rates, real-time pricing time-of-day rates, critical peak pricing rates, and rates to promote demand response and customer-owned generation.

Declining Block Rates. Declining block rates charge less as the amount of electricity increases. This could be applied to gas or water utilities. Declining block rates most often also include a customer charge. These are designed to promote sales. The following is an illustrative declining block based rate design.

0 – 100 kWh = 15 Cents per kWh

101 – 250 kWh = 12 Cents per kWh

251 – 500 kWh = 10 Cents per kWh

501 – 1000 kWh = 9 Cents per KWh

1001 – 2000 kWh = 8 Cents per KWh

2001 – above kWh = 7 Cents per KWh

Demand Rates. (Including "Ratcheted Demand Rates") Demand rates are primarily applicable to commercial and industrial customers. The purpose of demand rates is to give some effect to the amount of infrastructure (generators, transmission, and more tailored distribution equipment for electric utilities) investment that is required to reliably and economically serve larger customers. Historically and, to a large extent today, demand rates are based on the customer's highest demand set during a month or day and use thermal indicating demand meters.

Demand charges are a proxy for contribution to peak demand and the attendant cost of providing sufficient infrastructure to meet and slightly exceed the utility's peak. That is, demand charges assume the maximum demand of a customer will occur during the utility's peak (most expensive period when reliability may be an issue). One of the concerns, then, is that a customer that has its greatest demand during low use (off peak) periods is charged as if the customer was contributing to the cost of the utility's peak. In fact, such a customer should get a lower rates for utilizing the utility's facilities in a beneficial manner.

Increasingly, with increased sophistication of meters (e.g., Advanced Metering Infrastructure or AMI) and Smart Grid, it is possible for the utility to charge the customer based on the greatest demand at the utility's peak.

Some utilities, in an effort to discourage a customer's maximum demand will charge a **"ratcheted demand rate**" That is, once a customer has established its peak demand, the customer will be charged a percentage of established peak (perhaps 50% to 80% for the rest of year even if the customer's peak is below the ratcheted demand. Especially if the customer's peak demand is set during a very low use period, a ratcheted demand rate may prove to be inefficient for the utility. From the utility's perspective, it provides a more reliable stream of revenue.

Flat Rates. Flat rates are the simplest form of rate design. A utility could take the total revenue requirement for each customer class and divide it by the number of kWh sold to that class of customers during the test year. The price of each kWh is the same regardless of the amount or time of use. A flat rate may apply only to the residential class of customers. There is also likely to be a customer charge. While a flat rate is more likely to apply to the residential class, it could be applied to some larger customers. However, in addition to a flat rate, a customer will likely pay a customer charge and, potentially, a separate demand related charge.

Inverted Block Rates. Inverted blocks, in contrast to declining block rates, charge more as usage increases. This rate design is intended to discourage use (increase conservation) and reduce the bills of those least able to afford the service. Inverted block rates most often also include a customer charge. The following is illustrative.

0 – 100 kWh = 7 Cents per kWh

101 – 250 kWh = 8 Cents per kWh

251 – 500 kWh = 9 Cents per kWh

501 – 1000 kWh = 10 Cents per KWh

1001 – 2000 kWh = 12 Cents per KWh

2001 – above kWh = 15 Cents per KWh

- **Time-of-Use Rates (TOU)**: Time of Use rate structures recognize the price of providing electricity (natural gas, water) vary over time. There are various forms of TOU rates. Some, such as seasonal rates, are relatively simple and don't require any new investment in meters. As the accuracy of the rates to reflect changes in the cost of providing electricity improves, so too does the need to have increasingly sophisticated metering. Many utilities are installing Advanced Metering Technologies (AMI) and Smart Grid that could be used for sophisticated rate structures that more accurately reflect the costs of providing electricity over time.

  Time of Use rates are the foundation for Demand Response and Energy Efficiency. Moreover, some form of a Time-of-Use rate structure may provide the appropriate basis for customer-owned generation.

- **Seasonal Rates.** The peak season is defined as the months that are most likely to include the system peak. Higher prices are charged during the peak months. Seasonal rates are a simplistic form of a "*time of use rate"* that recognizes most utilities (electric, gas, and water) are likely to experience maximum demand during the summer or, especially in upper northern states, during the winter. This is a broadsword approach to recognizing that the cost to provide reliable and economic service are seasonal. However, it is a bit like saying *it's ok to wash your clothes in the spring but wait until fall to dry them*. In other words, very few people could take good advantage of seasonal rates but they do provide the utility with a more assured revenue stream. The following is an illustrative seasonal rate:

Summer (May – September)

0 – 100 kWh = 20 cents / kWh

101-1000 kWh = 18 cents / kWh

1001- Above kWh = 15 cents / kWh

Winter (October – April)

0 – 100 kWh = 13 cents / kWh

101 – 1000 kWh = 8 cents / kWh

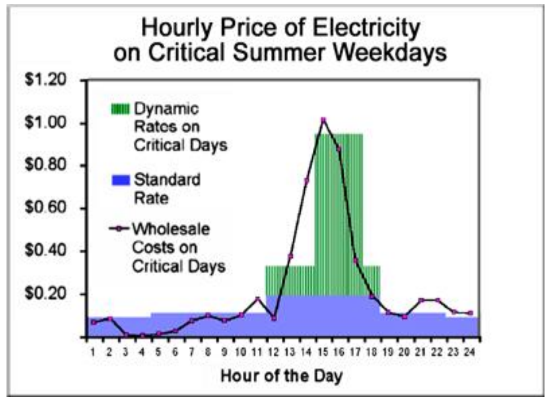
1001- above kWh = 5 cents / kWh

- **Time-of-Day Rates (TOD)**:

1. (Simplified TOD) A simplified version would charge more for periods when peak demand is likely to occur and require less sophisticated metering. That is, the peak rating period is designed to capture the most likely peak season and the hours during the day that is most likely to be a peak demand period. For example, the Time-of-Day Rate may have higher rates during the months of June through August and during the hours of 11 AM until 6 PM. All other periods are regarded as "off peak" with relatively lower prices.
2. (More Accurate TOD). As with the simplified version, peak periods are defined. However, more accurate TOD rates but would require more

sophisticated metering. A more sophisticated TOD rate structure would also consider the days of most probable peak demand and might have more than two rating periods during the peak day. For illustrative purposes, this form of TOD rate might be applicable during June through August, with the maximum peak demand occurring between 1 PM and 5 PM. A *shoulder peak rate* might be from the hours of 11 AM to 1 PM and from 5 PM – 8 PM with slightly lower rates. The off-peak rate, with lower prices, would be from 8 PM until 11 AM. A further refinement might be to define peak days as weekdays and to exclude holidays if, empirically, the peak demand has a low probability of occurring during weekends and holidays.

- **Critical Peak Pricing** (CPP). A further refinement to TOD rates would be to only apply peak rates when utilities experience a peak demand or anticipate a peak demand (e.g., due to extreme temperatures, humidity, or system conditions) that would result in significantly higher prices and / or compromise reliability. This might be limited to system emergency conditions. A utility's tariff may limit the number and timing of CPP (e.g., 1 p.m.—6 p.m., when temperatures exceed 90 degrees, when the humidity is over 70%, or when wholesale market conditions are being stressed). CPP could take the form of a rebate.
- **Real-Time Pricing** (RTP). Especially for utilities that (1) participate in RTO / ISO markets that receive 5 – 15 minute pricing intervals and (2) have AMI and – ideally – Smart Grid, it is now possible to design a Real-Time Rate structure that corresponds with the almost instantaneous changes in the price of electricity. However, for simplicity and convenience of some customers, Real-Time Pricing rates might be designed to be applicable to usage on an hourly basis.



- **Variable Peak Pricing** (VPP). VPP is a hybrid of Critical Peak Pricing and Real-Time Pricing where the different periods for pricing are defined in advance (e.g., limited to a specified number of hours during the expected peak months, during expected peak days – perhaps - only on weekdays and maybe not applied on holidays). The price for the on-peak period varies by utility and market conditions.

Rate of Change of Frequency (ROCOF): A measure of how quickly frequency changes following a sudden imbalance between generation and load. ROCOF is expressed in Hertz per second (Hz / second).

Rate of Return (ROR): The ratio (percentage) of profits (or earnings) compared to capital or assets. The basic formula for determining a revenue requirement is:

$$R \equiv B \cdot r + E + d + T$$

Where: R = revenue requirement

B = rate base, which is the amount of capital or assets the utility dedicates to providing its regulated services

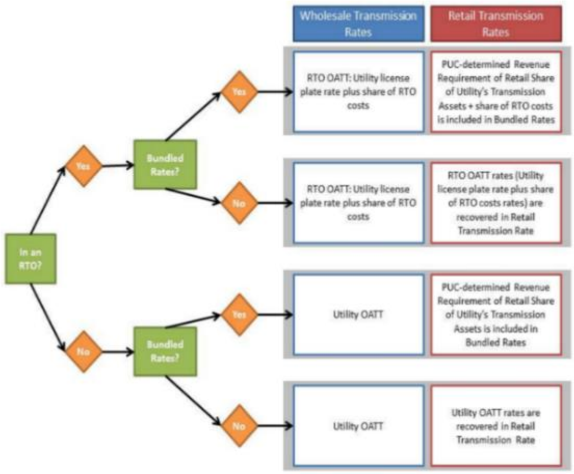
r = allowed rate of return, which is the cost the utility incurs to finance its rate base including both debt and equity

E = operating expenses, which are the costs of items such as supplies, labor (not used for plant construction), and items for resale that are consumed by the business in a short period of time (less than one year)

d = annual depreciation expense, which is the annual accounting charge for wear, tear, and obsolescence of plant

T = all taxes not counted as operating expenses and not directly charged to customers.

Rate Recovery of Transmission Investment (Illustrative and Simplified below)



Rate Schedule: A commission-approved document setting out rates and terms of service specific to a certain service and service provider.

Rated Capacity: The maximum power in megawatts that a power plant is designed to provide to the grid without reducing its design life.

Rating (Transmission): The operational limits of a transmission system element under a set of specified conditions.

Rating Period: Typically used in time differentiated rates to describe the time periods for when different rates (e.g. peak rates) are in effect.

Reactive Limitations: The maximum power flow possible into or through some particular part of the system to maintain post contingency system bus voltage within operating criteria.

Reactive Loads: Electric consuming devices such as fluorescent lights and motors that cause the electrons in the circuit to lag behind the voltage in time due to the way they use electricity.

Reactive Power: The portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current equipment. Reactive power must be supplied to most types of magnetic equipment, such as motors and transformers. Reactive power is provided by generators, synchronous condensers, or electrostatic equipment such as capacitors and directly influences electric system voltage. It is a derived value equal to the vector difference between the apparent power and the real power. It is usually expressed as kilovolt-amperes reactive (kVAR) or megavolt-ampere reactive (MVAR). (see Apparent Power, Power, Real Power.)

Reactive Service: (see also Ancillary Services.) Reactive Service maintains transmission voltages within acceptable limits. Generators whose active energy output is altered at the request of an RTO for the purpose of maintaining reactive reliability are credited hourly for lost opportunity costs if their output is reduced or suspended and credited in accordance with balancing operating reserve credit calculations if their output is increased. Generators operating as synchronous condensers for the purpose of maintaining reactive reliability at the request of the RTO are typically credited for each hour (or partial hour) of condensing operations.

Reactive Supply and Voltage Control: (see also Ancillary Services Market.) Transmission providers (including RTOs / ISOs) require reactive power to control system voltage for efficient and reliable operation of the AC bulk power system. At times, transmission providers need generators to either supply or consume reactive power for reliability or economic efficiency reasons (often for power delivered into major load centers). At the extreme, inadequate reactive power has led to voltage collapses and been a cause of power outages or a contributing factor to power outages. Order No. 888 included provisions regarding reactive power from generators as an ancillary service in Schedule 2 of the *pro forma Open Access Transmission Tariff (OATT)*. Reactive power may be supplied by several different sources, including transmission equipment such as *capacitors, reactors, static var compensators and static compensators*, *generators and synchronous condensers*. Reactive power does not travel over long distances at high line loadings due to significant losses on the wires. Thus, reactive power usually must be procured from suppliers near where it is needed. This factor limits the geographic scope of the reactive power market and, thus, the number of suppliers that can provide reactive power.

Real Dollars: These are dollars that have been adjusted for inflation. Real prices are calculated to reflect the change in the price of a commodity after taking out the change in the general price levels (i.e., the inflation in the economy). When an economist uses the term "real" (real dollars, real prices, real inflation rate) it is intended to reflect inflation.

Real Power: The component of electric power that performs work, typically measured in kilowatts (kW) or megawatts (MW)--sometimes referred to as Active Power. The terms "real" or "active" are often used to modify the base term "power" to differentiate it from Reactive Power and Apparent Power.

Real Time Contingency Analysis (RTCA): Used to determine the secure feasibility of the existing power system if components are removed from operation. Both real and reactive power flow and bus voltage violations are determined. The RTCA uses the results of the SE as the base case for its calculations. The RTCA

Real Time Cooptimization (RTC): Simultaneously optimizing the dispatch of resources and the procurement of ancillary services with the intention of finding the most cost-effective solution for both every five minutes.

Real Time Energy Market (see also Balancing Market, Ancillary Services, and Locational Marginal Cost Pricing)**;** The real-time energy market is a balancing market in which the clearing prices are calculated every five minutes based on the actual system operations security-constrained economic dispatch. The Real-Time Energy Market is based on the concept of Locational Marginal Pricing and is settled based on actual hourly (integrated) quantity deviations from day-ahead scheduled quantities and on real-time prices integrated over the hour.

Real Time Line Outage Distribution Factor Calculator (RTLODFC): Used as a back-up tool for the MISO Real Time Contingency Analysis (RTCA). Does not rely on a solved State Estimator case. Mainly used for identified flowgates.

Real Time Markets: Used by RTOs / ISOs to establish Real-Time Pricing.

Real Time Performance Study: Currently and in most cases, we find that utilities monitor distribution-system *Supervisory Control and Data Acquisition* (SCADA) alarms rather than conducting real-time performance monitoring. However, integrating *Distribution System Analysis* (DSA) tools into utilities' various applications, including the *Distribution Management System* (DMS), *Outage Management System* (OMS), *Energy Management System* (EMS), SCADA, and *Geographic Information System* (GIS), would allow system operators to perform simulations in real time and quickly respond to changing network conditions. Real-time performance analysis is the combination of computerized circuit modeling and continuous analysis, based on measured real-time consumption and generation, to determine the voltages and currents of all elements on the distribution grid (See et al. 2008). The computation results represent the near-term and future feeder states. This information is used by system operators, analysts, and management to facilitate generation dispatch, switching procedures, location and settings for reclosers and capacitors, and demand-side management needs. Power system state estimation is a data processing algorithm for converting redundant meter measurement into an estimation of the power system state (Primadianto and Lu 2016), and is essential for real-time studies. State estimation has been widely used by transmission and generation control centers, due to the very limited number of generators, transmission lines, in-line equipment and devices, and limited technical and economic feasibility to measure and communicate data from circuit elements. Redundant measurements can make the system mathematically observable to enable a state estimator to work. In contrast, distribution systems have a much larger number of nodes and feeder elements and low measurement redundancy. Thus, with an increasing number of DERs, it is extremely challenging to conduct state estimation studies on distribution systems due to the limited availability of input information and the large number of devices. Several different *distribution-system state estimation* (DSSE) methodologies have been proposed by researchers (Primadianto and Lu 2016), such as the weighted-least-squares–based DSSE method and the dynamic DSSE method. However, only a few utilities have implemented DSSE. New techniques, as well as a sufficient amount of continuously measured and communicated data, would be required in distribution systems to effectively demonstrate state estimation methods. Source: Grid Modernization Laboratory Consortium, U.S. Department of Energy.

Real-Time Pricing: The instantaneous pricing of electricity based on the cost of the electricity available for use at the time the electricity is demanded by the customer.

Rebound Effect: Is a reduction in expected gains from new technologies that increase the efficiency of a specific appliance or end-use due to behavioral responses. These responses usually tend to, at least partially, offset the beneficial effects of the new technology.

Recallability: The right of a transmission provider to interrupt all or part of a transmission service for any reason, including economic, that is consistent with Federal Energy Regulatory Commission policy and the transmission provider's transmission service tariffs or contract provisions.

Receipt Point (Natural Gas): A point on a pipeline where the natural gas is received on the system.

Recessions (see also Inflation Rate History and History of Interest Rates): Generally, recessions are regarded as two consecutive quarters (6 months) of a significant decline in economic activity (Gross Domestic Product or GDP is typical but the National Bureau of Economic Research – NBER - also considers a significant decline in economic activity spread across the economy lasting more than a few months normally including increased unemployment, declining real income, lower industrial production, reduced wholesale and retail sales. Recessions occurred in;

1969-70 11 months

This mild recession was caused by fiscal policy to reduce budget deficits due to the Vietnam War.

1973-1975 16 months .

A quadrupling of oil prices caused by OPEC, the cost of the Vietnam War, a significant drop in the stock market, inflation rates as high as 11%, unemployment increased to 9%, GDP fell by 3.2%,

1980 6 months

High unemployment and high inflation due to energy prices and the War in Vietnam

1981-1982 16 months

The Iranian Revolution and increased oil prices causing the 1979 energy crisis.

1990 8 months

1990 Oil Shock, high inflation and tight monetary policy to fight inflation.

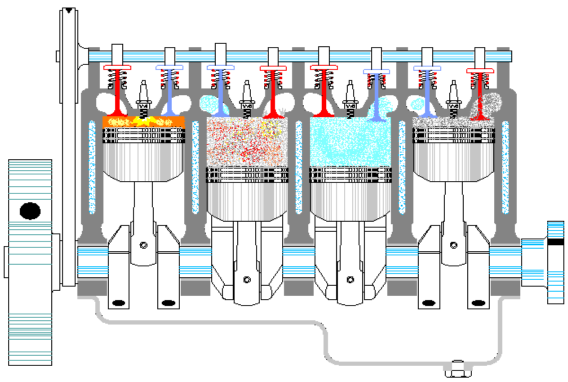
2001 8 months

After the longest period of growth in American history, the "dot com bubble," a sharp fall in business expenditures, and the 9/11 Attack.

2007 18 months

The Great Recession." A 5.6% drop in GDP, The "Subprime Mortgage Crisis contributed to a global crisis, collapse of several financial institutions such as Bears Stearns, Fannie Mae, Freddie Mac, Lehman Brothers, Citi Bank, AIG, a financial crisis in the automobile sector resulting in a $700 bank bailout, and a $787 billion stimulus.

Reciprocating Internal Combustion Engines (RICE): A Reciprocating internal combustion engine (RICE) is any internal combustion engine which uses reciprocating motion to convert heat energy into mechanical work. These can be used by utilities, office buildings, hotels, and other facilities. These are forms of *stationary reciprocating engines*. Stationary RICE differs from mobile reciprocating engines in that they are not used in vehicles. There are two basic types of stationary reciprocating engines - spark ignition and compression ignition. Spark ignition engines use a spark (across a spark plug) to ignite a compressed fuel-air mixture. Typical fuels for such engines are gasoline and natural gas. Compression ignition engines compress air to a high pressure, heating the air to the ignition temperature of the fuel, which then is injected. The high compression ratio used for compression ignition engines results in a higher efficiency than is possible with spark ignition engines. Diesel fuel oil is normally used in compression ignition engines, although some are dual-fueled (natural gas is compressed with the combustion air and diesel oil is injected at the top of the compression stroke to initiate combustion). See federal regulations (40 CFR Section 1068.30 and 40 CFR 63 subpart ZZZZ) and *National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines (*RICE-NESHAP).



Reciprocating Natural Gas Turbines: Traditionally, reciprocating engines were often oil / diesel fired units primarily suited to be peaking facilities due to their ability to provide capacity on short-notice (e.g., some can be synchronized to the grid in about 6 minutes and have fast *ramp rates*), relatively inexpensive to construct, small footprint, and reliable operations but run time was limited due to their relatively high cost fuel. Additionally, reciprocating four-stroke (four cycle) gas engines demonstrates some advantages in single-cycle efficiency. In addition to providing peaking capacity. These units can support renewable resources and Distributed Energy Resources (DERs). If thermal energy can be used, overall plant efficiency may exceed 90% and can be used with Combined Heat and Power (CHP) and *District Heating* by means of efficiently heating water from advanced heat recovery. Emissions are 16 times lower. GE's Áeroderivative & Heavy Duty Gas Turbines (below) is one example of new reciprocating gas turbines in the 34 MW to 557 MW range.

A reciprocating engine uses the expansion of gases to drive a piston within a cylinder, and converts the piston's linear movement to a circular (or rotating) movement of a crankshaft to generate power. There are several types of reciprocating engines, categorized not only by the number of piston 'strokes' it takes to complete one combustion cycle (two or four) but by the type of combustion (spark-ignited or compression-ignited) and the fuel—or fuels— the engine consumes.

Reclosers: In electric power transmission and distribution, a recloser, or autorecloser, is a circuit breaker equipped with a mechanism that can automatically close the breaker after it has been opened due to a *fault.* A recloser improves service continuity by automatically restoring power to the line after a momentary fault.

Reconductoring: To mitigate underrated transmission lines, the actual line conductors can be replaced with larger conductors to increase the transfer limit of the transmission line. Sometimes, multiple conductors are bundled together to obtain this improvement. As long as existing tower structures are adequate to support the additional weight of the new conductors, this alternative is useful to increase transfer capability. In some situations, this alternative may be cost-effective even when tower structures and insulators require modifications.

Recoverable Reserves of Coal

Redispatch Cost (see also Congestion Costs, Locational Marginal Cost Pricing, and Transmission Constraints): The cost to increase and/or decrease output from generation to manage transmission congestion.

Reference Case: (see "Base Case" or "Business as Usual").

Reference Coal Specification: The following table was from a Report by Science Applications International Corporation (SAIC) prepared for the Energy Information Administration Office of Energy Analysis, February 2013

Rank	Bituminous	
Seam	Illinois No. 6 (Herrin)	
Source	Old Ben Mine	
Proximate Analysis (weight %) (Note A)		
	As Received	Dry
Moisture	11.12	0.00
Ash	9.70	10.91
Volatile Matter	34.99	39.37
Fixed Carbon	44.19	49.72
Total	100.00	100.00
Sulfur	2.51	2.82
HHV [1], KJ/kg [2]	27,113	30,506
HHV, Btu/lb [3]	11,666	13,126
LHV [4], KJ/kg	26,151	29,544
LHV, Btu/lb	11,252	12,712
Ultimate Analysis (weight %)		
	As Received	Dry
Moisture	11.12	0.00
Carbon	63.75	71.72
Hydrogen	4.50	5.06
Nitrogen	1.25	1.41
Chlorine	0.29	0.33
Sulfur	2.51	2.82
Ash	9.70	10.91
Oxygen	6.88	7.75
Total	100.00	100.00

(1) High(er) heating value ("HHV").
(2) Kilojoules per kilogram ("KJ/kg").
(3) British thermal units per pound ("Btu/lb").
(4) Low(er) heating value ("LHV").

Regional Greenhouse Gas Initiative (RGGI) (Environmental/Carbon Reduction): The Regional Greenhouse Gas Initiative (RGGI) is the first mandatory market-based program in the United States to reduce greenhouse gas emissions. RGGI is a cooperative effort among the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont to cap and reduce CO_2 emissions from the power sector. Following a comprehensive 2012 Program Review, the RGGI states implemented a new 2014 RGGI cap of 91 million short tons. The RGGI CO_2 cap then declines 2.5 percent each year from 2015 to 2020. The RGGI CO_2 cap represents a regional budget for CO_2 emissions from the power sector.

Regional Transmission Organization (RTOs) (see also Independent System Operators or ISOs): An entity responsible for certain transmission functions and meeting specified criteria in accordance with FERC Orders 2000. Minimum characteristics of an RTO include:

1. independence from market participants,
2. appropriate scope and regional configuration,
3. operational authority for all facilities under the RTO's control, and
4. exclusive authority to maintain short-term reliability.

The minimum functions of an RTO are:

1. tariff administration and design,
2. congestion management
3. parallel path flow
4. ancillary services,
5. OASIS with Total Transmission Capability (TTC) and Available Transmission Capability (ATC),
6. market monitoring,
7. planning and expansion, and
8. interregional coordination.

Both RTOs / ISOs grew out of Orders Nos. 888/889, issued in 1996, where FERC suggested the concept of an ISO as one way for existing tight power pools to satisfy the requirement of providing nondiscriminatory access to transmission. Subsequently, in Order No. 2000, issued in 1999, FERC encouraged the voluntary formation of Regional Transmission Organizations (RTOs / ISOs) to administer the transmission grid on a regional basis throughout North America (including Canada).

Source: ISO/RTO Council (IRC)

FERC Order No. 2000 delineated 12 characteristics and functions that an entity, such as an ISO, must satisfy in order to become a RTO, including four minimum characteristics:

(1) independence from market participants; (2) appropriate scope and regional configuration; (3) possession of operational authority for all transmission facilities under the RTO's control; and (4) exclusive authority to maintain short-term reliability. Voluntary RTOs / ISOs have formed in many regions of the U.S. (see Figure 7), including California (CAISO), Southwest (Southwest Power Pool [SPP]), Midwest (MISO –the first approved RTO), Mid-Atlantic (PJM), New York (NYISO), New England (ISO-NE), and Texas (ERCOT – most of Texas). Similar organizations operate in the Canadian provinces of Alberta (Alberta Electric System Operator) and Ontario (Independent Electricity System Operator). For ease of reference, the term RTO is used herein to encompass RTOs / ISOs.

RTOs / ISOs do not own transmission facilities. They operate the transmission system in accordance with NERC and regional reliability criteria on behalf of their member transmission owners, administer the regional OATT, ensure non-discriminatory access to the transmission system, and manage and plan for the reliability of the transmission system.

Regression (Statistical): a line drawn through the points on a scatter-plot to summarize the relationship between the variables being studied. When it slopes down (from top left to bottom right), this indicates a negative or inverse relationship between the variables (demand for a good decreases when the price of the good increases); when it slopes up (from bottom right to top left such as a business is more willing to produce a good if the price increases), a positive or direct relationship is indicated. The regression line often represents the ***regression equation*** such as the following:

$Y = a + bX + e$

Where:

Y is the dependent variable

a is the intercept

b is the slope or regression coefficient

X is the independent variable (or covariate)

e is the error term – (note the error term represents unexplained (or residual) variation after fitting a regression model. It is the difference - or left over - between the observed value of the variable and the value suggested by the regression model.)

A regression equation indicates the nature of the relationship between two (or more) variables. In particular, it indicates the extent to which you can predict some variables by knowing others, or the extent to which some are associated with others.

Regulating Frequency Response (see also Ancillary Services Market): Regulation and Frequency Response provides for following the moment-to-moment variations in the demand and maintaining scheduled Interconnection frequency. Regulation and Frequency Response Service is necessary to provide for the continuous balancing of resources (generation and interchange) with load and for maintaining scheduled interconnection frequency at sixty cycles per second (60 Hz). Regulation and Frequency Response Service is accomplished by committing on-line generation whose output is raised or lowered (predominantly through the use of automatic generating control equipment) and by other non-generation resources capable of providing this service as necessary to follow the moment-by-moment changes in load.

Regulating Reserves: An amount of reserve responsive to Automatic Generation Control which is sufficient to provide normal regulating margin.

Regulation Market Clearing Price (RMCP) (see also Ancillary Services): The price of supplying the last megawatt of *Regulation* needed to satisfy the Regulation Requirement. The RMCP is calculated every five minutes through joint co-optimization of Regulation, Synchronized Reserve, Non-Synchronized Reserve and energy to achieve the lowest cost alternative. The RMCP is used with the Regulation Market Performance Clearing Price to calculate the Regulation Market Capability Clearing Price.

Regulation of Green House Gases - Massachusetts v. EPA: The Supreme Court, in 2007, held that the Environmental Protection Agency has the authority to regulate carbon dioxide (CO_2) and other greenhouse gases (GHGs) under the *Clean Air Act* (CAA) of 1973 and its 1990 amendments. This ruling provided the legal foundation for further regulation such as the *Clean Power Plan* (CPP) under the CAA. In 2009, the EPA released its scientific findings, concluding that global warming emissions presented a danger to public health (known as the “endangerment finding”).

Regulation Service: The process whereby one Balancing Authority contracts to provide corrective response to all or a portion of the ACE of another Balancing Authority. The Balancing Authority providing the response assumes the obligation of meeting all applicable control criteria as specified by NERC for itself and the Balancing Authority for which it is providing Regulation Service. (NERC)

Regulatory Asset: A specific cost of service recovery, subject to approval by the relevant regulatory agencies, permits a U.S. public utility to defer to its balance sheet. These amounts would otherwise be required to appear on the company's income statement as current period expenses. The booking of regulatory assets (as well as regulatory liabilities) is the purpose of regulatory accounting for the utilities sector to match revenues and expenses, and to smooth out rate recoveries. Government Accounting Standards Board (GASB) Statement No. 62 governs the recording of regulatory assets. According to the statement, regulatory assets are created when certain expenses are recognized as deferrals instead of period expenses. These expenses may include environmental and decommissioning costs, deferred power costs, losses on asset retirements, extraordinary repair and maintenance costs, unrealized derivative losses, advance refunding costs, storm damage costs and debt issuance costs.

Regulatory Commissions: The Federal Energy Regulatory Commission (formerly the Federal Power Commission) regulates the wholesale electric and natural gas markets. State regulatory commissions regulate retail power markets (distribution systems). Most states regulate vertically-owned electric utilities that own and / or operate generation, transmission, and distribution. Typically, these states have some form of Integrated Resource Planning (IRP). Increasingly, states are trying to integrate IRP with distribution system planning and operations as well wholesale market planning and operations. Some state commissions, in *restructured states* that permit retail competition, do not have significant regulatory authority over the construction and operation of generating facilities. To varying extents, state commissions regulate natural gas at the local distribution company (LDC) level but do not regulate pipeline transport, storage, or production. (see National Association of Regulatory Utilities Commissioners at NARUC.org)

Regulatory Lag: Is typically defined as the time between the filing of a case and a regulatory commission's final order and is not inherently good or bad. There is some time and definitional variation among state and federal commissions. Historically, regulatory lag generally has been regarded as increasing risk which may result in cost increases for the utility. Regulatory lag could also be detrimental to utility customers if the results of a rate case produce lower rates and / or better service. However, under certain conditions, regulatory lag may be beneficial to a utility or its customers. Following the boom in power plant construction during the 1970s and 1980s, regulatory lag prevented the utilities from timely recovery of the costs of construction and other costs. It was common for utilities to have more than one rate case pending before state commissions (pancaked rate cases). Automatic adjustment clauses (also known as trackers or riders) that recognized some costs were largely outside the control of the utility (e.g., fuel costs, interest rates, inflation) were established to alleviate the pancaking of rate cases. From the 1990s through the current period, rate cases became infrequent. Infrequent rate cases *may not* be in the public interest because it limits transparency, may foster inefficiency (e.g., reticence to adopt cost-effective technologies) and complacency, may not result in the lowest rates reasonably feasible, and may not promote the desired levels of reliability and performance.

Regulatory Pricing Model (RPM): In the PJM, the capacity market design includes a series of auctions to satisfy the reliability requirements of the PJM region for a Delivery Year.

Relative Root Mean Square Error (rRMSE – statistic for EM&V of energy efficiency and demand response): PJM, to achieve greater accuracy for the *customer's baseline*, uses the rRMSE because it gives greater weight to larger errors than a *Mean Absolute Percentage Error*. A rRMSE of 0.10 would infer that a base line would have an average hourly error of 10% of actual hourly load. The rRMSE fitness function is based on the standard Root Mean Squared Error (RMSE) typically based on the absolute error. The relative error can also be used to create a slightly different fitness measure. By taking the square root of the mean squared error, the error is reduced. The rRMSE of an individual program *i* is evaluated by the equation:

$$E_i = \sqrt{\frac{1}{n}\sum_{j=1}^{n}\left(\frac{P_{(ij)} - T_j}{T_j}\right)^2}$$

Where: $P_{(ij)}$ is the predicted value of a program *I*, and T_j is the target value for fitness case *j*.

Relays: A device that controls the opening and subsequent reclosing of circuit breakers. Relays take measurements from local current and voltage transformers, and from communication channels connected to the remote end of the lines. A relay output trip signal is sent to circuit breakers when needed. Relays include switches that can be operated remotely and control and protection relays that are switches used to signal and control the operation of electrical equipment and systems. They include electronic and electromechanical relays and components; high-voltage protection, substation control and communications; automated substation components; and distribution relays.

Relay Setting: The parameters that determine when a protective relay will initiate operation of circuit breakers or other control equipment.

Reliability Coordinator: The entity that is the highest level of authority who is responsible for the Reliable Operation of the Bulk Electric System, has the Wide Area view of the Bulk Electric System, and has the operating tools, processes and procedures, including the authority to prevent or mitigate emergency operating situations in both next-day analysis and real-time operations. The Reliability Coordinator has the purview that is broad enough to enable the calculation of Interconnection Reliability Operating Limits, which may be based on the operating parameters of transmission systems beyond any Transmission Operator's vision. (NERC)

Reliability Index (RI) is a value that is used to assess the bulk electric power system's future occurrence for a loss-of-load event. A RI value of 10 indicates that there will be, on average, a loss of load event every ten years. A given value of reliability index is the reciprocal of the *Loss of Load Expectation* or LOLE.

Reliability Must Run (RMR) see also Must Run: These are generating facilities that are necessary during certain operating conditions in order to maintain the security of power systems in a competitive environment. Absence of RMR units may result in insecure operation of a system.RMR refers to a generating unit that is slated to be retired by its owners but is needed to be available for reasons of reliability. Typically, it is requested to remain operational beyond its proposed retirement date until transmission upgrades are completed.

Reliability: Electric system reliability has two components – ***adequacy and security***. Adequacy is the ability of the electric system to supply the aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and unscheduled outages of system facilities (e.g., generation, demand response etc.). Security is the ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system facilities.

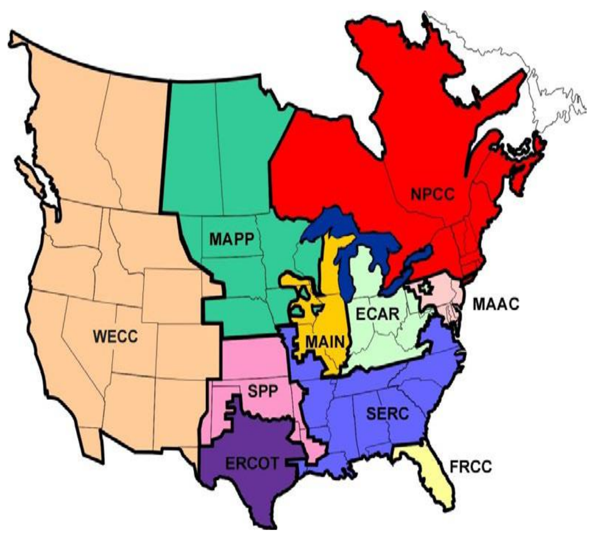
Reliability Assessment Commitment (RAC) (see also Day-Ahead and Unit Commitment): Most RTOs / ISOs have a reliability backstop tool that enables them to ensure sufficient resources are available and on-line to cover forecast load. RTOs / ISOs perform a Day-Ahead RAC process after the Day-Ahead Energy Market has been run and has established final Day-Ahead schedules. The Day-Ahead Market clears based only on the bids, offers, self-schedules and bilateral schedules that Market Participants have submitted, without regard to the RTO's / ISO's load forecast. In the event that the Day-Ahead Market closes significantly below the load forecast and adequate resources have not been committed to meet that forecast, the RAC process provides a reliability backstop to enable the RTO / ISO to commit additional supply if needed to meet the system load forecast and reserve requirements in compliance with NERC and RRO reliability criteria, as well as local reliability needs.

Reliability Coordinator (see also Reliability Authority): The entity that is the highest level of authority who is responsible for the reliable operation of the Bulk Electric System, has the Wide Area view of the Bulk Electric System, and has the operating tools, processes, and procedures, including the authority to prevent or mitigate emergency operating situations in both next-day analysis and real-time operations. The Reliability Coordinator has the purview that is broad enough to enable the calculation of Interconnection Reliability Operating Limits, which may be based on the operating parameters of transmission systems beyond any Transmission Operator's vision.

Reliability Councils (see also NERC): The North American Electric Reliability Council (NERC) is responsible for overseeing and regulating the reliability of the North American electric grid. NERC is composed of eight Regional Reliability Councils. The jurisdiction covered by these councils includes the United States, Canada and a portion of Baja California, Mexico. NERC and the reliability councils are managed by an independent board of trustees elected by the stakeholders across the spectrum of the electricity industry. The stakeholders include Regional Transmission Organizations/Independent System Operators, investor-owned utilities, federal power agencies, rural electric cooperatives, state power agencies, municipal utilities, provincial utilities, independent power producers, power marketers, and end-use customers.

Reliability Must Run (RMR): In an effort to maintain reliabilty, RTOs may enter into agreements to keep certain generatin facilities from retiring, perhaps until there is a transmission upgrade. There are concerns that RMR may adversely affect the wholesale market signals.

Regional Reliability Councils



Reliability Pricing Model (RPM): Capacity Market construct used by the PJM to develop a long term pricing signal for capacity resources and Load Serving Entity obligations that is consistent with the PJM Regional Transmission Expansion Planning Process (RTEP) process (see also Capacity Market).

Renewable Energy: Generally, these include Electricity that is generated from a source that is naturally replenished in a reasonably short period of time such as solar, wind, geothermal, biomass, and hydro. Sometimes the term is not applied to large-scale hydro due to assumed environmental impacts of large hydro projects.

Renewable Natural Gas (RNG): Farms, landfills and wastewater plants are common sources of waste for RNG production.

Renewable Portfolio Standards (RPS): A mandate, or goal, set to require or promote the use of renewable resources for electric generation. The Standard generally states that a certain percentage of a retail electric provider's overall or new generating capacity or energy sales must be derived from renewable resources, with the percentage increasing gradually over time.

Renewable Resources (see also Intermittent Resources): Renewable energy resources are naturally replenishable, but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Some (such as geothermal and biomass) may be stock-limited in that stocks are depleted by use, but on a time scale of decades, or perhaps centuries, they can probably be replenished. Renewable energy resources include: biomass, hydro, geothermal, solar and wind. In the future they could also include the use of ocean thermal, wave, and tidal action technologies.

Renewable Zones: To develop transmission plans to facilitate the development of the most cost-effective renewable resources located in areas or zones within an Interconnection. By considering zones, this will better enable evaluation all economically and engineering feasible renewable resource technologies that are likely to contribute to the viability of the zone. Once the zone(s) is selected, the next step is the development of a reliable and economically efficient interstate transmission network that can move power from the zone to other markets.

Renewal Rate: Percent of assets replaced. Current year-to-date to be reported monthly, is calculated on an asset class basis as the ratio (expressed in terms of percent) of number of assets replaced or refurbished to total number installed.

Reportable Disturbance: Any event that causes the ACE to change greater than or equal to 80% of the Balancing Authority's or Reserve Sharing Group's most severe contingency.

The definition of a reportable disturbance is specified by each Regional Reliability Organization.

Repowering: Refurbishment of a plant by replacement of the combustion technology with a new combustion technology, usually resulting in better performance and greater capacity.

Reserve Margin (RM–see also Capacity Margin): The percentage difference between rated capacity and peak load divided by peak load. Reserve Margin = [(Capacity-Demand)/Demand]. A 15 percent reserve margin is equivalent to a 13 percent capacity margin. Capacity Margin = [(Capacity-Demand)/Capacity].Typically, this refers to "Planning Reserve Margin" or "Capacity Margin." (see also *Operating Reserve Margin, Capacity Margin, and Planning Reserve Margin).*

$$\text{Reserve Margin} = \frac{Resources - Peak\ Firm\ Demand}{Peak\ Firm\ Demand}$$

Reserve Sharing Group (RSG): A group whose members consist of two or more Balancing Authorities that collectively maintain, allocate, and supply operating reserves required for each Balancing Authority's use in recovering from contingencies within the group. Scheduling energy from an Adjacent Balancing Authority to aid recovery need not constitute reserve sharing provided the transaction is ramped in over a period the supplying party could reasonably be expected to load generation in (e.g., ten minutes). If the transaction is ramped in quicker (e.g., between zero and ten minutes) then, for the purposes of Disturbance Control Performance, the Areas become a Reserve Sharing Group.

Reserves: Capacity that current is not being used but can be quickly available to compensate for an unexpected loss of load.

Resiliency: A new (2013) term to describe the ability of a system or elements of the system to recover after a disaster such as hurricanes, earth quakes, blackouts, and cyber-security events.

Resilience: For electric and natural gas utilities, resilience encompasses the ability of an electric grid (or natural gas system) to respond to shocks to the system such as extreme weather events (e.g., Super Storm Sandy, Hurricane Katrina, Polar Vortex, tornados, blizzards, earthquakes, a massive electromagnetic pulse from a solar flare, cyber-attacks, etc.). It is a subset of reliability with distinctions that are not always clear. With the increasing inter-dependence of renewable resources and natural gas, resilience for one industry has ramifications for the other. As of 2020, there is no comprehensive approach to establishing resiliency standards which would require coordination between the North American Electric Reliability Corporation (NERC) and the natural gas industry (there is no corollary for NERC in the natural gas sector). Integrated planning processes-including Distribution System Planning may provide some answers for resiliency and reliability. In October of 2017, the Department of Energy issued a Notice of Proposed Rulemaking for FERC and, by extension the NERC, to provide additional value to baseload coal and nuclear generation in RTO markets that are predominantly serving retail competition states.

Reservoir: An underground deposit of natural gas.

Residential customer: An end user that uses gas or power in a home. While there may be significant differences in the amount of use, the usage patterns are more homogenous within seasons than for commercial and industrial customers. This has implications for rate design, cost-of-service, DSM, and forecasting.

Residual Auction: Allows market participants to buy and sell capacity to balance their portfolios in advance of the Planning Year. This includes a locational requirement that must be secured from resources within the Zone to meet reliabilty requirements.

Resource Adequacy (RA) (see also Reliability and Reserve Margin): Planning Coordinators such as RTOs / ISOs establish Resource Adequacy requirements (and the resulting long-term_planning reserve margins for their member utilities) to ensure that sufficient resources such as electric generation, transmission, demand response, and customer-owned generation are available to allow Planning Coordinators to reliably meet its forecast requirements. RTOs / ISOs often utilize transparent forward (future) capacity price signals. The allocated Reserve Margin and the estimated future prices of capacity, in turn, may be used by individual utilities in the development of their long-term Resource Plans.

Ultimately, assuring that reasonable actions are taken to ensure long-term demands are likely to be satisfied, this should provide greater assurance that real-time operational reserve requirements are also satisfied.

Under ideal conditions and with consideration to transmission constraints and appropriate information / assurances, the ability of any utility to meet its RA requirements should consider resource purchases outside their area (or zone) and outside their region (e.g. inter-RTO).

In addition to RA ensuring sufficient resources to meet long-term demand for electricity, RA, along with "security" are the components of the definition of *reliability.* Traditionally, states have had primary responsibility to assure that sufficient generation, demand response, and other resources were available to satisfy the demand for electricity. However, with EPAct 2005, FERC also has responsibility for reliability. *States that have authority over generation and other resources may require higher reserve margins (greater adequacy) than those required by the relevant Planning Coordinator (Authority) but cannot require a lower reserve margin.*

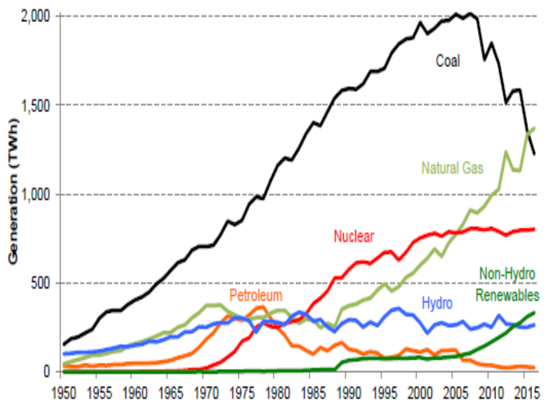
Resource Availability and Need (RAN): A phrase used by the Midcontinent ISO to address reliability concerns throughout the year rather than over-emphasizing the maximum peak demand, especially given the transformation of the generating fleet from heavy reliance on baseload coal and nuclear to other resources. Greater coordination of scheduled outages is a major consideration. More effective utilization of *Load Modifying Resources* with greater attention to correctly assessing resource capabilities. See *Resource Availability and Need – Evaluation Whitepaper*, September 10, 2018.

Resource Clearing Price: A locational and product-specific clearing price paid to a resource that clears in PJM's Reliability Pricing Model Auction (RPM).

Resource Contingency Criteria (RCC – NERC definition): An interconnection's resource contingency criteria (RCC), which is the largest identified simultaneous category C (N-2) event, except for the Eastern Interconnection, which uses the largest event in the last 10 years.

Resource Diversity (see also Fuel Diversity, Load Diversity, and Weather Diversity)**:** In an electric system, resource diversity may be characterized as utilizing multiple resource types to meet demand. A more diversified system is intuitively expected to have increased flexibility and adaptability to: 1) mitigate risk associated with equipment design issues or common modes of failure in similar resource types, 2) address fuel price volatility, and 3) reliably mitigate instabilities caused by weather and other unforeseen system shocks. In this way, resource diversity can be considered a system-wide tool to ensure a stable and reliable supply of electricity. Resource diversity itself, however, is not a measure of reliability. Relying too heavily on any one fuel type may create a fuel security or resilience issue because the level of resource mix diversity does not correlate directly with a resource portfolio's ability to provide sufficient generator reliability attributes. However, fuel and resource diversity are closely related. Resource diversity entails with more detailed information about the operational characteristics of each resource. Resource diversity is also related to load diversity. The value of resource diversity can change dramatically due to changes in the capital cost of different resources, the profitability of different resources in the dispatch, the of capital costs associated with alternative resources, and the dynamics of the pricing and projected prices of different fuels. By way of example, if there was very high confidence that the operating cost of natural gas-fired units (primarily combined cycle) were going to be lower than coal for several years, coal-fired units would not be as desirable; particularly new coal-fired units due to high capital costs. In addition to the lower capital costs and construction lead times compared to coal-fired units, the flexible operations of natural gas-fired units (lower start up times, greater ramping capability, lower heat rates, lower O&M costs) also has some inherent operational and reliability advantages over coal-fired units so some of the traditional values of resource diversity may not be as significant.

Resource Mix: The Nation's resource mix has changed over time (AEO 2016) and will continue to do so as technologies change, fuel cost differentials change, customer needs, reliability imperatives, environmental policies, and other public policy changes.



Resource Planner: The personnel within an entity that develops a long-term (generally a planning horizon of 10-30 years) plan for the resource adequacy to satisfy specific loads (customer demand and energy requirements) within a utility's or Planning Authority's Area (see also Transmission Planner). Unlike traditional transmission planners that were concerned with the maximum demand on individual transmission system elements (which may not be coincident with the system peak demand) and the ability to withstand various situations such as N-1 and N-2 contingencies, a resource planner focuses on planning all of the resources needed to meet a utility's maximum (coincident peak demand). However, there is a general consensus that coordination is essential among transmission and resource planners to better ensure a reliable and economic system.

Resource Subsidies: Historically, all of the primary electricity producing technologies have benefited from federal, state, local, and private industry subsidies. Subsidies include direct spending on facilities (e.g., nuclear) as well as research and development (e.g., Clean Coal research), tax breaks (e.g., Production Tax Credits for wind and solar energy) and exemptions, low-interest loans, loan guarantees, loan forgiveness, grants, discounted royalty fees to mine federal lands, and federally-subsidized external costs, such as insurance (e.g., the Price-Anderson Act to limit liability for operators of nuclear power plants), health care expense (e.g., Black Lung care), environmental remediation (e.g., nuclear storage and coal mining activities), and siting assistance (e.g., the DOE's National Interest Corridors). Examples of state laws that provide preferences / incentives for specific resources include incentives for constructing nuclear power plants, expedited siting, use of specific coal – the Supreme Court found an Illinois law giving preference to Illinois Basin Coal violated the Interstate Commerce Clause, off-shore wind, *Renewable Portfolio Standards*. See for example: "Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013" published March 2015. In October 2017, the DOE under Secretary Rick Perry issued a *Notice of Proposed Rulemaking* (for FERC to give value for ***resiliency*** to coal-fired and nuclear power plants that were often not dispatched (out of the money).

Resource Value Test (RVT)**:** This test refers to the primary cost-effectiveness test that a jurisdiction uses. The National Standard Practice Manual that was issued in the Spring of 2017 offers a seven-step Resource Value Framework to guide states in their development of a primary cost effectiveness test.

Response Rate: The ramp rate that a generating unit can achieve under normal operating conditions expressed in megawatts per minute (MW / min). (NERC)

Resistance: A material's opposition to the flow of electric current measured in ohms (Ω) - Ohm's Law

Restoration: The process of returning generators and transmission system elements and restoring load following an outage on the electric system.

Restructuring: Changes in regulatory rules that result in change in control, ownership, or regulatory mechanisms applicable to specific industry sectors which include retail competition or retail access.

Retail access: The opportunity for an end user to buy gas or electric supply from someone other than its regulated utility distribution company.

Retail Competition: A regulatory system under which more than one electric provider can sell to retail customers, and retail customers are allowed to buy from more than one provider (see also Direct Access). In most states (Michigan being a partial exception), state regulatory commissions have little to no ability over siting, construction, or rate recovery for generating facilities. This then alters the traditional authority of state regulatory commissions to ensure reliability by limiting authority over Resource Adequacy. To the extent that states no longer have authority over RA, this leaves RA to the Federal Energy Regulatory Commission.

Retail Marketer: A firm that sells products and services directly to end users

Retained Earnings: Net income over the life of a corporation less all dividends. Also called reinvested earnings.

Retroactive Ratemaking: Changing rates, typically outside of a rate case, because the utility experienced higher (or lower) revenues or expenses than were anticipated in the last rate case. Generally not allowed, except for adjustment clauses or trackers.

Return: The amount of money included in the revenue requirement to provide earnings and/or to pay back debt.

Return on Equity (ROE see also Return on Revenue Requirement)**:** ROE is the amount of net income returned as a percentage of shareholders equity. Return on equity measures a corporation's profitability by revealing how much profit a company generates.

Return on Investment (ROI): Ratio of net profit after taxes to the investment used to make the net profit.

Revenue Conversion Factor: The calculated revenue requirement includes an adjustment for a change in tax rates referred to as the revenue conversion factor. In context, the change in revenue requirement is intended to address a revenue short-fall or over-collection and is adjusted by the revenue conversion factor.

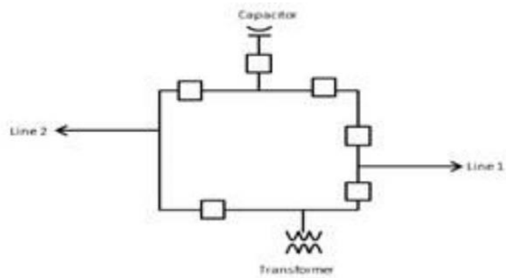
Revenue Sufficiency Guarantees (RSG): These are *uplift charges* that are paid by all market participants (*socialized)* because they are not anticipated, predictable, and cannot be uniquely allocated based on cost causation principles to a specific customer or group of customers.

Reverse Power Flow: Reverse power flow or Back-feeding is the flow of electrical energy in the reverse direction from its normal flow. For example, back-feeding may occur when electrical power is injected into the local power grid from a source, such as a Distributed Energy Resource, other than a utility company generator.

Rig Count (see also Drilled Uncompleted wells or DUC): The rig count is a key proxy for US production levels and shale-industry investment. On March 17, 2017, due to robust production — which has outpaced the pace of the rig count's climb — has undermined efforts by the Organization of Petroleum Exporting Countries (OPEC) to lift prices by cutting output. The US oil-rig count rose this week by 14 to a total of 631 and The gas-rig count rose by 21 to 789 according to Baker Hughes.

Right of First Refusal (ROFR): This is the legal right to construct, own and propose cost recovery for any new transmission project that is located within an incumbent transmission owner's service territory and approved for inclusion in a transmission plan developed through FERC guidelines; FERC Order 1000 stated that it is unjust and unreasonable to grant incumbent transmission providers a federal right of first refusal with respect to certain transmission projects because doing so may result in the failure to consider more efficient or cost-effective solutions to regional needs and, in turn, result in the inclusion of higher-cost solutions in the regional plan.

Ring Bus (see also Bus, Breaker-and-a-Half and Straight Bus): For stations having three to five circuits, a ring bus is often used. As more circuits are added, the configuration may evolve to a breaker-and-a-half arrangement. The ring bus configuration is composed of several bus sections connected through bus-tie circuit breakers as shown below. One transmission element is connected to a dedicated bus section; therefore, the isolation of one transmission element requires the operation of two bus-tie circuit breakers. In addition, each element is connected to the bus via a disconnect switch, circuit switcher or circuit breaker. This would ensure that the bus stays intact while one or more of the elements connected to the bus stay out of service for an extended period of time for scheduled maintenance or repairs. The ring bus configuration would be mostly preferred in areas where: 1. No future expansion is anticipated 2. Land availability is limited 3. Physical location and the layout of the buses and the lines entering or leaving the substation may introduce reliability concern if the breaker and a half scheme is utilized. If a ring bus configuration is used, the bus should be designed in such a way that conversion to a breaker-and-a-half design is possible if needed.



Ring Fencing: This concept, applied to regulated utilities, is an attempt to limit only approved transfers of assets from the regulated utility to an unregulated parent corporation (e.g., a holding company) or affiliates of the regulated utility. Ring fencing is intended to protect the regulated utility’s customers. One application of ring-fencing to protect consumers is in banking regulation. Bank regulations may compel banks to separate traditional consumer banking services from investment activities within a financial institution to protect consumers from risker investment banking activities. Historically, these riskier banking activities have resulted in financial losses to consumers, investors, and, in extreme cases, resulted in bank failures. Ring fencing may be more generally applied to prevent corporations from hiding assets – such as transfers to off shore accounts - in an effort to reduce tax liabilities and shield assets from creditors.

Risk Premium (see Capital Asset Planning Modle or CAPM)**:** The risk-free rate of return on an investment is expected to yield a higher return compared to a risk free rate of return (Expected Rate of Return – Risk Free Rate of Return). A risk premium is compensation for investors willing to tolerate extra risk, compared to a risk-free asset (e.g., a U.S. bond), It is likened to hazardous duty pay.

Rolling Blackouts (See also Blackouts and Cascading Blackout): Sometimes referred to as a *rolling blackout, rotational load shedding,* or *feeder rotation*, is an intentionally engineered electrical power shutdown where electricity delivery is curtailed for non-overlapping periods of time over different parts of the distribution region. Rolling blackouts are a last-resort measure used by an electric utility to avoid a total blackout of the power system.During the California Energy Crisis, Southern California Edison (SCE), for example, instituted rotating blackouts for an hour in specific feeders. SCE shut down power by geographical groups – known as “Rotating Outage Groups” or “Rotating Outage Group Blocks” – to help ease the demand on the electrical grid. Rotating Outages help prevent larger and longer power outages.

Roll-Off of the Effects of Existing DSM Programs: Simply stated, as energy efficiency measures are replaced or their effectiveness diminishes, it is important to recognize these effects in developing energy efficiency programs and integrating roll offs into load forecasts and resource planning.

Root Cause Analysis (RCA)**:** Root Cause Analysis is an objective process or procedure that helps guide discovery to understand the initiating causes of a problem, with the goal of determining missing or inadequately applied controls that will prevent recurrence.

Root Mean Square Error (RMSE - statistics): The regression line predicts the average y value associated with a given x value which is also necessary to get a measure of the spread of the y values around that average. To construct the RMS error, the residuals need to be determined first [Residuals are the difference between the actual values and the predicted values]. The residual values can be positive or negative as the predicted value under or over estimates the actual value. Squaring the residuals, averaging the squares, and taking the square root gives us the RMS error. You then use the RMS error as a measure of the spread of the y values about the predicted y value.

$$RMSErrors = \sqrt{\frac{\sum_{i=1}^{n}(\hat{y_i} - y_i)^2}{n}}$$

As with a Normal Distribution, you can usually expect 68% of the y values to be within one RMS error, and 95% to be within two RMS errors of the predicted values.

Rights of Way (ROW*)*: This is a corridor of land on which electric lines may be located; the Transmission Owner may own the land in fee, own an easement, or have certain franchise, prescription, or license rights to construct and maintain lines on the land.

RTEP (Regional Transmission Expansion Planning): Used in the PJM (see MTEP for MISO.) RTEP is the transmission expansion planning process, with a 15 year planning horizon, used by PJM to ensure needed transmission is built in a timely manner for continued reliabile and economic operation of the transmission system. RTEP identifies trasmission projects – including upgrades and enhancements – that provide operational, economic, public policy, and reliability benefits to the PJM region.

Rural Electric Membership Cooperative (REMC or REC): A utility owned by its customers and fostered by the Rural Electrication Act and the United States Department of Agriculture (USDA) that initially was intended to serve rural areas. Over time, REMCs have expanded service. Some REMCs have formed Generation and Transmission Cooperatives to provide resources to their member cooperative systems.

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S Curve: May be used to describe the adoption rate of a new technology or product. S-Curves describe the growth of a variable in terms of another variable, often expressed as units of time. An S Curve would depict a slow, then a more rapid –perhaps - exponential increase in sales for a period time, then reaches a maximum, followed by a tapering or leveling off.

Safe Limits: System limits on quantities such as voltage or power flows such that if the system is operated within these limits it is secure and reliable.

Sales for Resale (Electric): A type of wholesale sales covering energy supplied to other electric utilities, cooperatives, municipalities, and Federal and state electric agencies for resale to ultimate consumers. (FERC definition)

Sales to End Users: Sales made directly to the consumer of the product. Includes bulk consumers, such as agriculture, industry, and utilities, as well as residential and commercial consumers.

Salvage Value (see also depreciation)**:** Salvage value is the estimated resale value of an asset at the end of its useful life. Salvage value is subtracted from the cost of a fixed asset to determine the amount of the asset cost that will be depreciated. Thus, salvage value is used as a component of the depreciation calculation. For example, a company buys an asset for $100,000, and estimates that its salvage value will be $10,000 in five years, when it plans to dispose of the asset. This means that the company will depreciate $90,000 of the asset cost over five years, leaving $10,000 of the cost remaining at the end of that time. The company expects to sell the asset for $10,000, which will eliminate the asset from the accounting records. If it is too difficult to determine a salvage value, or if the salvage value is expected to be minimal, then it is not necessary to include a salvage value in depreciation calculations. Instead, simply depreciate the entire cost of the fixed asset over its useful life. Any proceeds from the eventual disposition of the asset would then be recorded as a gain.

Savings Load Shapes: The difference between the hourly use of electricity in a baseline condition and the hourly use post-installation of the energy efficiency measure (e.g., the difference between hourly use of an electric resistance water heater and a heat pump water heater, or between the hourly lighting use in a commercial building pre- and post-installation of daylighting control or occupancy sensor) over the course of a year. (LBL)

Scenario or Scenario Analysis: A term or phrase used to describe equations used in utility planning, economics, financial planning, and statistics to describe the possible future and possible alternative outcomes or futures and address uncertainties and their attendant risks. That is, a scenario uses assumptions about variables (drivers) that are likely to be significant in understanding the future as well as assessing possible alternative futures which would provide management with insights to develop a resilient strategy to provide a flexible response to changing circumstances. For example utilities might want to use different scenarios to assess which combination of resources may result in the lowest Present Value of Revenue Requirements (PRVV), the most reliable system, the lowest CO2 emissions, greatest integration of renewable resources, or other objective functions over a specific Planning Horizon (1 year is common for some analysis like financial forecasts while 20 + years is common for resource planning because of the capital intensity of some investments and the point of inflection where benefits start exceeding costs to customers maybe several years in the future). This utility might want to construct scenarios to examine how the objective function is satisfied by changes in in future demand, fuel costs, compliance costs for environmental regulations, and other significant factors (variables) over the planning horizon. Scenarios, should be constructed to not only the most likely future world, but also provide plausible alternative scenarios to the most expected or base case, and some scenarios to stress the utility's system by using drivers that have relatively low probabilities of occurrence but significant ramifications if those unlikely events occurred. The more extreme cases might be regarded as bookends around the most expected case(s). This might include, what some would consider, black swan events but the scenario might not be the basis for planning because of its low probability of occurrence. Scenario analysis may be enhanced by injecting probabilistic analysis into the construction of the scenario and its variables. To use scenario analysis to better understand uncertainties and their potential risks, utility planning scenarios should be constructed to produce different resource mixes (different futures). it is also important to develop a narrative (story) to explain the rationale for the scenario. To further assess the potential risks, sensitivities (changes to specific variables to assess the unique changes to a specific scenario caused by the change in the variable).

Schedule: A statement of the pricing format of electricity and the terms and conditions governing its applications.

Scheduled Outage: The shutdown of a generating unit, transmission line, or other facility for inspection or maintenance, in accordance with an advance schedule.

Scheduling Path: The Transmission Service arrangements reserved by the Purchasing-Selling Entity for a Transaction. (NERC)

Scheduled Outage Factor (SOF): The percent of time that a generating unit (or transmission facility) is out of service due in a specific period to either a planned or a maintenance outage. A lower SOF is desirable.

Scheduling Coordinators: Entities certified by the Federal Energy Regulatory Commission (FERC) that act on behalf of generators, supply aggregators (wholesale marketers), retailers, and customers to schedule the distribution of electricity.

Scheduling, System Control, and Dispatch Service (see also Ancillary Services Market): This service is required to schedule the movement of power through, out of, within, or into a Control Area or RTO / ISO. Scheduling, System Control and Dispatch Service is to be provided directly by the Transmission Provider (e.g., an RTO / ISO or Control Area Operator).

Scientific Method: Became a formalized construct in the 17th Century. The scientific method is a continuous process that requires an identification of a problem (systematic *observation*), assessing and quantification of relevant (empirical) data, formulating a *hypothesis* (conjecture about some population) from these data, designing an unbiased (*controlled*) experiment, testing and, if necessary, modifying the hypothesis for continued testing. The objective is to formulate a prediction that has *reproducible* results. Electric and natural gas utilities may employ the scientific method in load research, DSM research, to understand the integration issues of Distributed Energy Resources (DER), to assess the cost-effectiveness of various elements of the system (e.g., meters, transformers).

Screening Curves for Electric Utility Resource Planning: A depiction of time versus total cost (capital and operating expense per hour) of an online electric generating unit (EGU) for that time. Screening curves can be used to simplify the problem of determining "merit order" for dispatch of existing and proposed EGUs, a critical element in the capacity planning problem.[EPRI]

Seams Issues: Seams include operational and planning interfaces between two (or more) Planning Authorities (aka Planning Coordinators), utility control areas, systems, and markets. **Seams issues** can result in operational and planning inefficiencies sometimes referred to as *Market Friction*. In some instances, they manifest themselves as trade barriers that adversely affect short and / or long-term economic efficiency and reliability that are, ultimately, detrimental to customers and utilities. These inefficiencies among wholesale electricity markets may be the result of transmission constraints, differences in market structures, different market rules, definitional differences, incompatibility of systems, differences in software, differences in operational or planning procedures, or attitudinal differences.

Seasonal Energy Efficiency Ratio (SEER): Ratio of the cooling output divided by the power consumption. It is the Btu of cooling output during its normal annual usage divided by the total electric energy input in watt hours during the same period. This is a measure of the cooling performance for rating central air conditioners and central heat pumps. The appliance standards required a minimum SEER of 10 for split-system central air conditioners and for split-system central heat pumps in 1992. (The average heat pump or central air conditioner sold in 1986 had an SEER of about 9.)

Seasonal Rates: Different seasons of the year are structured into an electric rate schedule whereby an electric utility provides service to consumers at different rates. The electric rate schedule usually takes into account demand based on weather and other factors.

Second Best: The preferred allocation of goods and services or set of allocations is not achievable. As a result of limiting conditions, a second best solution (or allocation) is necessary to maximize a social welfare function.

Second Contingency Basis (see also first contingency basis): Aspects of the bulk power system are often planned to protect against adverse consequences of a failure or malfunction of any two bulk power facilities (transmission, generation, and other resources). This is often referred to as *N-2 contingency***.** The loading on all bulk power facilities are intended to be within normal continuous ratings and maintenance of Voltages within predetermined normal schedules at all load levels; such that, immediately following any single facility malfunction or failure, the loading on all remaining facilities can be expected to be within emergency ratings. That is *System Stability* – including an acceptable Voltage profile - is maintained to avoid a cascading outage.

Secondary Energy: A conversion from a primary energy source such as electricity.

Secondary Frequency Control: Actions provided by an individual Balancing Authority to correct the resource-to-load imbalance that created the original frequency deviation that will restore both Scheduled Frequency and Primary Frequency Response. Secondary Frequency Control comes from either manual or automated dispatch from a centralized control system such as Automatic Generation Control (AGC). Includes the deployment of area regulation and synchronized reserves (if required). Happens within the recovery period which is 1-10 minutes following a disturbance. (NERC Reliability Guideline on Primary Frequency Control)

Secondary Network Grids: Typically located under streets and alleys in a manhole and duct system. Systems are designed to be redundant such that failure of any one piece of equipment (cable section, transformer) does not result in a customer outage. Each network is supplied by two or more primary feeders, often five or six. The primary feeders are generally supplied by the same substation. Secondary grid voltages can be either 120/208 volts or 277 /480 volts. While 277 /480 is typical, some might be listed as 266/460. Transformers range from 200, 500, 750, 1000, 1500, 2000, and 2500 kVA. [O'Neill Management Consulting and Charles Fijnvandraat].

Secondary Networked Distribution: Is the most reliable system since it has multiple sources of supply and is commonly found in big cities. According to O'Neill Management Consulting and Charles Fijnvandraat: "*Customers are served from a set of three-phase, four wire, low voltage circuits supplied by multiple network transformers whose low-voltage terminals are connected to the low-voltage circuits through network protectors. The secondary network has two or more high-voltage primary feeders, with each primary feeder typically supply 10-30 network transformers*. *The system also includes automatic protective devices to isolate faulted primary feeders, network transformers, or low-voltage cable sections while maintaining service to the customer served from the low-voltage circuits."*

Secondary Reserves: Reserve capability that can be converted fully into energy within a 10- to 30-minute interval. Secondary Reserve need not be electrically synchronized to the power system.

Securitization: Securitization allows utilities to segregate the regulatory asset into a special purpose entity (SPE). The SPE issues bonds to cover the asset in one lump sum that is remitted to the utility. Debt service on the bonds is collected from ratepayers through a non-bypassable charge that the state commission agrees will not rescind. As a result, the bonds generally carry a high investment grade credit rating and very low interest rates; thus reducing the overall cost to ratepayers by lowering the financing costs on the assets relative to the company's overall cost of capital.

Securitize: To aggregate contracts into one pool, which then offers shares for sale in the investment market. This strategy diversifies project risks from what they would be if each project were financed individually, thereby reducing the cost of financing.

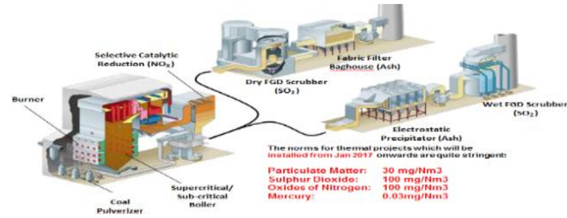
Security: The ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system elements. Security and Resource Adequacy are the two components of the definition of Reliability.

Security Constrained Economic Dispatch (SCED): When congestion occurs, least-cost generation often must be passed over for purposes of system security. For this reason, this market model – where the system operator acts as a clearing agent *and* manager of system security – is called *bid-based, security-constrained economic dispatch.*

Security Constrained Unit Commitment (SCUC): Security-constrained unit commitment is a critical tool used by Regional Transmission Organizations / Independent System Operators in the day-ahead (24 hours) electric power market to better ensure the most cost-effective generation schedules consistent with reliability and constraints (e.g., line limits do not exceed limits following a contingency). For dispatchers / schedulers, SCUC is to decide which resources to interconnect over a specified period of time. SCUC typically utilizes *Mixed Integer Linear Programming* to solve for non-linear characteristics such as bus voltage limits, line flow limits and resolving constraints such as expected demands, spinning reserves, ramping, minimum up and down time, and emissions limitations. Co-optimization, for RTO / ISO facilitated markets, entails the simultaneous clearing of two or more commodity markets (e.g., the energy and ancillary services) within the same optimization problem.

Selective Catyaltic Reduction (SCR): Injects product into the air stream as it passes over a catalyst causing NOx to be converted to nitrogen and water.

Based on the chemical reduction of the NOx (nitrogen oxide) molecule emplyoing a metal-based catalyst with activitated sites to increase the rate of the reduction reaction. The primary components of the SCR include the ammonia storage and delivery system, ammonia injection grid, and the catalyst reactor. A nitrogent-based reducing agent (reagent), such as ammonia or urea derived ammonia, is injected into the post-combustin flue gas. The reagent reascts selectively with the flue gas NOx within a specific temperature range and in the presence of the catalyst and oxygen to reduce the NOx into molecular ntirogen (N_2) and water vapor (H_20). SCR is typically implemented on stationary source combustion units requiring a higher level of NOx reduction than achievable by *selective noncatalytic reduction* (SNCR) or combustion controls. Theoretically, SCR systems can be designed for NOx removal efficiencies close to 100%. In practice, commercial coal,oil, and natural gas–fired SCR systems are often designed to meet control targets of over 90%. In the U.S., SCR has been installed on more than 300 coal-fired power plants ranging in size from 147 MWe to 750 MWe. SCRs are also used on 650 combined cycle natural gas turbines, and some industrial boilers. About 80% of electric utilities use ammonia (anhydrous and aqueous), and the remainder use urea. SCRs capital costs vary by the type of unit, fuel type, the inlet NOx level, the outlet NOx design level. Source EPA.



Self Healing: A self-healing grid uses digital components and real-time communications technologies to monitor its own electrical characteristics at all times and can provide a number of benefits that support a more stable and efficient system. Three of its primary functions include: **Real-time monitoring and reaction** which allows the system to constantly tune itself to an optimal state; **Anticipation**, which enables the system to automatically look for problems that could trigger larger disturbances; and **Rapid isolation**, which allows the system to isolate parts of the network that experience failure from the rest of the system to avoid the spread of disruption and enables a more rapid restoration. As a result of these functions, a self-healing smart-grid system is able to reduce power outages and minimize their length when they do occur. Beyond managing power disturbances, a smart-grid system has the ability to measure how and when consumers use the most power. This information allows utility providers to charge consumers variable rates for energy based on supply and demand. Ultimately, this variable rate will give consumers an incentive to shift their heaviest use of electricity to times of the day when demand is low. To transform our current infrastructure into a self-healing smart grid, several technologies must be deployed and integrated. The ideal smart-grid system consists of microgrids, which are small, mostly self-sufficient power systems, and a stronger, smarter high-voltage power grid, which serves as the backbone to the overall system. Upgrading the grid infrastructure for self-healing capabilities requires replacing traditional analog technologies with digital components, software processors, and power electronics technologies. These must be installed throughout a system so that it can be digitally controlled, which is the key ingredient to a grid that is self-monitoring and self-healing. *The 'Self-Healing' Power*, The Institute, (IEEE), Massoud Amin, 4 November 2013

Self Schedule: Is the action of a market participant to commit or schedule its resource at a determined output level to provide generation within an hour, regardless of price or whether the RTO / ISO could have scheduled or dispatched the resource to provide the service.

Self-Scheduled Generator Offers: In RTO markets, some generating units are self-scheduled. These units generate a specific amount. *Self-Scheduled and Dispatchable* are units that are self-scheduled for their minimum economic output but are dispatchable to their economic maximum. In contrast, fully dispatchable units are available to be economically dispatched as needed.

Self-Scheduled Resource: A generating resource that is turned on by the operating company and committed into the energy market by the operating company. Also known as running for company.

Self Selection Bias: A bias in an outcome that is introduced when individuals select themselves into an experimental group.

Self Supply: When a participant provides itself with a market product from its own resources rather than purchasing it from the market.

Sensitivities: Sensitivities are often layered on individual scenarios to assess the unique uncertainties and risks associated with a specific change in a primary driver (variable) such as fuel prices, load changes, the cost of alternative resources, potential changes in environmental regulations. Isolating a range of changes in a selected primary variable provides the utility with a better understanding of the uncertainties and risk associated with that specific variable and aids in the evaluation of all of the various planning scenarios. For example, a "reference" or "business as usual case" may be altered by changing the forecasted price of natural gas or changes in environmental regulation such as carbon costs to determine a range of these specific potential risks.

Service: Electrical components that connect the service transformer to the customer including the wires that run into the facility, the meter that measures electric deliveries, and the protective devices that ensure the safety of the service and circuits within the customer facility,

Service Conductor: The wires that connect a customer facility to the utility distribution system.

Service Configuration: The way that the distribution facilities including the service transformers are connected to provide service to a customer. Key parameters include whether the service is two-wire, three-wire, or four-wire; whether the service is single-phase or threephase; and if three-phase, whether the service is delta or wye.

Service drop: Overhead conductors used to connect the distribution system to a customer facility.

Service Lateral: Underground conductors used to connect the distribution system to a customer facility.

Service Territory: Sometimes referred to as "franchised service territory." The geographical area served by a utility as approved by state regulatory commissions and limits competition within those approved boundaries.

Service transformer: A transformer that converts the voltage of the primary distribution line to the voltage on the secondary distribution line required by a customer.

Service Voltage: The voltage delivered by the utility to a customer facility.

Settling Frequency: The point at which frequency is stabilized following formation of the frequency *nadir.* Lawrence Berkely Lab 2018

Seven Factor Test (FERC **–** see also bulk power and distribution systems**):** Order 888, (31.771 and 21/981) FERC articulated the seven factors that would attempt to create more of a bright line between transmission and distribution facilities and services. These include: (1) local distribution facilities are normally in close proximity to retail customers; (2) local distribution facilities are primarily radial in character; (3) power flows into local distribution systems, and rarely, if ever flows out; (4) when power enters a local distribution system, it is not re-consigned or transported on to some other market; (5) power entering a local distribution system is consumed in a comparatively restricted geographic area; (6) meters are based at the transmission/local distribution interface to measure flow into the local distribution system; and (7) local distribution systems will be of reduced voltage. Order No. 888 at 31,771 and 31,981.

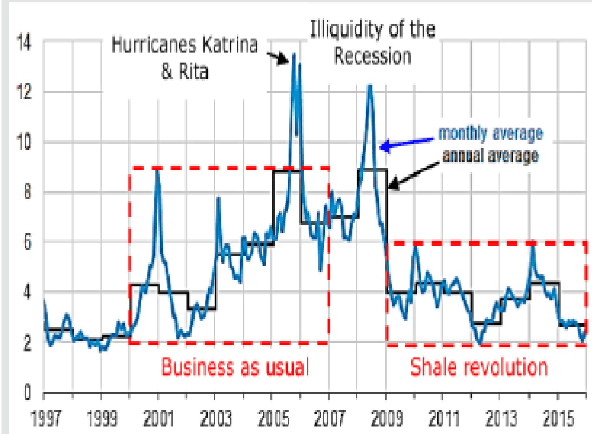
Shadow Flicker: The pulse of shadows and reflections that is sometimes cast by the moving turbine blades which *may* affect people living in close proximity to wind farms

Shadow Price (see also Locational Marginal Price): Regional Transmission Organizations use shadow price to calculate the Locational Marginal Cost (LMP) for transmission constraints. A positive shadow Price indicates a congested transmission line or element. A zero shadow price is indicative of no constraints. The constraint shadow price represents the incremental reduction in congestion cost achieved by relieving a constraint by 1 MW. The shadow price multiplied by the flow (in MW) on the constrained facility during each hour equals the hourly gross congestion cost for the constraint. More technically the shadow price is defined. In constrained optimization in economics as the instantaneous change, per unit of the constraint, in the objective value of the optimal solution of an optimization problem obtained by relaxing the constraint. In economics, the shadow price is the marginal utility of relaxing the constraint, or, equivalently, the marginal cost of strengthening the constraint. The shadow price is the value of the Lagrange multiplier at the optimal solution, which means that it is the infinitesimal change in the objective function arising from an infinitesimal change in the constraint.

Shale Gas and Tight Oil (Natural Gas): The boom of oil and natural gas shale production in the 2010s is now seen as the single biggest development in U.S. energy markets in recent decades. Recoverable volumes of gas, condensate, and crude oil from development of shale plays. Tight oil plays are those shale plays that are dominated by oil (that is, recovery of oil is the primary objective) and associated gas, such as the Bakken in North Dakota. There are some plays that are primarily to recover natural gas. In December 2016, a much larger find of oil and natural gas was confirmed in the Permian Basin.

Monthly and annual average natural gas spot price at Henry Hub (1996-2015)

Dollars per million British thermal unit



Source: W.J. Culver and M. Hong; The Electricity Journal 29. September 2016, from U.S. Energy Infomation Administration data

Shared Reserves: An agreement among RTOs to assist the opposite pool in faster recovery from a sudden loss of generation or energy purchase than it would otherwise have achieved without outside assistance**.**

Shipper (Natural Gas): An entity (such as a natural gas producer) that engages a pipeline for transportation of natural gas and retains the title to the natural gas during transportation on the pipeline.

Shipper Must Have Title (Natural Gas): A FERC policy stating that shippers must retain the title to the natural gas in order to transport the natural gas on the pipeline.

Short Circuit: An electric current taking an unintended path with very low or no resistance The resulting high short circuit current has the potential to damage the rest of the circuit.

Short Circuit Current: The current flowing freely through an external circuit that has no load or resistance; the maximum current possible.

Short Circuit Ratio: a measure of the stability of an electromechanical generator. It is the ratio of field current required to produce rated armature voltage at open circuit to the field current required to produce the rated armature current at short circuit. (Wikipedia)

Short Cycling: Must Run status is a means of preventing the short cycling of generators because coal-fired units were not designed to cycle on / off throughout a week or day. Coal units typically need to stay online for extended periods (e.g., a week) to prevent damage due to excessive on / off cycling and to better ensure environmental compliance.

Short Term Firm Point-to-Point Transmission Service: In the Open Access Transmission Tariff (OATT) this services is less than one year**.**

Short Ton: Exactly 2000 pounds (907.18 kilograms). In the United States, a short ton is used to differentiate from the long ton (typically 2,240 pounds which is a metric ton).

Sieverts (symbol is **Sv**); A derived unit of ionizing radiation dose in the International System of Units (SI) and is a measure of the health effect of low levels of ionizing radiation on the human body. One sievert equals 100 rem. The rem is an older, non-SI unit of measurement. The sievert is important in dosimetry and radiation protection, and is named after Rolf Maximilian Sievert, a Swedish medical physicist renowned for work on radiation dose measurement and research into the biological effects of radiation. Quantities measured in sieverts are intended to represent the stochastic health risk, which for radiation dose assessment is defined as the probability of cancer induction and genetic damage. One sievert carries with it a 5.5% chance of eventually developing cancer based on the linear no-threshold model. A New York Times article on efforts by a robot to locate the missing nuclear fuel in the Fukushima nuclear unit 2, as a step in remediation of the radiation, failed due to siverts in excess of 70.

Simple Cycle Gas Turbine (SSGT): A natural gas combustion turbine. Primarily used during peak load conditions.

Simultaneity (Statistics): A term that means at least one explanatory variable within a multiple linear regression equation model is determined jointly with the dependent variable. An example to demonstrate simultaneity is the murder rate (y) as the dependent variable and the independent variable (x) is the size of the police force. Then to realize that x is partly determined by y. When x is partly determined by y, x is generally also correlated with the error term, so simultaneity meets the definition of endogeneity. Where simultaneity exists, the outcome variable is said to be endogenous and Ordinary Least Squares (OLS) regression in this situation would lead to biased estimators. If an explanatory variable is determined outside of the regression, simultaneity does not occur.

Simultaneous transmission Import Limit (SIL): A series of power flow studies that, per FERC order 697, assess the capabilities of all transmission facilities connected to neighboring regions under peak load conditions to determine the simultaneous import capability. FERC Order, 124 FERC 61,147, issued August 6, 2008.

Single-Circuit Line: A transmission line with one electric circuit. For three-phase supply, a single circuit requires at least three conductors, one per phase.

Single Contingency: The sudden, unexpected failure or outage of a system facility(s) or element(s) (generating unit, transmission line, transformer, etc.). Elements removed from service as part of the operation of a remedial action scheme are considered part of a single contingency.

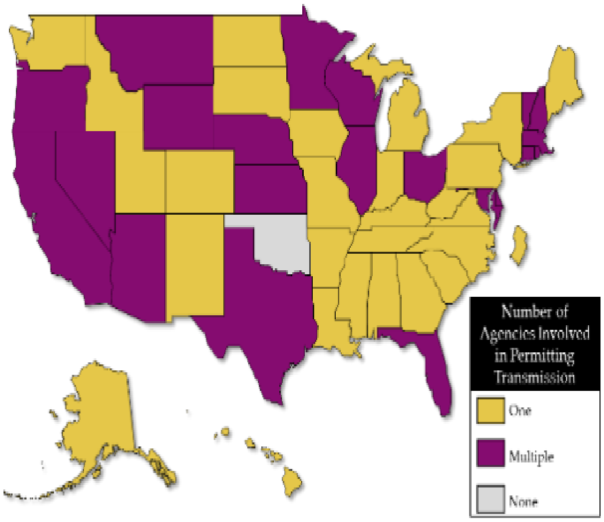
Single Issue Ratemaking: Some state regulatory commissions are statutorily prohibited from making adjustments to revenue requirements and rates outside of a rate case. That is, the concern for single issue ratemaking is that it considers changes for one expense (or revenue) in isolation and could ignore potentially offsetting revenues or expenses. As a result, a single adjustment – set in a vacuum – could overstate or understate the utility's overall revenue requirement. Vermont, for example, did not permit Fuel Adjustment Clauses because it was deemed to violate the statutory prohibition against single issue ratemaking.

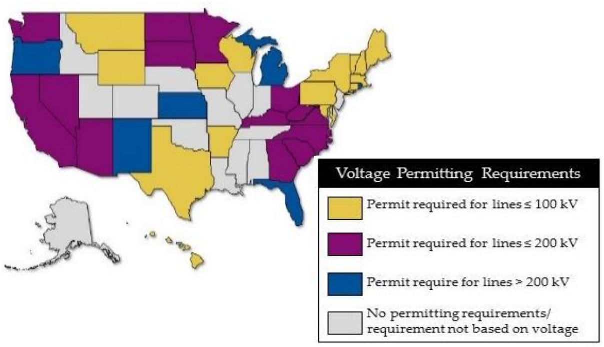
Single Phase Service: Service of small electrical loads of residential customers, small commercial customers, and streetlights at 120V/240V and requires less and simpler equipment and infrastructure to support and tends to be less expensive to install and maintain.

Sink: (see also Point of Delivery.) delivery point of a transmission line, also referred to as the Output-, Receiving-, or Load-End. (see *also "Source")*

Site Characterization: An onsite investigation at a known or suspected contaminated waste or release site to determine the extent and type(s) of contamination.

Siting: Some states have vested the authority to approve the location (siting) of electric transmission and / or generation resources with state commissions, siting boards, or other state agencies. Some states may also have authority to site *intra-state* natural gas pipeline facilities. (Note the FERC has authority for siting interstate natural gas pipelines). The maps below depicts state authority in 2013.





Sleved Purchase Power Agreement: Contracts that may be sold by a generator to a utility for sale to a corporate customer (corporate off-taker). A customer pays the utility a sleeving fee to the utility for transmitting the power from the generator to the customer. The suppler also "tops up" the electricity delivered to the Corporation and provides a balancing function. Sometimes referred to as "Off-Site Physical PPAs or Back to Back PPAs."

Slurry Dam: A repository for the silt or culm from a preparation plant. Slurry is a viscous liquid with a high solids content.

Small Generator Interconnection Agreement (SGIA): A FERC pro forma tariff issued Rule July 21, 2016, like the Large Generator Interconnection Agreement, requiring newly interconnecting small generating facilities, of 20 MW or less, to ride through abnormal frequency and voltage events and not disconnect during such events. The specific ride through settings must be consistent with Good Utility Practice and any standards and guidelines applied by the transmission provider to other generating facilities on a comparable basis. (See also Voltage and Low Voltage Ride Through).

Small Hydro: Hydroelectric power facilities with an installed capacity of 10 MW or less.

Small Modular Reactors (SMRs) (Nuclear): SMRs are modular nuclear reactors capable of producing no more than 300 MWe. Many utilities are interested in SMRs as their size makes them well-suited to replace units of the aging fossil-fueled fleet. Size and other features also make SMRs attractive for a number of applications that are inappropriate for large nuclear plants or fossil-fired units. Many consider them a solution to a number of challenges associated with large nuclear generating and other power generating facilities. Several vendors are anticipated to deploy small modular reactors in the U.S. over the next ten years.

- **Cost and Schedule.** After their production becomes routine, SMR units are anticipated to be less costly than large nuclear plants, thereby facilitating financing and reducing risk exposure. Many SMRs can be "mass produced" in factory settings and shipped to the installation site by rail, barge, or large transport vehicle. Shop building SMRs in an assembly-line process, similar to the auto industry, has the potential to revolutionize the global nuclear power industry.

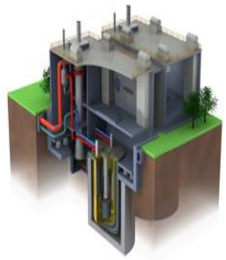
- **Safety.** Most SMR designs involve passive safety systems, requiring no electricity or off-site water supply for safe shut down. The smaller size also reduces the potential amount of radioactive release should a catastrophic accident occur.

- **Applications.** Because of their small size and transportability, individual SMRs can be located in remote or isolated "off-grid" sites to support facilities such as mines and shale oil recovery installations.

- **Load Following.** SMR developers indicate that, within limits, their technology can ramp up and down to adjust to grid demand, a capability large nuclear plants and coal plants do not have. Load following becomes more important as intermittent sources of supply (e.g. wind and solar) are added to the grid.

Two examples include the following:

- **PRISM.** A sodium-cooled pool-type fast reactor with passive design features that increase plant safety. Its modular design allows factory fabrication and ultimately lower construction costs. PRISM consumes used nuclear fuel while generating 622 MWe.



- **Westinghouse SMR** (Nuclear): The Westinghouse 225 MWe SMR is an integral pressurized water reactor based

on Westinghouse's 1100 MWe AP1000 design. It employs electric driven pumps to circulate coolant through the core and steam generator. Safety analysis has shown the reactor can go for seven days without AC power. Westinghouse's goal is to make the SMR competitive with large reactors, so it has simplified the reactor's design as much as possible. For example, by omitting the need for large forgings, the SMR components can be produced by more suppliers. Westinghouse wants to have 100% of the SMR American-made and plans on submitting for NRC Design Certification in 2014.

Small Signal Stability: Reducing oscillations by using synchronous condensers.

Smart Device: An electric device that is either remotely controllable or has local intelligence making the device settings responsive to specific conditions.

SmartGrid: Refers to a class of computer-based two-way communications technologies that remotely control and automate the operation of the electric grid. This general concept has been used for decades in other industries but is in its infancy in electricity networks. Smart Grid offers several potential benefits to utilities and consumers. These potential benefits include enhanced energy efficiency of the electricity grid, enhanced cyber-security, improved integration of renewable energy sources, more expeditious response to outages, improved system awareness and control that improves reliability and resiliency. Smart Grid is generally integrated with Advanced Metering Infrastructure which, in combination, provides a wealth of customer usage data that improves operational and long-term system planning.

Smart Inverter: Like a traditional inverters, Smart Inverters convert direct current (DC) to alternating current (AC) for solar photovoltaic systems and other *distributed intermittent resources* (DER). Unlike a traditional inverter, however, a Smart Inverter disconnects when the system gets out of tolerance for volts / VAR (see volt ampere reactive). See IEEE standards.

Smart Meter: An advanced solid-state meter that includes remote communication of data and may also provide remote control capabilities.

Solid State Meter: A meter that measures consumption electronically, stores data digitally, and has an electronic register.

Smyth v. Ames (1898 – see also Bluefield v. West Virginia Public Service Commission 1923, FPC v Hope 1944, and Munn v Illinois 1877): The United States Supreme Court held that, even though a railroad was constructed by a private corporation, the railroad derived its existence and powers (e.g., of eminent domain) from the state and could be regulated by the state. The Supreme Court established the calculation of reasonable rates was to be based on the <u>fair value</u> <u>of utility property used and useful in the public interest.</u> The Court enumerated three factors to be considered in estimating fair value of utility property: (1) the original cost of construction; (2) the present cost of construction; and (3) other matters including, but not limited to, the expense of permanent improvements, the property's probable earning capacity, and the monies required to meet operating expenses.

SO_2 Scrubbers: Injects a limestone/water mixture into the air stream, where it reacts to capture the SO_2.

SOARCA – State-of-the-Art Reactor Consequence Analysis. The Nuclear Regulatory Commission's comprehensive examination of potential safety failures with probabilities of "occurring more than once in a million reactor years, or more than once in ten million reactor years for accidents that may bypass containment features." The November 2013 report concluded: 1) Existing resources and procedures can stop an accident, slow it down or reduce its impact before it can affect public health; 2) Even if accidents proceed uncontrolled, they take much longer to happen and release much less radioactive material than earlier analyses suggested; and 3) The analyzed accidents would cause essentially zero immediate deaths and only a very, very small increase in the risk of long-term cancer deaths.

Socialization of Costs: The spreading of costs throughout a broader population when it is impossible or infeasible to determine a cost causer(s).

Sodium-Cooled Fast Reactors (SFR): The SFR uses liquid sodium as the reactor coolant, allowing high power density with low coolant volume, at low pressure. It builds on some 390 reactor-years experienced with sodium-cooled fast neutron reactors over five decades and in eight countries. A variety of fuels is possible. Most SFR plants so far have had a core plus blanket configuration, but new designs are likely to have all the neutron action in the core. Other R&D is focused on safety in loss of coolant scenarios, and improved fuel handling.

Soft Costs for Solar: Expenses related to a customer's financing, permitting, inspection, interconnection to their utility, and taxes.

Solar Magnetic Disturbance: Events that occur on the earth as a result of solar activity. The sun emits a stream of charged particles that flow to earth and disturb earth's magnetic field causing unwanted flows and possible damage in electrical transmission systems.

Source: Source of electricity on a transmission line, also referred to as the *Input-, Generator-, Transmitter-, or Sending-End*. For planning and operations purposes Source and Sink are typically linked. (see also Sink).

Southwest Power Pool (SPP): Southwest Power Pool, the independent system operator providing system operations in multiple states in the central U.S.

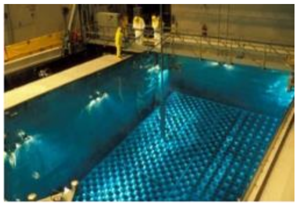
Spark Spread (see also "Dark Spread" for coal-fired generation): Is the positive or negative difference between the market price (spot or forward) of electricity and its cost of production using natural gas. A positive spark spread means the company profits from selling generation into the market. A negative spark spread means the utility company loses money. If the spark spread is small on a particular day, electricity generators may postpone their generation until a more profitable spread occurs. Spark spread calculation:

Power Price		Fuel Costs
($/MWh = power price ($/MWh)	-	[Cost of Fuel ($/ton or mcf) + Transport Cost ($ /ton or mcf + (Heat Rate in MMBtu / MWh / Heat Content (MMBtu / ton or mcf)]

Spatial Load Forecasting (Statistics): Spatial load forecasting is primarily used for transmission and distribution planning to not only forecast where, when, and how much load growth will occur in a given area(s) but also as a means of planning transmission systems to accommodate wind and other forms of generation. Spatial forecasts may use demographics, GIS land-use information, and utility load forecasting information.

Specific Power: As used in batteries, it is the maximum available power per unit mass. Specific power is a characteristic of the battery chemistry and packaging. It determines the battery weight required to achieve a given performance target

Spent Fuel Pool (Nuclear - see also Dry Cask Storage) is normally used as an interim storage method. Spent fuel from a nuclear reactor is carefully transferred to and sits deeply in a water-filled pool, where water actively cools down the spent fuel by circulation through heat exchangers and provides shielding



from radiation. Current capacity of spent fuel pools is not enough for the increasing generation of spent fuels. The Nuclear Regulatory Commission (NRC) loosened its policy in maximum inventory of spent fuels due to a lack of a permanent waste repository such as Yucca Mountain. Source: Hoi Ng, Submitted as coursework, Stanford University, Winter 2014.

Spinning Reserve: Ancillary service that provides additional capacity from electricity generators that are on line, loaded to less than their maximum output, and available to serve customer demand immediately should a contingency occur.

Spot Market (Electric): Energy bought or sold by Market Participants through the RTO / ISO

Interchange Energy Market at Locational Marginal Prices.

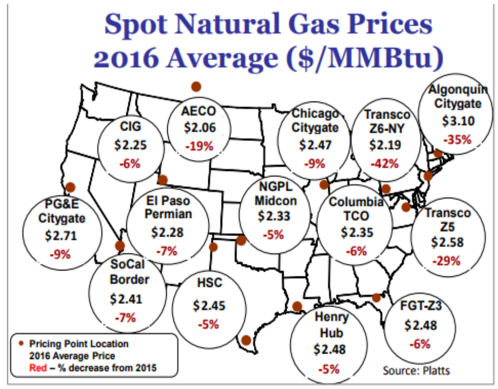
Spot Market (Natural Gas): A market in which natural gas is bought and sold for immediate or very near-term delivery, usually for a period of 30 days or less. The transaction does not imply a continuing arrangement between the buyer and the seller. A spot market is more likely to develop at a location with numerous pipeline interconnections, thus allowing for a large number of buyers and sellers. The Henry Hub in southern Louisiana is the best known spot market for natural gas.

Spot Market Energy: Energy bought or sold by Market Participants through the RTO Interchange Energy Market at Locational Marginal Prices (LMP).

Spot Market Price or **Spot Price**: The price for a one-time open market transaction for near-term delivery of a specific quantity of product at a specific location where the commodity is purchased "on the spot" at current market rates. See also spot market terms associated with specific energy types.

Spot Networks: Are also used in densely populated areas where two or more distribution lines (e.g., 13.2 kV) are supplied to the network class transformers which convert the primary voltage to a secondary voltage of 120 / 208 or 277/480 volts that supply a specific customer. It is called a spot network because it uses network-type transformers whose secondary network side terminals are interconnected by cables or a bus. It is very reliable due to the two or more feeds. [O'Neill Management Consulting and Charles Fijnvandraat].

Spot Price of Natural Gas: Natural gas spot markets provide opportunities for buying and selling gas for immediate or very near-term delivery, usually for a period of 30 days or less. A spot market is more likely to develop at a location with numerous pipeline interconnections, thus allowing for a large number of buyers and sellers. The Henry Hub in southern Louisiana is the best-known spot market for natural gas. In 2016 natural gas prices fell across the country with the Henry Hub averaging $2.48/MMBtu, the lowest level in 20 years. Above average temperatures in the 2015-2016 winter limited natural gas demand during the first three months of the year, leading to robust storage inventories at the start of the 2016 injection season in April, and reduced demand for storage injections through the summer. Prices fell to record lows in the first half of 2016, before climbing thorough the second half of the year driven by steady domestic demand, rising exports, and a drop in production. By December 31, the Henry Hub price had risen to $3.68/MMBtu.



Source: Derived from Platts Daily Price Survey data
Note: Average of Platts 2016 daily midpoint prices

Stability (Electric): The ability of an electric system to maintain a state of equilibrium during normal and abnormal conditions or disturbances. (NERC definition).

Stability Limit: The maximum power flow possible through a particular point in the system while maintaining stability in the entire system or the part of the system to which the stability limit refers.

Stability of the Power System: Power system stability is the ability of the bulk power system to withstand sudden disturbances such as short circuits or contingencies such as an unanticipated loss of a generator, transmission line, or a distribution facility. Utilities perform security analysis to ensure that the system can survive a transient and stay within established operating limits.

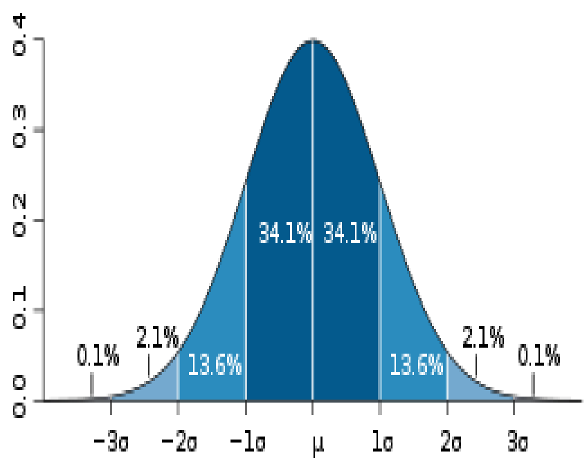
Stack: The collection of available generators arranged in economic order. This term is often applied in the context of a specific type of system operation. For example, the dispatch stack refers to all generating units that are available for dispatch (have been committed or are quick-start units). The commitment stack refers to all generation units that have been committed or are available for commitment. (NREL)

Stabilization Lagoon: A shallow artificial pond used for the treatment of wastewater. Treatment includes removal of solid material through sedimentation, the decomposition of organic material by bacteria, and the removal of nutrients by algae.

Staggers Act of 1980: This Act largely deregulated the railroad industry and provided railroads with latitude to price their services without significant regulatory oversight by the Interstate Commerce Commission (ICC); except for anticompetitive complaints. Because of the dependence of the electric industry on coal and transportation by railroads, the increased prices due to deregulation and reduced oversight of rail rates, adversely affected utilities that had service from only one railroad. The Staggers Act should be viewed in the context of competition from trucking that was facilitated by the development of the Interstate Highway system after World War II and the *Railroad Revitalization and Regulatory Reform Act* of 1976. The RRRRA reduced regulation and allowed greater latitude for railroads to price their services. It also allowed railroads greater ability to enter profitable markets and exit non-profitable markets. After WWII, expenditures on railroad maintenance and modernization of infrastructure declined. Correspondingly, safety and service declined. With the enactment of the Staggers Act, a rail carrier could establish any rate for a rail service unless the ICC were to determine that there was no *effective competition* for rail services. Rail shippers and rail carriers would be allowed to establish contracts subject to no effective ICC review unless the ICC determined the contract service would interfere with the rail carrier's ability to provide common carrier service (a finding rarely made that is not apparent in the history of the rail industry thereafter). The scope of authority to control rates to prevent "discrimination" among shippers was substantially curtailed. The Act also had provisions allowing the Commission to require access by one railroad to another railroad's facilities if one railroad had effective "bottleneck" control of traffic. The provisions dealt with "reciprocal switching" (handling of railroad cars between long-haul rail carriers and local customers) and trackage rights. Studies of the rail industry showed dramatic benefits for both railroads and their users from the alteration to the regulatory system. According to studies by the Department of Transportation's Freight Management and Operations, railroad industry costs and prices were halved over a ten-year period, the railroads reversed their historic loss of traffic (as measured by ton-miles) to the trucking industry, and railroad industry profits began to recover, after decades of low profits and widespread railroad insolvencies. In 2007 the Government Accountability Office reported to Congress "*The railroad industry is increasingly healthy and rail rates have generally declined since 1985, despite recent rate increases.... There is widespread consensus that the freight rail industry has benefited from the Staggers Rail Act."*

Standard Error or **SE** (Statistics see also T-Value, Alpha, Confidence Interval): is the *Standard Deviation* of the sampling distribution of a statistic, most commonly of the mean. In r*egression analysis*, the term "standard error" is also used in the phrase standard error of the regression to mean the ordinary least squares estimate of the standard deviation of the underlying errors

Standard Deviation (SD, or the Greek letter sigma σ or s) (see also T-Value, P-Value, and Confidence Interval): In probability theory and statistics, standard deviation (SD, S, or σ) is a measure of the variability or dispersion of a population, a data set, or a probability distribution. A low standard deviation indicates that the data points tend to be very close to the same value (the mean), while high standard deviation indicates that the data are spread out over a large range of values.



Standard Deviation is the square root of the Variance).

The "**Population** Standard Deviation": $\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i-\mu)^2}$

The "**Sample** Standard Deviation**"**: $s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i-\overline{x})^2}$

Divide by **N-1** (instead of **N**) when calculating a Sample Variance. Recall the Variance **σ** (or s^2

) = The average of the **squared** differences from the Mean. Merely summing the differences would result in the positive and negative differences cancelling out.

$$\operatorname{Var}(X) = \operatorname{E}\left[(X - \mu)^2\right].$$

Note from the normal distribution above 68.2% of the expected value is within 1 Standard Deviation, 95.4% are within two Standard Deviations, and 99.6% will be within three Standard Deviations.

Standard Industrial Classification (SIC): Replaced with North American Industry Classification System. (see also NAICS.)

Standard Market Design: This was an attempt by the FERC to develop a standardized market to reduce *market friction* inefficiencies for trading power over broad regions – even entire interconnections. The Congress blocked the effort but RTOs / ISOs try to overcome market differences with *Seams Agreements* and develop wholesale electricity market structures that incorporates many of the same design elements such as locational marginal pricing, day-ahead and real-time energy markets, and risk-management tools to hedge against the adverse impacts of having to pay higher locational marginal prices when transmission congestion occurs.

Standards of Conduct: Standards for transmission providers that were strengthened and simplified through FERC Order No. 717, issued October 16, 2008; the Standards include three primary rules:

1. The "independent functioning rule" requires transmission function and marketing function employees to operate independently of each other.
2. The "no-conduit rule" prohibits passing transmission function information to marketing function employees.
3. The "transparency rule," imposes posting requirements to help detect any instances of undue preference.

Standby Charge: A charge for the potential use of a utility service, usually done by an agreement with another electric utility service. These services include system backup support and other running and quick-start capabilities.

Standby Electricity Generation: Involves use of generators during times of high demand on utilities to avoid extra "peak-demand" charges.

Standby Facility: A facility that supports a utility system and is generally running under no-load. It is available to replace or supplement a facility normally in service.

Standby Service: Support service that is available as needed to supplement a customer, a utility system, or another utility if a schedule or an agreement authorizes the transaction. The service is not regularly used.

Startup/Flame Stabilization Fuel: Any fuel used to initiate or sustain combustion or used to stabilize the height of flames once combustion is underway.

State Estimator (SE or SERTNET for Real-Time Network Analysis: Computer software that takes redundant measurements of quantities related to system state as input and provides an estimate of the system state (bus voltage phasors). It is used to confirm that the monitored electric power system is operating in a secure state by simulating the system both at the present time and one step ahead, for a particular network topology and loading condition. With the use of a state estimator and its associated contingency analysis software, system operators can review each critical contingency to determine whether each possible future state is within reliability limits.

Static VAR Compensator (note VAR is volt ampere reactive): This is a set of electrical devices for providing fast-acting reactive power on high-voltage AC network. Since load varies considerably from one hour to another, the reactive power balance in a grid varies as well. The result can be unacceptable voltage amplitude variations, a voltage depression, or even a voltage collapse. A rapidly operating Static Var Compensator (SVC) can continuously provide the reactive power required to control dynamic voltage swings under various system conditions and thereby improve the power system transmission and distribution performance. Installing an SVC at one or more suitable points in the network can increase transfer capability and reduce losses while maintaining a smooth voltage profile under different network conditions. In addition, an SVC can mitigate active power oscillations through voltage amplitude modulation. Unlike a synchronous condenser which is a rotating electrical machine, a static VAR compensator has no significant moving parts other than internal switchgear.

The Siemens Static Var Compensator in the Radsted high-voltage switchgear station

Static Ratings: Static ratings tend to be very conservative and based on the worst-case scenarios of extreme temperatures. This often results in unnecessarily constraining transfers. Many transmission owners are considering dynamic or Ambient Adjusted Ratings (ARR).

Station: A node in an electrical network where one or more elements are connected. Examples include generating stations and substations.

Station Use:: Energy that is used to operate an electric generating plant. It includes energy consumed for plant lighting, power, and auxiliary facilities, regardless of whether the energy is produced at the plant or comes from another source.

Stationarity (Statistics): Is a stationary time series whose statistical properties such as mean, variance, autocorrelation, etc. are all constant over time. Most statistical forecasting methods are based on the assumption that the time series can be rendered approximately stationary (i.e., "stationarized") through the use of mathematical transformations. In other words, it is a stochastic process whose joint probability distribution does not change when shifted in time. A stationarized series is relatively easy to predict: you simply predict that its statistical properties will be the same in the future as they have been in the past, the stationarized series can then be "untransformed," by reversing whatever mathematical trans-formations were previously used, to obtain predictions for the original series. Thus, finding the sequence of transformations needed to stationarize a time series often provides important clues in the search for an appropriate forecasting model. Stationarizing a time series through differencing (where needed) is an important part of the process of fitting an ARIMA model. Another reason for trying to stationarize a time series is to be able to obtain meaningful sample statistics such as means, variances, and correlations with other variables. Such statistics are useful as descriptors of future behavior only if the series is stationary. For example, if the series is consistently increasing over time, the sample mean and variance will grow with the size of the sample, and they will always underestimate the mean and variance in future periods. And if the mean and variance of a series are not well-defined, then neither are its correlations with other variables. For this reason, caution should be taken about trying to extrapolate regression models fitted to non-stationary data.

Statistically Adjusted End Use Model (SAE): Is a forecasting model that combines end-use (e.g., information about the number of appliances / end-uses, the age, usage, the efficiency and other relevant information) modeling with econometric modeling.

Steady State: In systems theory, a system in a steady state has numerous properties that are unchanging in time. Steady state is a more general situation than dynamic equilibrium. If a system is in steady state, then the recently observed behavior of the system will continue into the future. In an electric utility system, steady state operations are more hypothetical because loads are continually changing causing the electric system to constantly adjust to over and under voltages. Steady state analysis (sometimes referred to as *static security assessment* is used for studying a wide variety of dynamic effects on the electric system primarily the transmission and distribution systems. Steady state analysis assesses the risk of certain conditions and contingencies such as voltage fluctuations, line losses, reverse power flow by Distributed Generation, the effectiveness of regulators and capacity banks. The *DC model* is often used because it assumes negligible resistances and flat voltage profiles, and relates the bus phase angles to real power injections.

Steam Electric Power Plant (Conventional): A plant in which the prime mover is a steam turbine. The steam used to drive the turbine is produced in a boiler where fossil fuels are burned.

Steam Expenses: The cost of labor, materials, fuel, and other expenses incurred in production of steam for electric generation.

Steam Turbine: A turbine whose blades are spun by the kinetic energy in moving steam.

Stochastic (Statistics): Situations or models containing a random element, hence unpredictable and without a stable pattern or order. All natural events are stochastic phenomena. Businesses and open economies are stochastic systems because their internal environments are affected by random events in the external environment.

Stochastic Error, is inherent in the structure of any forecasting model. Sampling error is one source of stochastic error. Each set of observations (the historical data) from which the model is estimated constitutes a sample. When one considers stochastic model error, it is implicitly assumed that the model is correctly specified and that it is using correctly measured data. Under these assumptions the error between the estimated model and the true model (which is always unknown) has certain properties. The expected value of the error term is equal to zero. However, for any observation in the sample, it may be positive or negative. The errors from a number of samples follow a pattern, which is described as the normal probability distribution, or bell curve. This particular normal distribution has a zero mean, and an unknown, but estimable variance. The magnitude of stochastic model error is directly related to the magnitude of the estimated variance of this distribution. The greater the variance, the larger the potential error will be.

Storage (electric)**:** Energy transferred form one entity to another entity that has the ability to conserve the energy (i.e., stored as water in a reservoir, coal in a pile, batteries, etc.) with the intent that the energy will be returned at a time when such energy is more useable to the original supplying entity.

Storage (natural gas): When natural gas production exceeds demand, natural gas can be stored for an indefinite period in underground storage facilities (e.g., depleted gas reservoirs - 80%, aquifer reservoirs -10%, and salt caverns-10%). Natural gas can also be stored above ground as Liquefied Natural Gas (LNG) or as *line pack* (increasing the pressure in pipelines with additional gas). Regardless of the type of storage facility, storage serves as a critical element of supply as well as an *insurance policy* to better assure adequate supply of working gas (the gas not needed by the pipeline/operator to maintain system integrity and for load balancing), particularly during high use periods. There are about 400 active storage facilities located in 30 states. These storage facilities can be located near market centers that do not have a ready supply of locally produced natural gas or in distant locations. The Prior to FERC Order 636, storage was part of a "bundled service" sold by pipelines to local distribution companies (LDCs) for resale to residential, commercial, and industrial customers. On December 19, 2016, The Pipeline and Hazardous Materials Safety Administration (PHMSA) published in the Federal Register an interim final rule (IFR) that revises the Federal pipeline safety regulations to address critical safety issues related to downhole facilities, including wells, wellbore tubing, and casing, at underground natural gas storage facilities. This IFR responds to Section 12 of the Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2016, which was enacted following the serious natural gas leak at the Aliso Canyon facility in California on October 23, 2015.

Storage As Transmission Only Assets (SATOA): A MISO initial construct to allow transmission owners the ability to develop storage to enhance transmission. The following picture is from Invenergy's Grand Ridge Battery Storage facility in Illinois.

Storage Capacity: The amount of energy an energy storage device or system can store.

Storage Hydroelectric Plant: A hydroelectric plant with reservoir storage capacity for power use.

Storage Service (Natural Gas): A service in which natural gas is held for a customer for redelivery at a later date, and is utilized to account for the seasonality of natural gas (e.g., natural gas use peaks in the winter). Storage services are also critical during the peak period for many interstate natural gas pipelines and distributors.

Storage Withdrawals: Total volume of gas withdrawn from underground storage or from liquefied natural gas storage over a specified amount of time.

Stored Energy Resources (SER): are a suite of technologies that are capable of receiving electric energy from the grid and storing it for later injection into the grid. The technologies would include batteries, compressed air energy storage, pumped hydroelectric, fly wheels and any other process that satisfies the definition of a Stored Energy Resource. Given this definition of SER, Demand Response (DR) would not be eligible since it does not inject power into the grid or into a distribution system.

Storm Hardening: Changes to the utility's generation, transmission, or distribution systems that make their systems less vulnerable to significant storms (e.g., flooding, ice, snow, wind, fires).

Straight Bus (see Bus, Breaker-and-a-Half, Ring Bus) The straight bus configuration is composed of a limited number of bus sections in which transmission elements terminate at a bus section through a circuit breaker.

Straight-Fixed Variable Costs (SFVC): (see also Performance Based Regulation and Decoupling.) While the natural gas industry has used SFV, historically the electric utility industry has applied the principles of straight fixed variable (SFV) cost rate design largely through a *demand charge.* The demand charge was intended to recover much of the utility's fixed costs. Increasingly, due in large part to customer-owned generation and other resources such as demand response and energy efficiency, there is interest in separating more of the fixed and variable costs for small commercial and residential customers (in addition to any monthly *customer charge*) to better ensure that the customer is paying their appropriate share of the utility's fixed costs. Provided the utility recovers its fixed costs, the utility should be indifferent to reduced energy sales. As a result, SFV may achieve the same goals as *decoupling*. As a caution, it should be recognized that defining those costs that should be include as "fixed costs" is subject to considerable debate.

Straight Line Depreciation (See also Accelerated Depreciation): Straight line depreciation is the default method used to gradually reduce the carrying amount of a fixed asset over its useful life. The method is designed to reflect the consumption pattern of the underlying asset, and is used when there is no particular pattern to the manner in which the asset is to be used over time. Under the straight-line method of depreciation, recognize depreciation expense evenly over the estimated useful life of an asset. The straight-line calculation steps are: 1) Determine the initial cost of the asset that has been recognized as a fixed asset. 2) Subtract the estimated salvage value of the asset from the amount at which it is recorded on the books. 3) Determine the estimated of the asset. It is easiest to use a standard useful life for each class of assets. 4) Divide the estimated useful life (in years) into 1 to arrive at the straight-line depreciation rate. 5) Multiply the depreciation rate by the asset cost (less salvage value).

Stranded Benefits: Benefits associated with regulated retail electric service which may be at risk under open market retail competition. Examples include conservation programs, fuel diversity, reliability of supply, and tax revenues based on utility revenues.

Stranded Costs: Stranded Costs refers to existing investments in infrastructure for the incumbent utility that may not be redundant in a competitive environment and therefore not *used and useful*. Stranded costs occur when the book value of an asset, like a generating unit, exceeds its market value. Between 1998 and 2001, as part of the *deregulation* movement, eighteen states mandated utilities divest themselves of generating assets. Most utilities in these states formed Independent Power Producer (IPP) affiliates of the Load Serving Entity (LSE). States agreed with the utilities' argument that some of the costs associated with generating units were not recoverable in market-based retail competition and allowed stranded cost recovery through a non by-passable charge that was paid by all customers regardless of the amount of stranded costs associated with their incumbent utility. The empirical evidence is that the benefits associated with competitive wholesale supply were largely negated by the recovery of stranded costs. In 2015 and 2016, low natural gas generation (and some renewable resources) often displaced coal and nuclear generation in economic dispatch. In December 2016, Illinois passed a law allowing a second round of stranded cost recovery for EXELON to recover stranded costs associated with their nuclear generation; this is also a non by-passable charge on all citizens of Illinois. In Ohio, AEP, FirstEnergy, and Dayton P&L sought approval for subsidies from the Ohio legislature and Commission due to nuclear and coal often being *out of the money* in economic dispatch and not being able to recover sufficient revenues to continue to operate some units. Michigan is considering stranded cost recovery for the Palisades nuclear facility. New York granted stranded cost recovery for their utilities. The argument for stranded cost recovery is that nuclear plants have zero emissions of NOx, SOx, CO_2, mercury, and ash. Moreover, maintaining the nuclear fleet, in particular, provides fuel diversity that may prove to be beneficial if natural gas prices rise. It is not clear if the price distortions caused by the subsidies will adversely affect the capacity markets and prices.

Strategic Petroleum Reserve (SPR): Petroleum stocks maintained by the Federal Government for use during periods of major supply interruption.

Stratification of Samples (Statistical Sampling – see Neyman and proportional allocation for sampling techniques): Simply put, sampling is concerned with the selection of a subset of individuals into more homogenous groups – stratum - from within a population to estimate characteristics of the whole population. Increasing the number of stratum (and, ideally, the number of observations within a stratum) will increase the precision of sample by reducing the variation with each stratum and within the entire sample. This results in increased precision of each stratum and the overall sample as a means of understanding the entire population. Sampling methods are designed to provide valid, scientific and economical tools for research problems.

Stratigraphic Test Well: A geologically directed drilling effort to obtain information pertaining to a specific geological condition that might lead toward the discovery of an accumulation of hydrocarbons. Such wells are customarily drilled without the intention of being completed for hydrocarbon production. This classification also includes tests identified as core tests and all types of expendable holes related to hydrocarbon exploration.

Stratosphere: The region of the upper atmosphere extending from the tropopause (8 to 15 kilometers altitude) to about 50 kilometers. Its thermal structure, which is determined by its radiation balance, is generally very stable with low humidity.

Stray Voltage (Inadvertent Energization of Structures): Stray voltage is the occurrence of electrical potential between two objects that ideally should not have any voltage difference between them. Typically, stray voltage occurs when a break in the insulation on a secondary voltage wire (120 Volts) comes in contact with a metal structure such as a light pool. Stray voltage can kill or harm people, livestock, and other animals. Utility distribution systems are grounded to the earth to ensure safety and reliability. Some of the first verified incidents occurred with dairy cattle and their milking machines. Stray voltage may also occur in water lines, street lights, electric signage, and other metalwork where some current flows through the earth at each point where the electrical system is grounded and a small voltage develops. This voltage is called neutral-to-earth voltage (NEV). In other words, stray voltage is this small voltage that is measured between two points. Detection of stray voltage in under-ground systems can be done by mobile units. Detection of stray voltage in over-head transmission and distribution lines is more difficult due to electromagnetic fields (EMF).

Stream-Flow: The rate at which water passes a given point in a stream, usually expressed in cubic feet per second.

Stressing the System (see also Black Swan and Integrated Resource Planning)**:** Stressing the system is a technique used in system planning is to consider the potential ramifications of extreme circumstances. In IRP, for instance, it is a common practice to have develop assumptions and narrative to describe an extreme high case and an extreme low case to form *book ends* in an effort to capture the broad range of uncertainties and risks.

Strike Price: The price at which an option contract entitles a buyer to purchase energy.

Strip Mine: An open cut in which the overburden is removed from a coal bed prior to the removal of coal.

Strip Mining (Surface): A method used on flat terrain to recover coal by mining long strips successively; the material excavated from the strip being mined is deposited in the strip previously mined.

Sub Hourly Energy Markets: Electricity markets that operate on time steps of 5 minutes. Approximately 60% of all electricity in the U.S. is currently traded in sub-hourly markets, running at 5-minute intervals so that maximum flexibility can be obtained from the generation fleet.

Subbituminous Coal: A coal whose properties range from those of lignite to those of bituminous coal and used primarily as fuel for steam-electric power generation. It may be dull, dark brown to black, soft and crumbly, at the lower end of the range, to bright, jet black, hard, and relatively strong, at the upper end. Subbituminous coal contains 20 to 30 percent inherent moisture by weight. The heat content of subbituminous coal ranges from 17 to 24 million Btu per ton on a moist, mineral-matter-free basis. The heat content of subbituminous coal consumed in the United States averages 17 to 18 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter).

Submetered Data: End-use consumption data obtained for individual appliances when a recording device has been attached to the appliance to measure the amount of energy consumed by the appliance.

Subsidies Actual: According to the Management Information Services report entitled "Two Thirds of a Century and $1 Trillion plus U.S. Energy Incentives: Analysis of Federal Expenditures for Energy Development, 1950–2016," May 2017. In Fiscal Year 2013, coal received $901 million in subsidies or other support. Natural gas and petroleum liquids received $690 million. The nuclear power industry received $1.7 billion. Renewable resources received $11.7 billion. For a more complete picture, the subsidies for each of the different technologies should be viewed over a much longer period of time. After World War II, for example, the federal government embarked on a massive research and development effort to develop nuclear energy. The *American Recovery and Reinvestment Act* of 2009, created substantial money for the development of renewable energy. DOE ***"****Staff Report on Electricity Markets and Reliability,"* August 2017.

Subsidies and Shifts in Supply and Demand Curves (see also producer surplus, consumer surplus, demand curves, supply curves, and welfare economics)**:** All other things being equal for energy utilities, changes that cause shifts in the demand curve include: A) changes in the prices of competing fuels; B) changes in incomes; C) changes in tastes (perhaps a desire to have more renewable resources); and D) changes in expectation (perhaps an expectation that natural gas prices will be lower than electricity may cause consumers to purchase more gas end-uses). Changes that cause movement along the demand curve are caused by a change in the price of the good or service. The supply curve shifts due to a change in input prices (e.g., for electric utilities, a change in fuel price, the cost of building a power plant), changes in technology, and changes in expectations. Movement along the supply curve are due to changes in the price of the good or service.

Substation: Facility equipment that switches, changes, or regulates electric voltage. Except for a few large industrial customers, most customers' equipment generally operates at only a few hundred volts, rather than at the hundreds of thousands of volts used for transmission. If high voltages were maintained up to the point of customer connection, fault protection would be extremely expensive. Therefore, distribution from the transmission line to customers is accomplished at much lower voltages, so transformers are required to reduce voltage before the power is introduced to a distribution or sub-transmission system. These transformers mark the end of the transmission line and are located at substations. Each transmission line starts from an existing substation and ends at a new substation. If the new transmission line were high-voltage direct current (HVDC), the origin substation would be expanded to accommodate AC-to-DC converters. Intermediate substations may also be required if there is a voltage change along the route, say, from 500 kV to 230 kV.

Distribution Substation

Transmission Substation

Sub-Transmission: A set of transmission lines of voltages between transmission voltages and distribution voltages with lines in the voltage range of 69 kV to 138 kV.

Sulfur: A yellowish nonmetallic element, sometimes known as "brimstone." It is present at various levels of concentration in many fossil fuels whose combustion releases sulfur compounds that are considered harmful to the environment. Some of the most commonly used fossil fuels are categorized according to their sulfur content, with lower sulfur fuels usually selling at a higher price. *Note:* No. 2 Distillate fuel is currently reported as having either a 0.05 percent or lower sulfur level for on-highway vehicle use or a greater than 0.05 percent sulfur level for off-highway use, home heating oil, and commercial and industrial uses. Residual fuel, regardless of use, is classified as having either no more than 1 percent sulfur or greater than 1 percent sulfur. Coal is also classified as being low- sulfur at concentrations of 1 percent or less or high-sulfur at concentrations greater than 1 percent.

Sulfur Dioxide (SO_2): A toxic, irritating, colorless gas soluble in water, alcohol, and ether. Used as a chemical intermediate, in paper pulping and ore refining, and as a solvent.

Summer and Winter Peaking: Having the annual peak demand reached both during the summer months (May through October) and during the winter months (November through April).

Sunk Cost: Part of the capital costs actually incurred up to the date of reserves estimation minus depreciation and amortization expenses. Items such as exploration costs, land acquisition costs, and costs of financing can be included. Economists typically do not consider sunk costs in making future investment decisions.

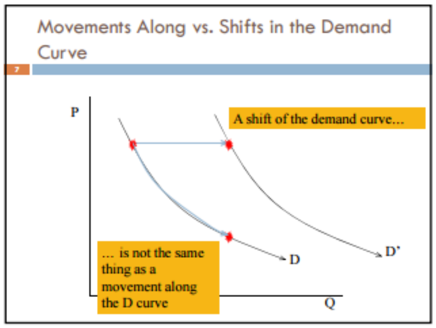
Superconductivity: The abrupt and large increase in electrical conductivity exhibited by some metals as the temperature approaches absolute zero.

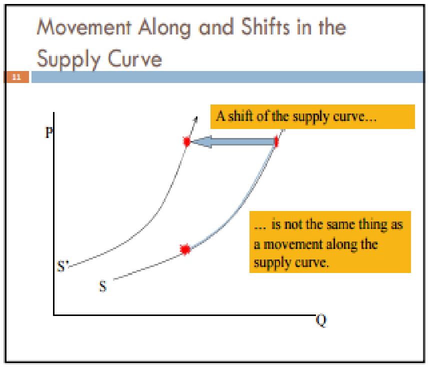
Supervisory Control and Data Acquisition (SCADA) (Electric): A system of remote control and telemetry used to monitor and control the transmission system. (NERC definition.)

Supplemental Reserve (see also Ancillary Services Market): A Supplemental Reserve requirement is necessary to provide additional capacity from electricity generators that can be used to respond to a contingency within a short period; usually within ten minutes.

Supply: Electricity available to the grid.

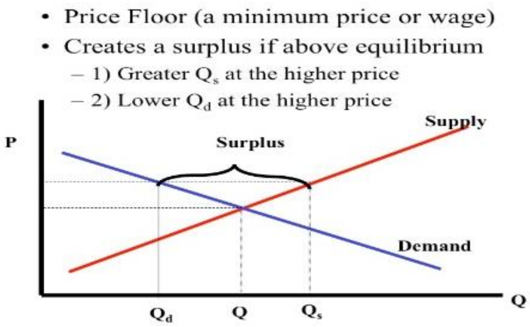
Supply and Demand: The economics and reliability of the power industry depend on the instantaneous ability to match demand with supply of electricity.



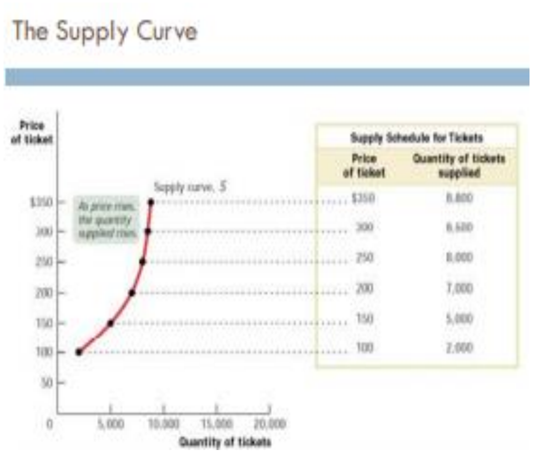


A shift in demand will cause a different quantity demanded at each and every price. A rightward shift in demand would increase the quantity demanded at all prices compared to the original demand curve. Subsidies on production will cause a shift the supply curve to the right. Subsidies may take the form of government incentives for development of specific resources such as the Production Tax Credit for renewable energy (of course, nuclear, coal, storage and other technologies have been subsidized. Crop subsidies and minimum wage are common examples). Subsidies shift the demand curve to the right to reflect that customers are more willing to buy at a lower price (elasticity of demand). Subsidies on consumption may take the form of rebates as incentives to replace less efficient appliances with more efficient appliances to increase the demand for a good.

The decision to intervene in the market is a *normative decision* of policy makers. Policymaker have to decide if the benefit of subsidies to encourage particular forms of energy are greater than the added cost to society. A subsidy creates a price floor (like a minimum wage) which – all other things being held constant (and they never are) the subsidy would create a surplus. Laborers that receive a minimum wage are happy because the wage rate increases but, in this simplistic case, the amount of jobs offered decrease.



Supply Curves (see also producer surplus, consumer surplus, demand curves. welfare economics, subsidies and shifts in demand curves)**:** The Law of Supply indicates that as price increases, there is more incentive for producers to provide their goods or services. The supply curve shows the combination of goods or services that will be produced at different prices. The characteristic of a supply curve is that it is upward sloping due to the positive relationship between price and quantity. The slope is a function of *elasticity*. Where the supply and demand curves intersect is the *point of equilibrium.* At an instant in time, a load shape (e.g., 24 hours) is a supply and demand curve. Factors that can shift the supply curve include: A) Changes in the price of fuel (e.g., a change in the price of natural gas relative to coal); B) Technological improvements (e.g, fracking or efficiency improvements that result in lower costs for renewable energy); C) The prices of other goods or services; D) Taxes and subsidies; E) Expectations (e.g., future price); F) Number of sellers in the market.



Supply Hub (Natural Gas): A location at which supply is available from more than one basin.

Surge: A transient variation of current, voltage, or power flow in an electric circuit or across an electric system. (NERC)

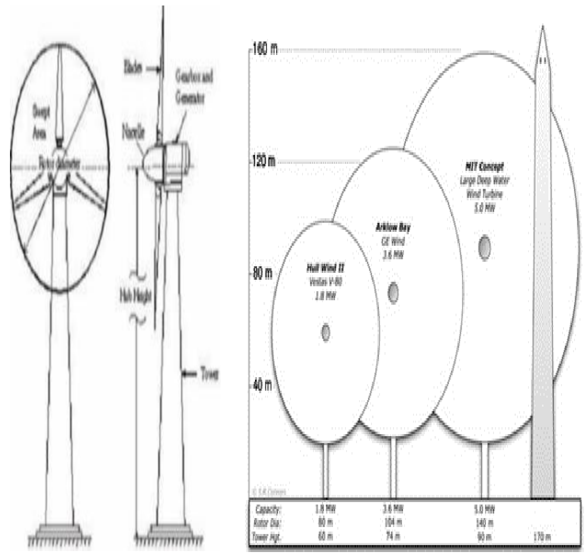
Surge Impedance Loading (SIL): Transmission line loading when the reactive power supplied by line capacitance equals the reactive power consumed by line inductance.

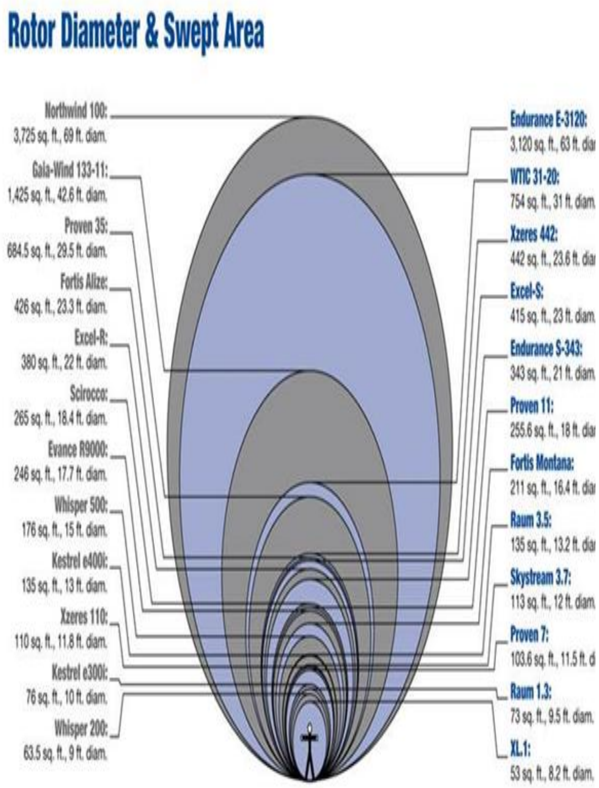
Sustained Outage: An outage that lasts longer than a specified amount of time. SAIDI, SAIDI and CAIDI are all based on sustained outage. The duration of a sustained outage varies from state to state. As of 2016, IEEE- 1366 defines the duration of a sustained outage to be 5 minutes.

Swaps (financial instrument – see also Collars, Derivatives, Hedging Contracts, and Options): Swaps can be used to hedge risks such as changing interest rates or to speculate on changes in future value. A swap is a derivative between two counterparties that have agreed to exchange one stream of cash flows for another stream of cash flows. These two cash flow streams are called the *legs* of the swap. The swap agreement defines the dates when the cash flows are to be paid and the way they are accrued and calculated. Most swaps are traded Over-the-Market such as *futures contracts*.

Swept Area for Wind Turbines: For a horizontal axis turbine, the swept area is A = A = π r ^{2}.

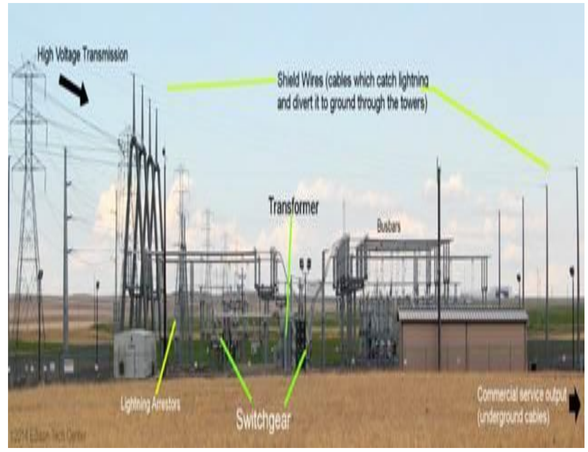
Where A = The Swept Area, r = the radius = r ~ 3.1415. for a vertical axis turbine, A = W X H where A = Swept Area, W = width, and H = height. By way of example, Siemens' SWT-3.0-101 Direct Drive Turbine has 49 meter (approx. 161 feet) blade lengths, and a rotor diameter of 101 meters (approx.331.4 feet), and a swept area of 8,000 meters (approx. 26247 feet) a nominal power rating of 3,000kW (3MW).





Swing Supply(ier) (Natural Gas): Refers to an alternative supplier (e.g., natural gas producer) that provides supply when demand is high and the customary supplier cannot meet demand.

Switchgear: In an electric power system, switchgear is the combination of electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment. Switchgear is used both to de-energize equipment to allow work to be done and to clear faults. This type of equipment is directly linked to the reliability.



Switching Station: Facility equipment used to tie together two or more electric circuits through switches. The switches are selectively arranged to permit a circuit to be disconnected or to change the electric connection between the circuits.

Switchyard: An enclosed area that includes the switching facilities and transformers that connect a power plant to the transmission system.

Synchronization: When two or more generators operate using the same interconnected transmission system, the generators must be synchronized. In the United States, this frequency is very near 60 hertz. Assuring synchronization maximizes power transfers and minimizes utility and customer equipment damage. In addition, synchronization helps to avoid transient instability and small-signal instability. (EIA definition)

Synchronized Reserve: Used to recover the Area Control Error after a resource loss, or to correct for large tie errors or under frequency conditions. Synchronized reserve resources must be fully capable within a short time (e.g., 10 minutes). Alternatively, customer loads that can be removed from the system within a short period (e.g., 10 minutes). Equipment must be electrically synchronized to the system.

Synchronized Reserve Market (SRMCP)**:** Real-time market for the purchase and sale of Synchronized Reserve, with the purpose of recovering Area Control Error after a resource loss, large tie errors and under frequency conditions. Resources must have capability that can be converted fully into energy within 10 minutes or customer load that can be removed from the system within 10 minutes of the request from the RTO / ISO dispatcher, and must be provided by equipment electrically synchronized to the system. Resource-specific offers are optimized in ASO to determine hourly commitments of inflexible Synchronized Reserves. In real time, the remaining RTO reserve needs are optimized simultaneously with energy to calculate a clearing price for Synchronized Reserve every five minutes based on current system conditions. The five-minute prices are averaged to calculate the hourly Synchronized Reserve Market Clearing Price that is used in settlements.

Synchronous Condenser: A synchronous machine that operates without mechanical load to supply or absorb reactive power for voltage control purposes.

Synchronous Generator: Converts mechanical energy into alternating current electric energy and is connected to the area's electrical grid operating at the same frequency. That is, the generator is synchronized.

Synchrophasor (and **Phasor Measurement Units**): are expected to aid transmission operators with: Disturbance Analysis, Compliance Verification, Determination of more accurate Operating Limits, For real-time information, synchrophasors are intended to provide: Improved Monitoring & Control of Critical Corridors, Wide Area Monitoring and control, and Improved State Estimation. Longer term, work with synchrophasors are intended to address the benefits of: Optimal Allocation of Static & Dynamic VAR Resources, Effective Power System Control Center Visualization, On Line Stability Determination and Control, Detection, Prevention and Mitigation of Cascading Events

Synthetic Natural Gas (SNG) (Natural Gas): (Also referred to as substitute natural gas) A manufactured product, chemically similar in most respects to natural gas, resulting from the conversion or reforming of hydrocarbons that may easily be substituted for or interchanged with pipeline-quality natural gas.

Synthetic Purchased power Agreement: Is a *contract for differences* between a generator and the customer. Typically, the parties agree to lock in a fixed *strike price* for the sale / purchase of power. Synthetic PPAs may have a comparative advantage over *sleeved PPAs* because of greater flexibility (e.g., able to serve multiple buyers) but are regarded as being more complex (e.g., potential to require derivative accounting practices).

System (Electric): Physically connected generation, transmission, and distribution facilities operated as an integrated unit under one central management or operating supervision. The electric system has grown from distinct utilities to integrated "grids" that are often referred to as the "bulk power system."

System (Natural Gas): An interconnected network of pipelines, valves, meters, storage facilities, and auxiliary equipment used in the transportation, storage, and/or distribution of natural gas or commingled natural and supplemental gas.

System Analysis Applied to Electric Utility Resource Planning: A systematic effort to credibly and accurately capture the complexities of interacting or inter-dependent elements. Because of the importance, the inherent complexities, and geographic scope, the interactions of the electric system, for instance, are difficult to describe, understand, design, predict, manage, and change. From a long-term resource (capacity) planning perspective, the physical and engineering attributes of the electric system are made even more complex by integrating customer responses, public policy changes, economic factors, innovation, weather, and other unanticipated factors and risks.

System Average Interruption Duration Index (SAIDI) (see Distribution Reliability Indices): Measure of system reliability defined as the minutes of sustained outages per customer per year.

This may exclude *Major Events.* **SAIDI = Σ(ri * Ni) / NT** where SAIDI is reported in minutes of interruption, ri = Restoration time in minutes, Ni = Total number of customers interrupted, NT = Total number of customers served.

Also see the following distribution system reliability indicies:

- Average Service Availability Index (**ASAI**),
- Customer Average Interruption Duration Index (**CAIDI**),
- System Average Interruption Frequency Index (**SAIFI**),
- Customer Average Interruption Frequency Index (**CAIFI**),
- Average Amount of Time Electric Service is Available (**ANSI**),
- **Worst CKAIDI** (Circuits with the worst circuit-level Average Interruption Duration Index),
- **Worst CKAIFI** (Circuits with the worst circuit–level Average Interruption Frequency Index),

- **CELID-X** — customers experiencing longest interruption durations;
- **CELID-8** is the percentage of customers who experienced outages exceeding 8 hours,
- **CEMI-X** — customers experiencing multiple interruptions; a measure of the percentage of customers who experienced X interruptions,
- **CEMMI-X** — customers experiencing multiple momentary interruptions; a measure of the percentage of customers who experienced X momentary interruptions and
- Momentary Average Interruption Frequency Index (MAIFI).

(See also Major Event Days which may include T_{MED} = Major Event Threshold, minutes. is any day that exceeds a daily SAIDI threshold called T_{MED}.) It is noteworthy that data for different states may be defined differently, as not every utility or utility commission uses IEEE-1366. In general, the European countries define sustained interruptions as outages lasting three minutes or more. Both the IEEE and LBNL studies referenced herein reveal that the definition of a sustained outage does not significantly impact reliability indices. Interruptions include a loss of a single phase on three-phase power.

See: Ito, J.H., & LaCommare, K.H. (2008). Tracking the Reliability of the U.S. Electric Power System: An Assessment of Publicly Available Information Reported to State Public Utility Commissions. Berkeley: Ernest Orlando Lawrence Berkeley National Laboratory and IEEE Power and Engineering Society. (2004). *1366 IEEE Guide for Electric Power Distribution Reliability Indices.* New York: The Institute of Electrical and Electronics Engineers Inc.

System Average Interruption Frequency Index (SAIFI): Measure of system reliability defined as the number of sustained outages per customer per year.

Major Events may or may not be included. SAIFI is the average number of times that a system customer experiences an outage during the year (or time period under study). The SAIFI is found by dividing the total number of customers interrupted by the total number of customers**.** $\underline{SAIFI = \Sigma(Ni) / NT}$. SAIFI = SAIDI and CAIDI. Also see:

- Average Service Availability Index (ASAI),
- Customer Average Interruption Duration Index (CAIDI).
- System Average Interruption Duration Index (SAIDI),
- Customer Average Interruption Frequency Index (CAIFI),
- Average Amount of Time Electric Service is Available (ANSI),
- Worst CKAIDI,
- Worst CKAIFI, CELID-X; CELID-8, CEMI-X —, CEMMI-X and MAIFI. (See also Major Event Days.)

Sytem Contingency Analysis (STCA): Similar to the Real Time Contingency Analysis, the STCA uses a base case that is established for specified power system conditions, The basecase is typically developed using power flow study results.

System's Frequency Response (see also Frequency Response): Changes in amplitude of impulse response and frequency response. Given one of the two, the other can be calculated.

System interconnection: A physical connection between two electric systems that permits the transfer of electric energy in either direction.

System Operating Limit: The value (such as MW, MVar, amperes, frequency, or volts) that satisfies the most limiting of the prescribed operating criteria for a specified system configuration to ensure operation within acceptable reliability criteria.

System Operator: The entity that manages the transmission grid by dispatching generation and scheduling reserves and transmission. In some cases system operators may also facilitate short-term energy markets, ancillary reserves markets, and capacity markets. NERC definition is: *An individual at a control center (Balancing Authority, Transmission Operator, Generator Operator, Reliability Coordinator) whose responsibility it is to monitor and control that electric system in real time.*

System Peak: The maximum load on an electrical system during a given period of time

System Peak Responsibility (1 CP, 4 CP, 12 CP – a cost-of-service allocation method see also Average and Excess): A one coincident peak method assigns costs to customers based on their contribution to the utility's maximum coincident system peak demand. A 4 CP method often determines the highest single hour's system demand during each of the individual 12 months and then uses the "system peak" as being an average of the four highest of these 12 system demands (the four demands are from four different months' hours). Each class's CP is that class's average demand over those four particular hours. Some utilities define 4 CP as a seasonal assignment of costs to customers based on their usage during the peak season. A 12 CP method assigns costs to customers based on each month's contribution to the utility's monthly system peak demand. Like any cost allocation method, it should reflect how the utility is actually planned and operated – including contribution to system peak - and reflect cost causation. That is, what costs are incurred by the utility to serve specific customers – or classes of customers. One factor to consider in selecting 1, 4, or 12 CP is that the system is typically planned to meet the forecast maximum coincident peak demand. Resource adequacy (Reserve Margins) are predicated on the utility's system peak demand.

System Planning Impacts of Distributed Energy Resources Working Group (SPIDERWG): A NERC working group to address distribution system planning, modeling, and reliability impacts to the bulk power system (BPS). This effort builds off of the work accomplished by the NERC Distributed Energy Resources Task Force (DERTF) and the NERC Essential Reliability Services Task Force/Working Group (ERSTF/ERSWG), and addresses some of the key goals in the Electric Reliability Organization's (ERO) Enterprise Operating Plan.

System Security: The ability of the power system to withstand sudden outages of generation or transmission components. System Security, when combined with System Adequacy are the two components of reliability.

System Support Resource (SSR): An RTO may find it necessary to have a power plant continue operations to reduce the potential for thermal violations and other reliability concerns at specific locations.

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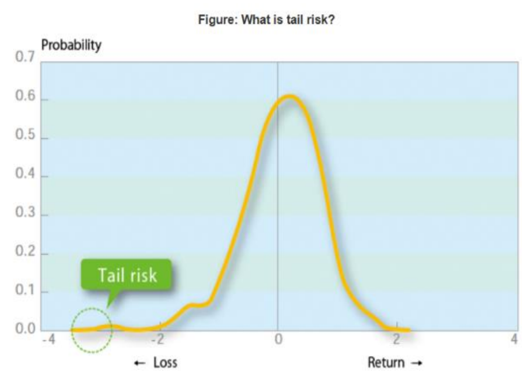
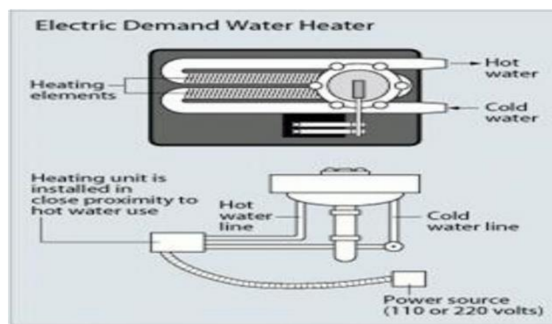
T MED (or T_{MED}): is the Major Event Day (MED) threshold value calculated at the end of each year using daily SAIDI of five sequential years. Any day (of the reporting) with daily SAIDI that exceeded the threshold value T_{MED} is classified as an MED. T_{MED} is calculated in accordance with the IEEE Standard 1366 (May 2012).

Tail Risk (see also Standard Deviation)**:** is the additional risk of an asset or portfolio of assets moving more than 3 standard deviations from its current price, above the risk of a normal distribution. ... Tail risk is sometimes defined less strictly, as merely the risk (or probability) of rare events.



Tank Farm: An installation used by trunk and gathering pipeline companies, crude oil producers, and terminal operators (except refineries) to store crude oil.

Tankless Water Heaters (see Instantaneous Water Heaters): Tankless water heaters, also known as *instantaneous water heaters* or *demand* or *point of use water heaters*, provide hot water only as it is needed without reliance on a tank to store hot water. Tankless water heaters are more expensive than traditional tank water heaters (2 to 4 times) but have lower operating costs (24-34% more efficient for a home using 41 gallons of water or less – *ENERGY STAR* estimates that a typical family can save $100 or more per year with an Energy Star qualified tankless water heater.) and longer life expectancy (20 or more years if well maintained). Water is heated using an electric element or a gas burner to provide a constant supply of hot water. However, a tankless water heater has a lower flow rate. Typically, the tankless water heaters currently in use, provide hot water at a rate of 2-5 gallons per minute. Gas-fired tankless water heaters have a higher flow rate. Some customers have, however, complained that even the largest gas-fired tankless water heaters cannot supply sufficient hot water if multiple there are multiple demands for hot water (e.g., dishwashing, showers). Under more extreme conditions, two or more tankless water heaters, connected in parallel may be required. While natural gas-fired tankless water heaters have higher flow rates than electric tankless water heaters, the constant use of a pilot light reduces some of the energy savings (this problem can be reduced by an *intermittent ignition device* instead of a standing pilot light.



A traditional water heater.

Energy Efficiency (EF) rating for electric water heaters are typically between 0.75 and 0.95. This means that between 75 and 95 percent of the energy used to heat the water ends up being delivered to your taps as usable hot water. The typical energy factor for a gas water heater is between 0.5 and 0.7. Manufacturers are continually changing designs, insulation and other features to make water heaters more efficient. For gas water heaters, the calculation requires an estimate of the unit cost of fuel by Btu (British thermal unit) or therm. (1 therm = 100,000 Btu) that you should be able to obtain from your gas bills. Given the cost of a Btu, 365 X 41045 ÷ EF X Fuel Cost (Btu) = estimated annual cost of operation. Therefore, a natural gas water heater with an EF of .57 and a fuel cost of $0.00000619/Btu, results in the following formula: 365 X 41045/.57 X $0.00000619 = $163. For electric water heaters, including heat pump units, The calculation requires the unit cost of electricity by kilowatt-hour (kWh). Given the cost per kWh, the formula is: 365 days/year x 12.03 kWh/day ÷ EF x Fuel Cost ($/kWh) = annual cost of operation. For example, a heat pump water heater with an EF of 2.0 and an electricity cost of $0.0842/kWh = 365 X 12.03 ÷ 2.0 X $0.0842 = $185.

Tar Sands: Naturally occurring bitumen-impregnated sands that yield mixtures of liquid hydrocarbon and that require further processing other than mechanical blending before becoming finished petroleum products.

Technical Assessment Guide (TAG): The Electric Power Research Institute or EPRI, prepares TAGs to provide cost (and cost escalation factors) and performance data on capital investments in power generation resources including battery storage and renewable energy resources. In addition to cost and performance data for resources, the TAG provides updatges on environmental emissions and control technologies as well as comparison of water usage by various technologies.

Technically Recoverable (see also Economically Recoverable Resources, Continuous Oil & Gas Accumulations, Proved Reserves): Those resources producible using currently available technology and industry practices. USGS is the only provider of publicly available estimates of undiscovered technically recoverable oil and gas resources.

Telemetering (Electric): The process by which measurable electrical quantities from substations and generating stations are instantaneously transmitted to the control center, and, by which, operating commands from the control center are transmitted to the substations and generating stations. (NERC definition.)

Ten Minute Non-Spinning Reserve (TMNSR, see also Spinning Reserve): A form of operating reserve provided by off-line generation that can be electrically synchronized to the system and increase output within 10 minutes in response to a contingency; also called 10-minute non-synchronized reserve. On-line generation that can increase output within 10 minutes also may provide this service because spinning reserve is higher quality than non-spinning reserve due to the fact that the possibility of a failed start does not exist.

Ten Minute Spinning Reserve (TMSR): A form of operating reserve provided by on-line generation that can increase output within 10 minutes in response to a contingency.

Terawatt: One trillion watts.

Tertiary Frequency Control: Actions provided by Balancing Authorities on a balanced basis that are coordinated so there is a net-zero effect on area control error (ACE). Examples of Tertiary Control include dispatching generation to serve native load, economic dispatch, dispatching generation to affect interchange, and re-dispatching generation. Tertiary Control actions are intended to replace Secondary Control Response by reconfiguring reserves. The actions happen within the period 10 – 60 minutes following a disturbance. (from NERC Frequency Response Initiative Report, 10/2012)

Refers to centrally coordinated actions (i.e., it is a "manual" form of what we have called secondary control) that operate on an even longer time scale (i.e., minutes to tens of minutes) than primary frequency response and secondary frequency control provided through AGC. LBL 2018

Therm: One hundred thousand (100,000) Btu.

Thermal: A term used to identify a type of electric generating station, capacity, capability, or output in which the source of energy for the prime mover is heat.

Thermal Conversion Factor: A factor for converting data between physical units of measure (such as barrels, cubic feet, or short tons) and thermal units of measure (such as British thermal units, calories, or joules); or for converting data between different thermal units of measure. (See Btu Conversion Factor.)

Thermal Efficiency: A measure of the efficiency of converting a fuel to energy and useful work; useful work and energy output divided by higher heating value of input fuel times 100 (for percent).

Thermal Energy Storage (TES see also Cool Storage and Thermal Storage): The storage of heat energy during utility off-peak times, for use during the peak. TES systems have the capability to shift electrical loads from high-peak demand to off-peak hours. TES has the potential to become a useful Demand Response or Demand Side Management program. Since HVAC systems for major buildings are at least partially automated with *energy management and control systems* (EMCS), this helps to avoid demand spikes caused by an immediate increase of cooling load (avoiding or minimizing the *rebound effect*). A common example is the use of molten salt to store the thermal energy in concentrating solar power plants like the 250 MW Solana plant in Arizona allowing them the flexibility to generate electricity when it is most needed.

Thermal Limit: The maximum amount of power a transmission line can carry without suffering heat-related deterioration of line equipment, particularly conductors.

Thermal Overloads: Exceeding any device's thermal limit by 100% of the device's rating. Transmission conductors are typically stranded from aluminum wires with a steel core added where increased strength is required. The temperature limit on all aluminum or ACSR conductors is specified on the basis of *maximum sag* or maximum loss of strength in the aluminum. Temperature limits in use today range from 50C to 150C. The temperature limit, corresponding to maximum sag, is normally selected at the time the line is designed. The higher this temperature, the higher the thermal capacity of the line, the maximum conductor sag, and the higher the structures required to maintain ground clearance. Temperature limits above 95C may result in significant *annealing* of aluminum and a total time duration at high temperature over the life of the line is normally specified to limit the resulting loss of strength.

Thermal Rating (Electric): The maximum amount of electrical current that a transmission line or electrical facility can conduct over a specified time period before it sustains permanent damage by overheating or before it sags to the point that it violates public safety requirements. (NERC definition)

Thermal Resistance: (R-Value*)* This designates the resistance of a material to heat conduction. The greater the R-value the larger the number.

Thermal Runaway: Thermal runaway refers to a situation where an increase in temperature changes the conditions in a way that causes a further increase in temperature, often leading to a destructive result. It is a kind of uncontrolled positive feedback. This arises when the current through a semiconductor creates sufficient heat for its temperature to rise above a critical value. The semiconductor has a negative temperature coefficient of resistance, so the current increases and the temperature increases again, resulting in ultimate destruction of the device.

Thermal Storage (see also Cool Storage, Thermal Energy Storage): Storage of heat or heat sinks (coldness) for later heating or cooling. Examples are the storage of solar energy for night heating; the storage of summer heat for winter use; the storage of winter ice for space cooling in the summer; and the storage of electrically-generated heat or coolness when electricity is less expensive, to be released in order to avoid using electricity when the rates are higher. There are four basic types of thermal storage systems: ice storage; water storage; storage in rock, soil or other types of solid thermal mass; and storage in other materials, such as glycol (antifreeze).

Thermocouple: A device consisting of two dissimilar conductors with their ends connected together. When the two junctions are at different temperatures, a small voltage is generated.

Thermocouple is an electrical device consisting of two dissimilar electrical conductors forming electrical junctions at differing temperatures. A thermocouple produces a temperature-dependent voltage as a result of the thermoelectric effect, and this voltage can be interpreted to measure temperature. Thermocouples are a widely used type of temperature sensor.

Thermodynamics: A branch of physics dealing with the energy and work of a system. The discipline of thermodynamics is based on the 19th century efforts to build and operate steam engines. Thermodynamics deals only with the large scale response of a system which we can observe and measure in experiments. Small scale gas interactions are described by *the kinetic theory* of gases. The methods complement each other; some principles are more easily understood in terms of thermodynamics and some principles are more easily explained by kinetic theory. There are three principal laws of thermodynamics which are described on separate slides. Each law leads to the definition of thermodynamic properties which help us to primarily predict the operation of physical systems such as propulsion and high speed flows. The numbering system for the three laws of thermodynamics is a bit confusing. We begin with the zeroth law. The *zeroth law* of thermodynamics involves some simple definitions of *thermodynamic equilibrium*. Thermodynamic equilibrium leads to the large scale definition of temperature as opposed to the small scale definition related to the kinetic energy of the molecules. The *first law of thermodynamics* relates the various forms of kinetic and *potential energy* in a system to the work which a system can perform and to the transfer of heat. This law is sometimes taken as the definition of internal energy, and introduces an additional state variable, *enthalpy*. *The first law of thermodynamics* allows for many possible states of a system to exist. But experience indicates that only certain states occur. This leads to *the second law of thermodynamics* and the definition of another state variable called *entropy*. The second law stipulates that the total entropy of a system plus its environment cannot decrease; it can remain constant for a reversible process but must always increase for an irreversible process.

Thermophotovoltaic Cell: A device where sunlight concentrated onto a absorber heats it to a high temperature, and the thermal radiation emitted by the absorber is used as the energy source for a photovoltaic cell that is designed to maximize conversion efficiency at the wavelength of the thermal radiation.

Thermosiphon System: A solar collector system for water heating in which circulation of the collection fluid through the storage loop is provided solely by the temperature and density difference between the hot and cold fluids.

Thermostat: A device that adjusts the amount of heating and cooling produced and/or distributed by automatically responding to the temperature in the environment.

Third-Party DSM Program Sponsor: An energy service company (ESCO) which promotes a program sponsored by a manufacturer or distributor of energy products such as lighting or refrigeration whose goal is to encourage consumers to improve energy efficiency, reduce energy costs, change the time of usage, or promote the use of a different energy source.

Third-Party Transactions: Third-party transactions are arms-length transactions between nonaffiliated firms. Producing country-to-company transactions are not considered to be third-party transactions.

Thirty Minute Operating Reserve (TMOR): A form of operating reserve provided by on-line or off-line operating reserve generation that can either increase output within 30 minutes or be electrically synchronized to the system and increase output within 30 minutes in response to a contingency.

Thorium (Nuclear): Thorium is more abundant in nature than uranium. It is fertile (upon absorbing a neutron will transmute to uranium-233 which is an excellent fissile fuel material. In this regard it is similar to uranium-238 which transmutes to plutonium-239). Rather than fissile, and can only be used as a fuel in conjunction with a fissile material such as recycled plutonium. Thorium fuels can breed fissile uranium-233 to be used in various kinds of nuclear reactors. Molten salt reactors are well suited to thorium fuel, as normal fuel fabrication is avoided. The use of thorium as a new primary energy source has been a tantalizing prospect for many years. Extracting its latent energy value in a cost-effective manner remains a challenge, and will require considerable R&D investment. World Nuclear Association, September 2015.

Three Pivotal Suppliers Test: Used by PJM to determine whether a resource *offer cap* is necessary to address transmission constraints and prevent the exercise of market power by anyone of the three or a combination of two or more suppliers acting in concert to the detriment of the market.

Three Phase Power: Power generated and transmitted from generator to load on three conductors. Residential current is generally single-phase AC power, but the rest of the power system from generation to secondary distribution employs three-phase AC. This means that transmission lines have three separate conductors, each carrying one-third of the power. The waveforms of the voltage in each phase are separated by 120°. That is, taking one voltage as the reference, the other two voltages are delayed in time by one-third and two-thirds of one cycle of the electric current. There are two major reasons that three-phase power became dominant. The first is that as long as the electrical loads on each phase are kept roughly balanced, only three wires are required to transmit power. Normally, any electric circuit requires both an "outbound" and "return" wire to make a complete circuit. Balanced three-phase circuits provide their own return; thus, only three, rather than six, wires are required to transmit the same amount of power as three comparable single-phase systems. Second, three-phase motors can be smaller and more efficient than comparable single-phase equipment.

Three-phase power: Power produced using three separate independent coils of wire in the generator. Three-phase power has three separate independent voltages with different timing and with each phase running through a separate conductor.

Three-wire service: A single-phase electric service from the utility to a customer facility that consists of three conductors: two hot conductors and one ground.

Tie Line (Electric): A circuit connecting two Balancing Authority Areas. Also, describes circuits within an individual electrical system. (NERC definition)

Tight Gas (Natural Gas): Is natural gas trapped in a highly mixed mineralogy sandstone, shale, or limestone formations which has very low permeability and porosity. While conventional natural gas accumulations, once drilled, contain gas that can usually be extracted quite readily and easily, a great deal more effort, including hydrofracturing, has to be put into extracting gas from a tight formation.

The term tight gas not have a specific technical, scientific, or geologic definition. The identification of tight gas as a separate production category began with the passage of the Natural Gas Policy Act of 1978 (NGPA), which established tight gas as a separate wellhead natural gas pricing category that could obtain unregulated market-determined prices. With the full deregulation of wellhead natural gas prices and the repeal of the associated Federal Energy Regulatory Commission (FERC) regulations, tight gas no longer has a specifically defined meaning. Tight gas and shale gas are reported separately in the EIA's Annual Energy Outlook (AEO); however, the distinction between tight gas and shale gas is fading because both are produced from low-permeability rock primarily with horizontal drilling and hydraulic fracturing.

Tight Oil: An industry convention generally referring to oil produced from very low-permeability shale, sandstone, and carbonate formations, with permeability being a measure of the ability of a fluid to flow through the rock. In limited areas of some very low-permeability formations, small volumes of oil have been produced for many decades. Tight gas and shale gas are reported separately in the EIA's Annual Energy Outlook (AEO); however, the distinction between tight gas and shale gas is fading because both are produced from low-permeability rock primarily with horizontal drilling and hydraulic fracturing.

Tight Power Pool: Prior to the formation of Regional Transmission Organizations or Independent System Operators, some regions formed tight power pools to more economically dispatch power. These included the New England Power Pool (NE Pool), New York Power Pool (NY Pool), and the Pennsylvania, New Jersey, and Maryland Pool (PJM), PJM was the first founded in the 1927. After the FERC's formation of RTOs / ISOs, these organizations became RTOs and ISOs.

Time Clocks or Timed Switches: Time clocks are automatic controls, which turn lights off and on at predetermined times.

Time Error: An accumulated time difference between Control Area system time and the time standard. Time error is caused by a deviation in Interconnection frequency from 60.0 Hertz.

Time Error Correction: An offset to the Interconnection's scheduled frequency to correct for the time error accumulated on electric clocks.

Time Series (Statistics): is a sequence of observations which are ordered in time. If observations are made on some phenomenon throughout time, it is most sensible to display the data in the order in which they arose, particularly since successive observations will probably be dependent. Time series are best displayed in a scatter plot. The series value X is plotted on the vertical axis and time t on the horizontal axis. Time is called the independent variable (in this case however, something over which you have little control).

Time Series Power Flow Analysis (TSPFA - sometimes referred to as quasi-steady-state analysis or quasi-static time series [QSTS]): TSPFA is composed of multiple steady-state power flow calculations with user-defined time step sizes between each calculation. TSPFA does not incorporate true dynamics from differential equations; thus, it ignores effects like inertia and damping. However, it does maintain discrete states (e.g., tap positions and switch and relay status) from one power flow solution to the next. The simulation periods can range from seconds to hours or years, and the time intervals depend on the need of the analyst and the availability of data. Utilities typically use TSPFA for load profile studies. With Distributed Energy Resources integrated into the distribution system, the TSPFA can help to study the effects of irradiance variations or wind fluctuations on power system controls, such as voltage regulators, Load Tap Changers (LTC), and switched capacitors. TSPFA can help verify the sequence and performance of automatic switching, voltage control, and protection system operations. It may include the effect of end-use load components turning on or off, which sometimes creates short-term overloads or voltage disturbances. In conjunction with other tools, TSPFA enables the study of grid interactions with customer-side resource (e.g., demand response, transactive energy) that are increasingly eligible to participate in markets and also potentially impact utility communication systems. In addition, TSPFA may also be used for power quality studies, such as studies looking at voltage swells and sags, but sub-second time steps are generally required. It should be noted that most distribution modeling systems use static data or a series of static "snapshots" that will yield TSPFA study results. This type of analysis is generally unable to perform dynamic or transient analyses that are common in the bulk power modeling arena. The use of data in the second to sub-second range is gaining greater levels of interest by researchers and utility engineers alike. Thus there is some emerging focus on the gap between dynamic and transient analysis and traditional distribution analysis, which focuses on longer periods of time. Issues such as flicker, perhaps due to cloud-induced variability in solar PV systems or wind gusts, can potentially be problematic for utilities and their customers if not mitigated. With greater levels of DER penetration, there is a higher level of interest in accurately modeling those impacts. Source: Grid Modernization Laboratory Consortium, U.S. Department of Energy.

Time-of-Day Lock-Out or Limit: A special electric rate feature under which electricity usage is prohibited or restricted to a reduced level at fixed times of the day in return for a reduction in the price per kilowatthour.

Time-of-Day Pricing (see also Rate Structures): A special electric rate feature under which the price per kilowatthour depends on the time of day.

Time-of-Day Rate: The rate charged by an electric utility for service to various classes of customers. The rate reflects the different costs of providing the service at different times of the day.

Time of Use Meter: A meter capable of registering and recording the amount of usage in multiple defined time periods such as peak and off-peak.

Times Interest Earned Ratio (TIER): Ratio that equals income before interest and taxes, divided by interest. The ratio shows the number of times interest is covered by earnings.

Timing Differences (Accounting): Differences between the periods in which transactions affect taxable income and the periods in which they enter into the determination of pretax accounting income. Timing differences originate in one period and reverse or "turn around" in one or more subsequent periods. Some timing differences reduce income taxes that would otherwise be payable currently; others increase income taxes that would otherwise be payable currently.

Tinted or Reflective Glass or Shading Films: Types of glass or a shading film applied to glass that, when installed on the exterior of a building, reduces the rates of solar penetration into the building. Includes Low E Glass.

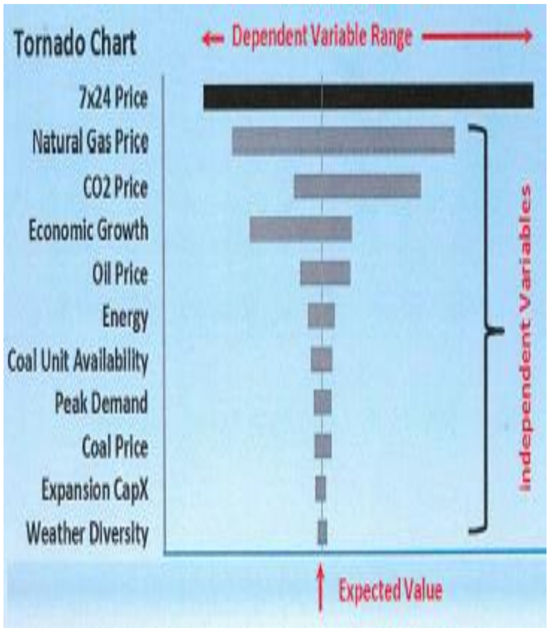
Tipping Fee: Price charged to deliver municipal solid waste to a landfill, waste-to-energy facility, or recycling facility.

Tolling Arrangement: Adherence to statute of limitations may be circumvented by using tolling agreements. That is tolling agreements allow parties, under specified terms and conditions (including the duration of the tolling agreement), to increase the time allowed for filing civil suits. Contract arrangement under which a raw material or intermediate product stream from one company is delivered to the production facility of another company in exchange for the equivalent volume of finished products and payment of a processing fee.

Ton Mile: The product of the distance that freight is hauled, measured in miles, and the weight of the cargo being hauled, measured in tons. Thus, moving one ton for one mile generates one ton mile.

Topping Cycle: A boiler produces steam to power a turbine-generator to produce electricity. The steam leaving the turbine is used in thermal applications such as space heating and/or cooling or delivered to other end user(s).

Tornado Chart: A graphic depiction of risk that ranks the most to the least significant risk factors. Tornado Charts can be used to illustrate the relative importance and risks of significant "drivers" of a utility's planning or operations such as fuel costs, environmental costs, and forecasts of customer usage. The following graphic was provided by the Indiana Municipal Power Agency (IMPA).

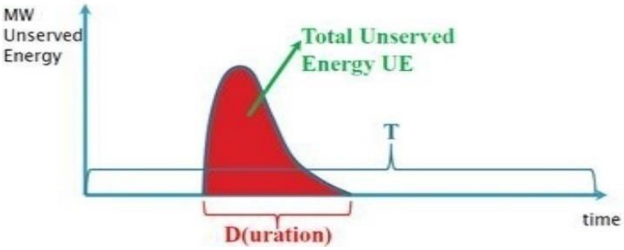


Total Gas In Storage: The sum of base gas and working gas Total Gas in storage.

Total Harmonic Distortion (**THD**): A measurement of the harmonic distortion present in a signal and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. THD is an important aspect in audio, communications, and power systems and should typically, but not always, be as low as possible. A voltage or current that is purely sinusoidal has no harmonic distortion because it is a signal consisting of a single frequency. A voltage or current that is periodic but not purely sinusoidal will have higher frequency components in it contributing to the harmonic distortion of the signal. In general, the less that a periodic signal looks like a sine wave, the stronger the harmonic components are and the more harmonic distortion it will have.

Total Transfer Capability (TTC): A best estimate of the total transmission or transfer capability of a defined path in a specific direction at a given time.

Total Unserved Energy (see also Expected Unserved Energy): The total amount of energy that was not able to be supplied to end-use customers. In contrast, the Expected Unserved Energy is The EUE is the summation of the expected number of megawatt hours of load that will not be served in a given year as a result of demand exceeding the available capacity across all hours. Reliability = P(UE>0) = LOLP = 1-(**D**/**T**) Severity = UE/T : D = Probabilistic Weighted Average of an Event or Stressor and T = Time



Trackers (see also Automatic Adjustment Clause also referred to as Riders**):** A tracker (or rider) is an automatic adjustment clause mechanism that follows or "tracks" some unpredictable costs that a utility incurs in providing service to consumers. The utility is allowed to recover these costs without the need for a rate case. Historically, these clauses were intended to reduce the "*pancaking of rate cases.*" Generally, these costs are outside the control of the utility and often the utility is not allowed to profit from these clauses. The rider is an additional charge for each kilowatt-hour and is increased or decreased based on variable costs such as fuel and market power. The rider is often adjusted monthly or quarterly. A Fuel and Purchased Power Adjustment Clause is an example of a rider.

Trackers have been criticized for explicitly shift financial risks from the utility to customers, for being perfunctory hearings with limited scrutiny of the costs that go into the trackers, difficult for customers to understand, and with the potential for skewing utility investments. In recent years, in many states, there has been a proliferation of trackers that add to the concern that they may skew utility investments and raise customer concerns.

Transco: An investor-owned entity that combines operation and ownership of transmission assets.

Transducers: Transducers that convert physical quantities into mechanical ones are called mechanical transducers; Transducers that convert physical quantities into electrical are called electrical transducers. Examples are a thermocouple that changes temperature differences into a small voltage, or a linear variable differential transformer (LVDT) used to measure displacement.

Transfer Capability: The overall capacity of interregional or international power lines, together with the associated electrical system facilities, to transfer power and energy from one electrical system to another.

Transfer Distribution Factor (TDF) (see also Distribution Factor), are the effects of specific power transfer transactions on specific flowgates and are used to determine if they are subject to Transmission Line Loading Relief (TDF). TDF is a measure of the change in a power transfer from one area to another expressed as a percent - up to 100%. (MW effect = Interchange Transaction in MW x TDF).

Transfer Price: The monetary value assigned to products, services, or rights conveyed or exchanged between related parties, including those occurring between units of a consolidated entity.

Transformer: An electromagnetic device for changing the voltage of alternating current.

Transformer Tap: Electronic switches that adjust the amount of reactive power and voltage on one side of the transformer by changing reactive power and voltage on the other side.

Transients (Also referred to as "Spikes" or "Ringing"): A momentary change or imbalance in an electric or control system; the term can also refer to a change in nuclear reactor coolant system temperature and/or pressure due to a change in power output of the reactor.

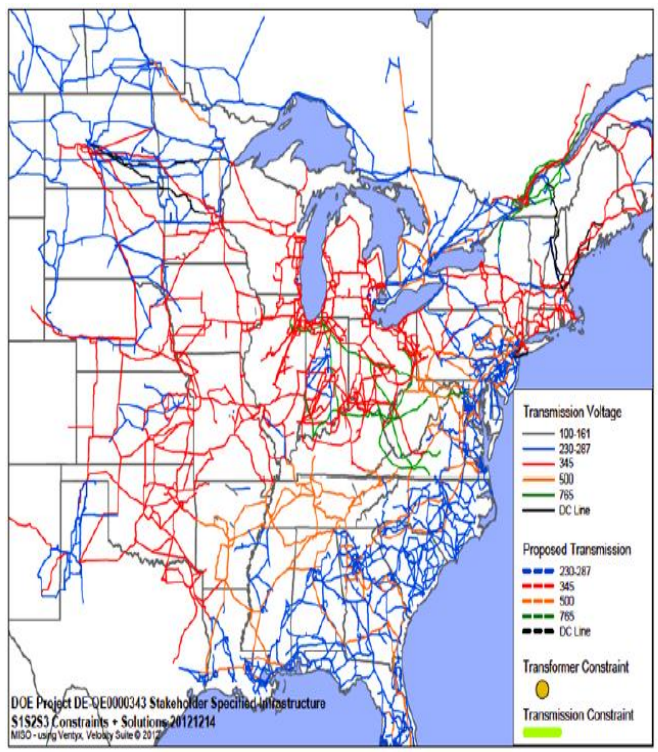
Transients are fluctuations in voltage or current caused by switching, relaying or other short-term disturbances. Their source can be in the utility's system or in customer equipment. Transients originating in one customer's equipment can affect another customer on the same feeder, and may not be apparent to the utility at all.

Transient Stability: The ability of an electric system to maintain synchronism between its parts when subjected to a disturbance and to regain a state of equilibrium following that disturbance.

Transient Stability Assessment Tool (TSAT): A time-domain simulation tool designed for comprehensive assessment of dynamic behavior of complex power system analysis.

Transition Matrix for Capacity Planning: A transition matrix is used in contrast to the *Load Duration Curves* to preserve the chronology in capacity planning models by retaining information from one period to another. This is not designed for modeling full hourly chronology in a multi-year planning model.

Transmission: Moving bulk energy products from where they are produced or generated, to distribution lines that carry the energy products to consumers. See the bulk power system map.



Transmission and Distribution Interface: The location where the transmission and distribution systems interconnect, typically at a distribution substation.

Transmission and Distribution Loss: Electric energy lost due to the transmission and distribution of electricity. Much of the loss is thermal in nature.

Transmission and Distribution Planning (T&D): planning is a complex process which requires the evaluation of numerous factors such as actual transmission and distribution transformer loadings at different times of the year (likely to be non-coincident with the system peak demand used by resource planners). Projections of future transformer bank loading is made based on the historic load growth combined with the transmission and distribution planners' knowledge of load additions within the area. The load growth in a distribution planning area tends to be somewhat more uncertain and difficult to predict than total system load growth used by resource planners.

T&D planning generally depends on the specific location of the loads (persistent congestion is a primary concern of transmission planners). Especially for distribution planners, the effects of customer-owned resources such as co-generation capacity on distribution planning is location-specific. T&D is more difficult to construct in urban areas due to zoning, construction costs, labor, and other factors.

Transmission system planners utilize the historical distribution substation transformer bank loading and trends, combined with the load forecast and resource plan to develop models of the transmission system. These models are used to simulate the transmission system performance under a range of credible conditions to ensure that expected performance meets the North American Electric Reliability Corporation (NERC) planning criteria. See FERC Form 715 Part 4.

Transmission Availability Data System (TADS): This is nation-wide system and database developed by the North American Electric Reliability Corporation (NERC) to collect operational and planning data about transmission.

Transmission Circuit: A conductor used to transport electricity from generating stations to distribution substations for ultimate distribution to customers.

Transmission Constraints (See also Redispatch Costs, Congestion Costs, and Locational Marginal Cost Pricing): Limitations on a transmission line or element that may be reached during normal or contingency system operations. Note, the calculations for determining the operational limits vary among transmission operators.

Transmission Corridor: Land zoned to be available for future electricity transmission projects; or a geographic area where transmission congestion or constraints adversely affect consumers.

Transmission Costs: Example Transmission Costs for New Facilities:

Line/Description	Unit	Base Cost
<230 kV Single Circuit Line, 300 MW Capability	$/Mile	$ 1,100,000
230 kV Single Circuit Line, 600 MW Capability	$/Mile	$ 1,150,000
230 kV Single Circuit Line, 900 MW Capability	$/Mile	$ 1,580,000
230 kV Double Circuit Line, 1,200 MW Capability	$/Mile	$ 1,800,000
345 kV Underground Line, 500 MW Capability	$/Mile	$ 19,750,000
345 kV Single Circuit Line, 900 MW Capability	$/Mile	$ 2,100,000
345 kV Single Circuit Line, 1,800 MW Capability	$/Mile	$ 2,500,000
345 kV Underground Line, 1,800 MW Capability	$/Mile	$ 25,000,000
345 kV Double Circuit Line, 3,600 MW Capability	$/Mile	$ 2,800,000
345 kV Underground Line, 3,600 MW Capability	$/Mile	$ 28,000,000
500 kV Single Circuit Line, 2,600 MW Capability	$/Mile	$ 3,450,000
765 kV Single Circuit Line, 4,000 MW Capability	$/Mile	$ 5,550,000
500 kV HVDC Bi-pole Line, 3,500 MW Capability	$/Mile	$ 1,600,000
<230 kV Substation, 4 Bay	$	$ 7,750,000
230 kV Substation, 4 Bay	$	$ 9,500,000
345 kV Substation, 4 Bay	$	$ 16,000,000
500 kV Substation, 4 Bay	$	$ 26,500,000
765 kV Substation, 4 Bay	$	$ 44,000,000
230 kV Transformer	$	$ 5,500,000

Transmission, Distribution and Storage System Improvement Charge (TDSIC-Indiana Utility Regulatory Commission): Indiana's statutory requirements in *Indiana Code § 8-1-39-9* establishes the requirements to be met so that the Commission can approve the recovery 80% of the TDSIC costs through the tracker mechanism and the deferral of the remaining 20% to be recovered in the next base rate case. The utility's Petition must: 1) Use the customer class allocation factor based on firm load and was approved in the most base rate case order; 2) Include the utility's most recently approved 7-Year Plan for eligible TDSIC projects; and 3) Identify projected effects of the plan on retail rates and charges.

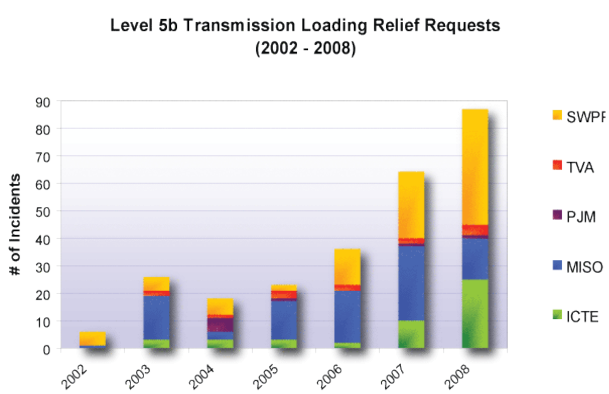
Transmission Ground Fault Over Voltage (GFOV): May occur on subtransmission Circuits by rotating machine and photovoltaic inverter genertion. Lightning and opening the line on the AC side of a converter station may also cause over voltage.

Transmission Line (Electric): A system of structures, wires, insulators and associated hardware that carry electric energy from one point to another in an electric power system. Lines are operated at relatively high voltages varying from 69 kV up to 765 kV, and are capable of transmitting large quantities of electricity over long distances. (NERC definition)

Transmission Line Loading Relief (TLR): A procedure that seeks to prevent power outages or property damage when the electric load threatens to get to high for the transmission line to handle.

Level 5b TLR's have been rising exponentially over the past five years, with over 85 occurring in 2008 as compared with only five in 2002. More than 50% of level three Energy Emergency Alerts called in 2007 and 2008 were due to TLR 5a or 5b declarations, when firm load interruption was imminent or in progress. While TLR's are more an indicator of congestion on popular paths, they do indicate that the grid is being pushed harder than it was in the past – which does raise reliability concerns.

Leading Indicator
Transmission Loading Relief Requests



The TLR Procedure is an Eastern Interconnection-wide process that allows reliability coordinators to mitigate potential or actual operating security limit violations while respecting transmission service reservation priorities.

Over-scheduling transactions on Firm Point-to-Point Transmission Service paths is an indication of increased congestion. Trends towards increasing number of TLR Level 5 or higher may provide an early warning signal that ability of the system to reliably supply electricity during times of peak period is declining.

Transmission Network: A system of transmission or distribution lines so cross-connected and operated as to permit multiple power supply to any principal point.

Transmission Operator (Electric): The entity responsible for the reliability of its localized transmission system, and that operates or directs the operations of the transmission facilities. (NERC definition)

Transmission Overload: A state where a transmission line has exceeded either a normal or emergency rating of the electric conductor.

Transmission Owner (Electric): The entity that owns and maintains transmission facilities. (NERC definition)

Transmission Planner: The personnel of an entity that develops a long-term (generally one year to 10 year planning horizon to comport with current (2014) transmission planning requirements of NERC) plan for the reliability (adequacy) of the interconnected bulk electric transmission systems within its portion of the Planning Authority Area (see also Resource Planner). There is an emerging consensus that transmission planning cannot be done without considering the planning of other resources.

Transmission Planning: Historically, transmission planners adhere to NERC requirements to conduct 10 year reliability analysis. In contrast, Resource Planners typically have longer planning horizons due to the capital intensity, and the relatively long lead-times from inception to being in-service of some investments such as large generation or transmission facilities. Transmission planners, also base their analysis on the maximum demand on transmission system elements whenever the maximum occurs (this may not be coincident with the maximum demand on the utility's system). Resource Planners base their planning on the System Peak (maximum) demand. However, since transmission planning cannot be conducted without consideration of all other resources, the differences between historical transmission planning and resource planning are likely to be minimal or non-existent in the near future. For example, the Midcontinent ISO's planning process is referred to as MTEP – *MISO Transmission Expansion Plan* and PJM's is the *Regional Transmission Expansion Plan* (RTEP).

Transmission and distribution (T&D) planning is a complex process which requires the evaluation of numerous factors such as actual transmission and distribution transformer loadings at different times of the year (likely to be non-coincident with the system peak demand used by resource planners). Projections of future transformer bank loading is made based on the historic load growth combined with the transmission and distribution planners' knowledge of load additions within the area. The load growth in a distribution planning area tends to be somewhat more uncertain and difficult to predict than total system load growth used by resource planners.

T&D planning generally depends on the specific location of the loads (persistent congestion is a primary concern of transmission planners). Especially for distribution planners, the effects of customer-owned resources such as co-generation capacity on distribution planning is location-specific. T&D is more difficult to construct in urban areas due to zoning, construction costs, labor, and other factors.

Transmission system planners utilize the historical distribution substation transformer bank loading and trends, combined with the load forecast and resource plan to develop models of the transmission system. These models are used to simulate the transmission system performance under a range of credible conditions to ensure that expected performance meets the North American Electric Reliability Corporation (NERC) planning criteria. See FERC Form 715 Part 4.

Transmission Reliability Margin (TRM): The amount of transmission transfer capability necessary to provide reasonable assurance that the interconnected transmission network will be secure. TRM accounts for the inherent uncertainty in system conditions and the need for operating flexibility to ensure reliable system operation as system conditions change.

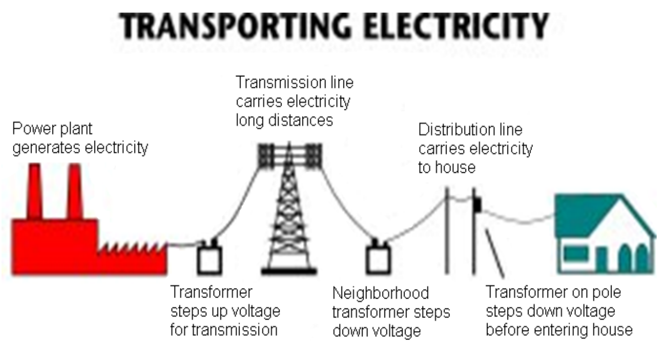
Transmission Service Provider (Electric): The entity that administers the transmission tariff and provides Transmission Service to Transmission Customers under applicable transmission service agreements. (NERC definition.)

Transmission Service Request: A request made by a participant for short or long-term transmission service. Typically the request is for a specific path and a specific megawatt amount.

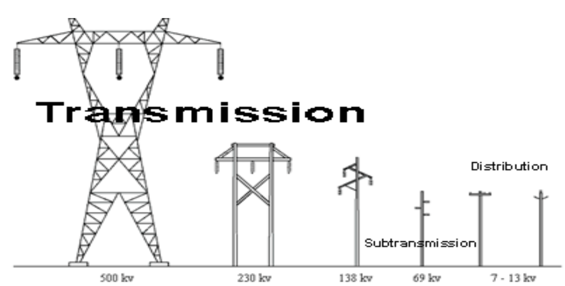
Transmission System (Electric): An interconnected group of electric transmission lines and associated equipment for moving or transferring electric energy in bulk between points of supply and points at which it is transformed for delivery over the distribution system lines to consumers or is delivered to other electric systems.

Transmission System Operator: The entity responsible for scheduling and operating a transmission system and sometimes for facilitating real-time markets.

Transmission substation: A substation located on the transmission grid, usually where two or more separate transmission lines interconnect.



Transmission Towers: Are tall structures used to support transmission wires on *Rights of Way***.** Structures needed to support wires for the transmission of electricity. The towers are built on "*rights of way.*" **"**Are tall structures used to support transmission wires on *Rights of Way***."**



Source: OSHA Electric Power Illustrated Glossary

Transmitting Utility: A regulated entity which owns and may construct and maintain wires used to transmit wholesale power. It may or may not handle the power dispatch and coordination functions. It is regulated to provide non-discriminatory connections, comparable service, and cost recovery. According to the Energy Policy Act of 1992, it includes any electric utility, qualifying cogeneration facility, qualifying small power production facility, or Federal power marketing agency which owns or operates electric power transmission facilities which are used for the sale of electric energy at wholesale.

Trip: The opening of a circuit breaker or breakers on an electric system, normally to electrically isolate a particular element of the system to prevent it from being damaged by fault current or other potentially damaging conditions. See “Line Trip” for example.

Trunk line: A main or primary natural gas pipeline to deliver gas from production areas to consumption points such as the Local Distribution Company (LDC). The trunk pipelines are large diameter carbon steel pipelines with diameters ranging from 20 inches to 48 inches or more and cover more than 2000 km distances.

Turbine: A machine for generating rotary mechanical power from the energy of a stream of fluid (such as water, steam, or hot gas). Turbines convert the kinetic energy of fluids to mechanical energy through the principles of impulse and reaction, or a mixture of the two.

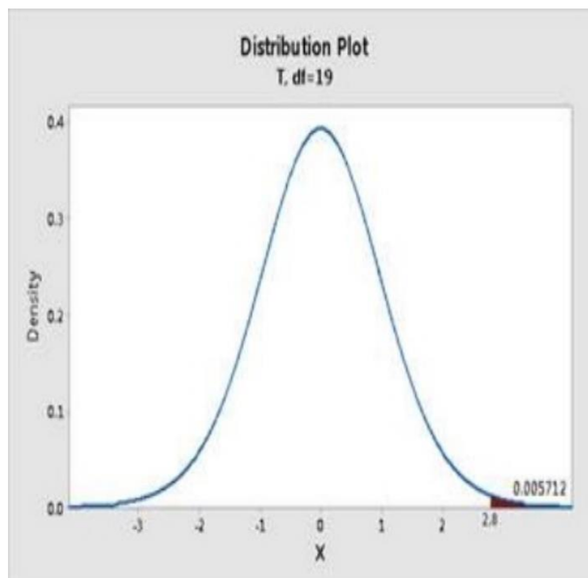
Turbine-Hours (TH) are equal to the number of turbines in the group or sub-group times the number of Calendar Hours in the period. TH for any given condition for a given sub-group is equal to the total number of Calendar Hours that each wind turbine *(WTG)* in the sub-group spent in the given condition.

All of the following time/condition classifications are considered to be in turbine-hours.

For example, the number of TH for a group of 12 WTG in January (with 744 hours in January) would be 12 x 744 or 8,928 TH. If one of those turbines were mothballed, the Period Turbine-Hours *(PTH)* would be 11 x 744 or 8,184 PTH with 744 Inactive Turbine-Hours.

Turn-Key (or Turnkey Project), is a type of project – such as the construction of a power plant – that can be sold to a buyer as a completed product. This is contrasted with build to order where the constructor builds an item to the buyer's exact specifications, or when an incomplete product is sold with the assumption that the buyer would complete it. The contractor has the legal responsibility for the design and performance. The term is a reference to the fact that the customer, upon receiving the product, just needs to turn the ignition key to make it operational.

T-Value note also Student T (Statistics – see also P-Value, Alpha, Confidence Interval): A T-Test is typically used to find evidence of a significant difference between population means or between the population mean and a hypothesized value (1-sample t). The t-Value measures the size of the difference relative to the variation in your sample data. That is, T is the calculated difference represented in units of standard error. The greater the magnitude of T (it can be either positive or negative), the greater the evidence against the null hypothesis that there is no significant difference. The closer T is to 0, the more likely there isn't a significant difference. Larger T-Values (positive or negative) are less likely (see the tails of the probability distribution curve and note that obtaining a T-Value of 2.8 or greater is .005712). In other words, the probability of attaining a T-Value of 2.8 or higher from the same population mean is less than .006.This is the P-Value.



The highest part (peak) of the above probability distribution curve is where you expect most of the t-values to fall. Most of the time, you’d expect to get t-values close to 0. The mean of most random samples from the population should be close to the overall population mean, making their differences (and thus the calculated t-values) close to 0.

Two Factor Modeling for Commodities (Dynamic Modeling – see also Black-Scholes): The Two Factor Modeling is a form of dynamic model using probabilistic methods. This allows planners to recalculate the forecasting / planning model at any future point. By way of example, suppose a planner wants to assess the probability that the price of natural gas will go from $2.20/MMBtu in 2018 to exceeding $7/MMBtu in 2038. This is a refinement of the *Black-Scholes option pricing formula.* Black-Scholes and early studies typically assumed commodity prices followed a "random walk" described by geometric Brownian motion. In the B-S model, prices are expected to grow at some constant rate with the variance in future spot prices increasing in proportion to time. If prices increase (or decrease) more than anticipated in one time period, all future forecasts are increased (or decreased) proportionally. See *Short-Term Variations and Long-Term Dynamics in Commodity Prices*, E. Schwartz & J. Smith, *Management Science,* Vol. 46, No. 7, pp. 893-911.

Two-wire service: An electric service from the utility to a customer facility that consists of two conductors; it may include two hot conductors or one phase conductor and one gro

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U-75: The number of hours or percentage of a year when a transmission path is operated at or above 75% of its safe operating limit.

U-90: The number of hours or percentage of a year when a transmission path is operated at or above 90% of its safe operating limit.

Ultimate Customer: A customer that purchases electricity for its own use and not for resale.

Ultra High Voltage (UHV) (see also High Voltage AC and DC as well as EHV AC and DC): Typically, UHV is regarded as about 800 kV to 1000 kV transmission lines. There are some problems in constructing 1000 kV and 1200 kV AC transmission facilities relating to the cost-effectiveness of new transformers, breakers, arresters, shunt reactors, and series capacitors that are needed for Ultra High Voltage Transmission. UHV transmission may further facilitate the transmission of large amounts of power over vast distances. As with EHV AC or DC, UHV transmission may provide a more economic means of transmitting power from wind rich regions to load centers that need the resources.

Ultra-Low Sulfur Diesel (ULSD) Fuel: Diesel fuel containing a maximum 15 parts per million (ppm) sulfur.

Ultra-Super Critical Coal-Fired Generation (USC): USC power plants have potential efficiencies of about 47 percent while current operating subcritical coal-fired power plants in the United States have an average efficiency of 35 percent. Many of the large pulverized coal power plants in existence today produce supercritical steam, and have an efficiency of a little more than 40 percent. Increasing the temperature and pressure of steam improves the efficiency of boilers and turbines that use steam as the working fluid. These higher efficiency boilers and turbines require less coal and produce less greenhouse gases, ash, sulfur dioxide, nitrogen oxide, mercury, and particulate matter. American Electric Power's 600 MW Turk Power Plant in Arkansas began construction in 2006 and came on-line in 2013. AEP invested $1.3 billion of the total $1.8 billion in the technology. It is currently the only USC power plant operating in the United States. The National Energy Technology Laboratory (NETL) is working with a consortium of experts to develop materials that have high creep rupture strength, resist embrittlement, and other characteristics that make it possible to achieve higher temperatures.

Unaccounted for Capacity: The capacity reported on the load and capacity printout (10), minus the calculated operating capacity, minus scheduled capacity not available in 30 minutes. This is the amount of capacity that is reported available at the time of the Instantaneous Reserve Check (IRC), but cannot be accounted for based on system conditions at the time of the IRC.

Unaccounted for Natural Gas: Represents differences between the sum of the components of natural gas supply and the sum of components of natural gas disposition. These differences maybe due to quantities lost or to the effects of data reporting problems. Reporting problems include differences due to the net result of conversions of flow data metered at varying temperatures and pressure bases and converted to a standard temperature and pressure base; the effect of variations in company accounting and billing practices; differences between billing cycle and calendar-period time frames; and imbalances resulting from the merger of data reporting systems that vary in scope, format, definitions, and type of respondents.

Unavailable Capability: Generation that is out of service due to forced, maintenance, or planned outages.

Unavailable Hours (UH): = Sum of all Planned Outage Hours (POH) **+** Forced Outage Hours (FOH) **+** Maintenance Outage Hours (MOH).

Unbalance: A steady state quantity defined as the maximum deviation from the average of the three phase voltages or currents, divided by the average of the three phase voltages or currents, expressed in percent. The primary source of voltage unbalance less than two percent is unbalanced single phase loads on a three-phase circuit. Voltage unbalance can also be the result of capacitor bank anomalies, such as a blown fuse on one phase of a three-phase bank. Severe voltage unbalance (greater than 5%) can result from single-phasing conditions. Voltage unbalance is most important for three phase motor loads. ANSI

C84 (Preferred Voltage Ratings for AC Systems and Equipment) recommends that the maximum voltage unbalance measured at the meter under no load conditions should be 3%. Unbalance greater than this can result in significant motor heating and failure if there are not unbalance protection circuits to protect the motor. Given changes in the engineering of new appliances and end-uses and concerns about power quality, there may be changes in the definition of unbalance.

Unbundled Services (Electric): As part of the movement toward *retail competition* some states restructured their vertically-integrated electric system by separating the generation, transmission, and distribution systems. This allowed the generating units to compete directly in the wholesale power markets (e.g., RTOs / ISOs) that typically operated and planned the transmission systems to facilitate wholesale competition. This allowed marketers and aggregators to serve retail customers. The Local Distribution Company provided access to the distribution system and often served as the provider of last resort to retail customers not served by a marketer or aggregator.

Unbundled Services (Natural Gas): The natural gas industry is an unbundled industry in that each link in the natural gas value chain remains independent of the others and is not related to the ownership of the gas. For instance, pipeline companies do not own the natural gas they transport; the gas remains under title of the shipper (e.g., natural gas producer), with the title transferred to purchaser (e.g., Local Distribution Company -LDC, marketer) at the delivery point.

Unbundling: Separating vertically integrated monopoly functions into their component parts for the purpose of separate service offerings.

Uncertainty: Uncertainty is a situation which involves imperfect and / or unknown information. For utilities, for example, future environmental regulations, load growth, the price of fuels, the cost of purchasing renewable resources are significant uncertainties. Assessing the *RISK* of these uncertainties is a complex but necessary undertaking for long-term planning of resources and financing.

Uncertainty vs. Risk: Risk is the possibility of suffering harm or loss while uncertainty is the condition of being in doubt – according to the American Heritage Dictionary. There is a tendency to use the terms interchangeably but they are not always the same. With the purchase of a lottery ticket, the uncertainty could be in the millions of dollars. However, the risk is limited to the price of the ticket. In utility planning, one approach to assessing uncertainty is to run scenarios or sensitivities from the base case and measure the spread between the extreme low and high results. Another approach is to run vary different combinations of inputs to get a distribution of outcomes so a mean, variance, and standard deviation can be calculated. A portfolio with a higher variance could be less risky if the expected cost is low enough. As applied to Integrated Resource Planning, too often, rigorous analysis is limited to uncertainties where there is at least a perception of more firm data and, as a result, misses some potentially significant factors such as technology change, market disruption, federal/state politics, and environmental regulation. Ultimately, the objective of an IRP is a systematic and on-going effort to recognize uncertainties and minimize the adverse effects of risk.

Unconstrained Path: Any posted path not determined to be a constrained posted path (defined in FERC Order 889).

Unconventional Gas Resources (Natural Gas): Defined as those low permeability deposits that are more continuous across a broad area. The main categories are coalbed methane, tight gas, and shale gas, although other categories exist, including methane hydrates and coal gasification.

Unconventional Oil Accumulation (see also Economically Recoverable Resources, Technically Recoverable, Continuous Oil & Gas Accumulations, Proved Reserves): A "continuous" or "unconventional" oil accumulation means that the oil resource is dispersed throughout a geologic formation(s) rather than existing as discrete, localized occurrences, such as those in conventional accumulations. Unconventional resources often require special technical drilling and recovery methods.

Unconventional Oil and Natural Gas Production: An umbrella term for oil and natural gas that is produced by means that do not meet the criteria for conventional production. See Conventional oil and natural gas production. Note: What has qualified as "unconventional" at any particular time is a complex interactive function of resource characteristics, the available exploration and production technologies, the current economic environment, and the scale, frequency, and duration of production from the resource. Perceptions of these factors inevitably change over time and they often differ among users of the term. For these reasons, the scope of this term will be expressly stated in any EIA publication that uses it.

Under-Frequency Load-Shedding (UFLS): An extreme measure to arrest frequency decline that disconnects large, pre-set groups of customers at predetermined frequency set points. LBL 2018

Underground Transmission: Underground cables are used where overhead lines are inappropriate due to environmental or land use considerations, such as in high-density urban areas or ecologically sensitive areas. Cables are insulated and are typically routed through underground conduits, and often require cooling systems to dissipate heat. Cables may use copper instead of aluminum, balancing the greater cost of copper against its superior conductivity and lower resistive heating. Undersea (submarine) cables are usually made of copper, and may be surrounded by oil or an oil-soaked medium, then encased in insulating material to protect from corrosion.

Undiscovered Oil, Natural Gas, and Coal Resources: Resources postulated, on the basis of geologic knowledge and theory, to exist outside of known fields or accumulations. Included also are resources from undiscovered pools within known fields to the extent that they occur within separate plays.

Undue Discrimination: Some forms of discrimination are reasonable and legal and it is important to make the distinction between "due" discrimination and "undue discrimination." Matinees and happy hours are examples of due discrimination because have a legitimate business rationale. Similarly, utility pricing to reduce peak demand, by charging more during the peak period and less during off-peak periods, serve legitimate business and public policy objectives. Courts, for example, have held that investor-owned utilities cannot have tariffs that discriminate against public power utilities. Open-Access Transmission Tariffs (OATT) were intended to prevent unduly discriminatory use of the transmission system.

Unforced Capacity (UCAP): The MW value of a capacity resource in the market (e.g., a capacity market). For a generating unit, the unforced capacity value is equal to installed capacity of unit multiplied by (1- unit's EFORd). For demand resources and energy efficiency resources, the unforced capacity value is equal to demand reduction multiplied by Forecast Pool Requirement. In the New York Independent System Operator (NYISO), UCAP is the percentage of installed capacity (ICAP) that is available at any given time; UCAP is the unit used for buying and selling capacity on NYISO's ICAP market.

Uniform System of Accounts: Prescribed financial rules and regulations established by the Federal Energy Regulatory Commission for utilities subject to its jurisdiction under the authority granted by the Federal Power Act.

Uninstructed Deviation (UD): UD is the difference between the actual energy exchange in a given time interval and the dispatch instructions. Regional Transmission Organiztions (ISOs) have attempted to provide appropirate incentives for resources to follow dispatch instructuions to improve reliabilty by reducing reliance on resources that are not responsive to dispatch instructions, for suppliers to achieve higher ramp rates, and reducing price volatility that resultes in the need for make whole payments to compensate resources fairly. (see: Area Control Error).

Unit Commitment (UC or UCED for Unit Commitment Economic Dispatch): Economic Dispatch (ED) in power systems reduces the cost of producing power to the benefit of consumers and power producers. There are two basic methods available. One is classical method where all units are committed and consumption of fuel is optimized by an optimization method. Second one is Unit Commitment (UC) method. In UC, units are committed based on their economic / engineering efficiency order and on load demand with most efficient unit committed first and the least efficient being committed last. A third approach is a refinement called Unit Commitment with Economic Dispatch (UCED) that combines these two methods.

Unit Energy Consumption (UE) (see Energy Intensity): The amount of energy consumed by a specific appliance / end-use.

Unloaded Capacity: Generating capacity that is spinning and synchronized to the grid, but is not providing energy.

Unplanned Outage Hours (UOH): UOH is the sum of all hours experienced during Forced Outages (U1, U2, U3) **+** Startup Failures (SF) **+**

Maintenance Outages (MO) **+** Maintenance Outage Extensions (ME).

Unproved Reserves: Unproved reserves are based on geologic and/or engineering data similar to that used in estimates of proved reserves; but technical, contractual, economic, or regulatory uncertainties preclude such reserves being classified as proved.

Unregulated Affiliates: (see also Codes of Conduct and Affiliate Rules, Ohio Power Gap Case): Utility holding companies that operate regulated utilities often have unregulated affiliated subsidiaries. Regulatory commissions often institute "affiliate rules" and "codes of conduct" to provide some assurance of separation such that the regulated utility is not adversely affected by its unregulated affiliates and to ensure that unregulated affiliates do not take unreasonable advantage of the utility's name / market presence, financials, expertise, data, equipment, materials, etc. Historically, some utilities purchased coal companies or other companies that provided materials and equipment for the utility operations (in antitrust parlance this is referred to as vertical integration – see Ohio Power Gap as an example of concern). In the 1980s and early 1990s, several utility holding companies purchased a wide range of businesses. In addition to foreign energy companies and unregulated energy companies (such as pipelines), utilities invested in Savings & Loans (S&L scandal provides context), land speculation, malls, hotels, automobile auctions, and others. In general, Wall Street and Bond Rating Companies were not enthusiastic about utilities entering businesses that were not part of their core expertise and experience.

Up To Congestion Transactions (see also Virtual Transactions)**:** A UTC is a bid (a virtual transaction) in the *Day-Ahead Market* to purchase congestion and losses between two points. UTC bids can be based on the prevailing flow direction where the UTC is buying a position on the Day-Ahead Market congestion or they can be in the counter-flow direction where they are paid to take a position. In either case, like INCs and DECs, UTCs are bids that impose flows on the transmission network in the Day-Ahead Market that do not exist in real time and therefore classify as a virtual transaction. A major difference between an INC or a DEC and a UTC is that an INC or a DEC is a discrete injection or withdrawal at a location whereas a UTC transaction is an injection at a source point and a withdrawal at a sink point. Effectively, the UTC transaction takes an identical MW position at two different locations that from an energy perspective net to zero (absent losses) but do not for congestion and losses.

Uplift Charge: This is an hourly and daily charge applied to all buyers of energy on the wholesale market to cover the cost of administering the hourly and day-ahead markets, respectively, as well as a monthly charge to cover planning. This is sometimes referred to as "socialization" of costs because they cannot be easily assigned to specific customers.

Uprating Power Plants – for Reliability, Economics, or Environmental: Uprating or *upgrading* of existing power plants are considered to be an alternative to capacity additions or adding environmental controls (*environmental uprates)*. A critical examination will objectively consider the tradeoffs between building a new generating facility or uprating an existing unit for increased power output or to control pollutants. Uprating may include boilers, reactors, turbines, generators can increase the electrical output and improve reliability. As the interconnectedness of the power system increases, transmission system operators emphasize the need for more VAR (volt ampere reactive) support to supply reactive power to serve load centers. Environmental uprates are needed to comply with Environmental Protection Agency (EPA) requirements.

Uprating Substation Equipment: Just as thermal limits define maximum current flow values on transmission lines, equipment located at the terminating ends of a transmission line also have maximum current limits. In some situations, the limiting capacity may be linked to the equipment capabilities at the substation and not to the transmission line. If this is the case, the equipment at the substation can be replaced with larger components to increase the effective transfer limit of the line and its associated equipment. Argonne National Labs, The Design, Construction and Operation of High Voltage Electricity Transmission Technologies.

Upstream Oil and Gas Activities (Natural Gas): Consist of all activities and expenditures relating to oil and gas extraction, including exploration, leasing, permitting, site preparation, drilling, completion, and long-term well operation.

Uranium (Nuclear): A naturally occurring element that can be found in low levels within all rock, soil, and water. Uranium is also the highest-numbered element to be found naturally in significant quantities on earth and is always found combined with other elements. Natural uranium ore is 99% U-238 and 1% U-235 and is mined for use as fuel in nuclear reactors.

URI – A winter storm February 13 – 17 2021 (see Polar Vortex) that resulted in 4.5 million affected by cascading blackouts in Texas (primarily in the Electric Reliability Council of Texas). A retrospective assessment (January 2, 2022) tabulated the death toll to be at least 259 in the United States at a cost estimated to be in excess of $196.5 billion. Several coal plants were unavailable due to frozen equipment at the power plants. Snow-covered solar panels and frozen wind turbines contributed. Outages in different parts of Texas, including sections of the natural gas system that are electrically operated were not available due to problems such as pumps and antifreeze injection systems. This led to the shutdown of even more power plants.

Usage: The same as energy in kWh or MWh. Usage may also apply to natural gas as sales of Mcf.

Used and Useful: A fundamental regulatory concept requiring assets to be physically used and useful for current customers before customers pay the costs associated with the assets. The utility must also demonstrate that the investment was prudent. See Smyth v. Ames 169 U.S. 466 - 1898.

Useful Life: The estimated lifespan of a depreciable fixed asset, during which it can be expected to contribute to company operations.

Utility Demand-Side Management Costs: The costs incurred by the utility to achieve the capacity and energy savings from the (DSM) Program. Costs incurred by consumers or third parties are to be excluded. The costs are to be reported in nominal dollars in the year in which they are incurred, regardless of when the savings occur. The utility costs are all the annual expenses (labor, administrative, equipment, incentives, marketing, monitoring and evaluation, and other) incurred by the utility for operation of the DSM Program, regardless of whether the costs are expensed or capitalized. Lump-sum capital costs (typically accrued over several years prior to start up) are not to be reported. Program costs associated with strategic load growth activities are also to be excluded.

Utility Distribution Company (UDC)**:** A regulated utility that provides distribution services to end users.

Utility Scale: There is no commonly accepted definition as to what size constitutes "utility-scale." There is a wide range of definitions from greater than 25 kilowatts (kW) to greater than 50 megawatts (MW). The characteristics of the facility may be more useful in defining Utility Scale. A utility-scale facility might be defined as providing power directly into the transmission system rather than supplying power to a customer with the potential for the customer to sell excess power to the utility. The Solar Energy Industries Association, for example, defines utility scale solar as greater than 1 MW. The National Renewable Energy Laboratory (NREL) used 5 MW as a threshold.

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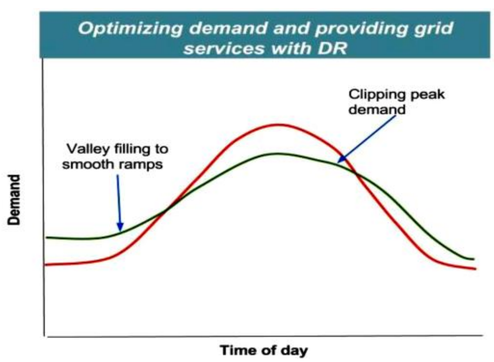
Valence: The formal definition of valence is the maximum number of univalent atoms that may combine with an atom. Usually, the definition is based on the maximum number of either hydrogen atom or chlorine atoms. Note the IUPAC only defines a single valence value (the maximum), while atoms are known to be capable of displaying more than one valence. For example, copper commonly carries a valence of 1 or 2.

Valley Filling (DSM term): Valley filing can be either a deliberate effort to improve *load factor* or a consequence of customers reducing peak demand and deferring some electrical use to periods when the cost of electricity is not as high. This can be accomplished by rate design and / or in conjunction with demand response programs. Valley filling may be particularly useful in systems that have substantial reliance on baseload generation such as coal-fired or nuclear power plants. In systems with a high percentage of intermittent resources, valley filling may not be as efficacious due to operational factors.

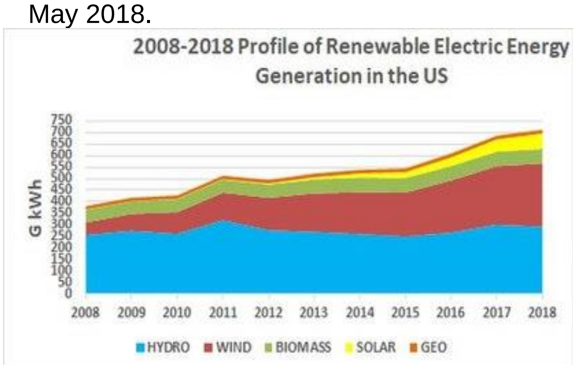


Value of Lost Load (VOLL): The value that represents a customers' willingness to pay for reliable electricity service, generally measured in dollars per unit of power (i.e. $/kWh or $/MWh). Assessments of *Resource Adequacy* and reserve margins often consider VOLL to tailor the amount of reliability to better meet the needs of customers.

Variable Costs: In contrast to Fixed Costs. Costs that change or vary with usage, output or production.

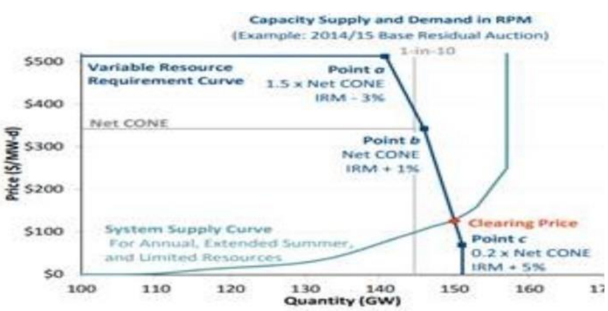
Variable Frequency Drives: Nikola Tesla recognized that 3-phase alternating current (AC) induction motors that he invented in 1888 were more efficient and reliable than Thomas Edison's direct current (DC) motor. However, the AC motor speed control requires either varying the magnetic flux or changing the number of poles on the motor. For decades after the induction motor gained widespread use, changing the frequency for speed control remained an extremely difficult task — and the physical construction of the motor prevented manufacturers from creating motors with more than two speeds. By the 1980s, AC motor drive technology became reliable and inexpensive enough to compete with traditional DC motor control. These variable-frequency drives (VFDs) accurately control the speed of standard AC induction or synchronous motors. There are three common types of VFDs. Current Source Inversion (CSI), Voltage Source Inversion (VSI), and Pulse-Width Modulation (PWM). VFDs are most commonly used in industry because of excellent *power factor,* higher efficiencies, and lower cost.

Variable Renewable Resource (VRE – see Intermittent Resource): Lawrence Berkeley Laboratory found that with wind and solar resources there has been *"… a general decrease in average annual hourly wholesale energy prices with more VRE penetration, increased price volatility and frequency of very low-priced hours, and changing diurnal price patterns. Ancillary service prices rise substantially and peak net-load hours with high capacity value are shifted increasingly into the evening, particularly for high solar futures.*" - Energy Analysis and Environmental Impacts Division, Lawrence Berkeley National Laboratory, Electricity Markets Policy Group, May 2018.



Variable Resources (see intermittent resources): Renewable resources are characterized by intermittency of operations.

Variable Resource Requirement (VRR curve - see also CONE or Cost of New Entry): Used in the PJM's *capacity market* referred to as their *Resource Planning Model* (RPM). "Demand" in PJM's RPM auctions. The VRR curve is a segmented downward-sloping curve that supports the RPM objective of attracting and retaining sufficient capacity to meet *Resource Adequacy* objectives. A downward sloping demand curve for capacity should achieve the following objectives: 1. Provide an indication of the incremental reliability and economic value of capacity at different planning reserve levels, in contrast to a vertical demand curve in which the value of capacity is only defined at the installed reserve margin target 2. Avoid the extreme capacity price volatility that a vertical curve might produce by allowing capacity prices to change gradually with changes to supply and demand, and reflect the idea that capacity beyond the installed reserve margin target has value 3. Reduce the risk in capacity investment by mitigating price volatility and providing a consistent stream of revenue, encouraging investment when it is needed at a lower cost to the system 4. Mitigate the potential exercise of market power by moderating the change in price produced by a change in supply [PJM Definition].



PJM's VRR curve is anchored at point "b" where the price of Net CONE and quantity at one percentage point above the *Installed Reserve Margin* (IRM) needed to satisfy the system-wide *Resource Adequacy Requirement*. Net CONE is determined as the estimated nominal levelized fixed costs of new entry (Gross CONE) based on a 20 year asset life of a combustion turbine net of estimated energy and ancillary service (E&AS) margins (net revenues). The Reliability Requirement is the quantity needed to meet the 1 event in 10 years, or 1-in-10, loss 2 of load event standard. The VRR curve yields a capacity price equal to Net CONE at point "b", at the target *reserve margin* plus 1 percentage point, or IRM + 1%. For lower supply levels to the left of point "b", capacity prices increase linearly until the quantity drops to IRM - 3% at point "a", where the capacity price is capped at the greater of: (1) 150% of Net CONE, or (2) 100% of Gross CONE. At higher reserve margins to the right of point "b", capacity prices decline linearly until IRM + 5% at point "c", where capacity price is equal to 20% of Net CONE. At even higher reserve margins, the capacity price drops to zero.

Variable Resource Requirement Curve: This is a PJM administratively determined demand curve (defining prices for various levels of resource procurement) for the PJM Region or an LDA that is used in an RPM Auction.

Variable Shunt Reactors (VSR): VSRs are used in high voltage energy transmission systems to stabilize the voltage during load variations. A traditional shunt reactor has a fixed rating and is either connected to the power line all the time or switched in and out depending on the load. VSR is useful for situations requiring a wide reactive power range with a non-dynamic regulation (e.g. wind farms). Functions which may be achieved by VSRs include maintaining steady-state voltage limit conditions, maintaining reactive power flow within predefined limits, and maintaining a desired power factor.

Fluctuating production of solar and wind power requires the ability to provide flexible *reactive power*. VSRs are designed to keep voltage in the defined voltage band even with large voltage fluctuations. This also results in losses being minimized. VSR can interact with other systems such as *Static Var Compensators* (SVCs) and high-voltage direct current (HVDC) links in order to optimize the system operation and maximize dynamic capacity during failures. In contrast, traditional fixed shunt reactors can only be designed for constant load and generation conditions.

The VSR is similar in size with only a marginally higher investment than fixed shunt reactors.

Variable-Speed Wind Turbines: Turbines in which the rotor speed increases and decreases with changing wind speed, producing electricity with a variable frequency.

Variance (VC) (Statistical): In probability theory and statistics, the **variance** of a random variable, probability distribution, or sample is a measure of statistical dispersion, averaging the squares of the deviations of its possible values from its expected value (mean). Whereas the mean is a way to describe the location of a distribution, the variance is a way to capture its scale or degree of being spread out. The unit of variance is the square of the unit of the original variable. The positive square root of the variance, called the standard deviation, has the same units as the original variable and can be easier to interpret for this reason. If a random variable *X* has expected value (mean) μ = E(*X*), then the variance Var(*X*) of *X* is given by:

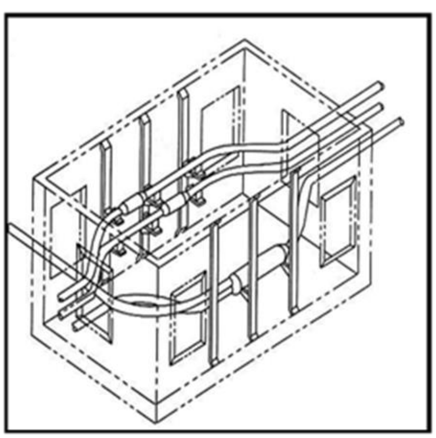
$$\operatorname{Var}(X) = \operatorname{E}[(X-\mu)^2].$$

This definition encompasses random variables that are discrete, continuous, or neither. Of all the points about which squared deviations could have been calculated, the mean produces the minimum value for the averaged sum of squared deviations.

This definition is expanded as follows:

$$\begin{aligned}\operatorname{Var}(X) &= \operatorname{E}[(X-\mu)^2] \\ &= \operatorname{E}[(X^2 - 2X\mu + \mu^2)] \\ &= \operatorname{E}(X^2) - 2\mu\operatorname{E}(X) + \mu^2 \\ &= \operatorname{E}(X^2) - 2\mu^2 + \mu^2 \\ &= \operatorname{E}(X^2) - \mu^2.\end{aligned}$$

Vaults: In the electric distribution system of major cities, vaults are used to house electric cables, transformers, network protectors. The following are courtesy of O'Neill Management Consulting and Charles Fijnvandraat.



A Manhole Structure

Vehicle to Grid (V2G) V2G with appropriate pricing (e.g., real-time rates) would provide price signals for electric vehicles to charge their batteries during the day to utilize solar and other renewable energy resources and discharge some amount into the electric system during periods of peak demand. Electric vehicles may change the time of the peak and alter current load shapes. City / school buses, commercial and private electric vehicles would discharge stored energy to the grid as electric demand declines during the night.

Vertical Integrated Utility: An arrangement whereby the same company owns all the different aspects of making, selling, and delivering a product or service. In the electric industry, it refers to the historically common arrangement whereby a utility would own its own generating plants, transmission system, and distribution lines to provide all aspects of electric service.

Vertical Integration: The combination within a firm or business enterprise of one or more stages of production or distribution. In the electric industry, it refers to the historical arrangement whereby a utility owns its own generating plants, transmission system, and distribution lines to provide all aspects of electric service.

Vertical Merger (see also Horizontal Merger): Vertical mergers have the objective of improving a company's efficiency or reducing costs by combining with businesses that are typically at different stages of production. For an electric or natural gas utility, a vertical merger might entail purchasing a coal mine or a natural gas pipeline or production company. A vertical merger can help secure access to important supplies and reduce overall costs by eliminating the need for finding suppliers, negotiating deals and paying full market prices. A vertical merger can improve efficiency by synchronizing production and supply between the two companies and ensuring availability of the items as needed. From an antitrust perspective, when companies combine in a vertical merger, competitors may face difficulty obtaining important supplies, increasing their barriers to entry and potentially reducing their profits. There is also the potential for abusive conduct such as a utility with a fuel adjustment clause purchasing fuel from a subsidiary at higher than market price (see the *Ohio Power Gap*).

Vertical-Axis Wind Turbine (VAWT): A type of wind turbine in which the axis of rotation is perpendicular to the wind stream and the ground.

Virtual Bids and Virtual Offers: A virtual offer or bid is a financial instrument that does not require physical generation or load. Virtual offers and bids provide added liquidity to the markets and are used in the Day-Ahead Energy Markets to make increment offers or decrement bids.

Virtual Hybrid Energy Systems (VHES): Two or more technologies that are physically separated but are virtually integrated using technologies. Contrasted to co-located or full hybrid enegy systems (HES).

Virtual Net Metering (VNM): VNM may be applicable to "community solar" projects, municipal buildings, owners or operators of a multi-tenant, multi-meter properties, and other types of customers where the owner or operator elects to allocate a percentage of the total metered output of a renewable generating facility to a specific delivery point. In contrast, traditional Net Metering allows individuals to sell excess energy produced by their on-site back to the utility and receive credits on their electric bill. By 2013, California, Connecticut, Illinois, Maine, Massachusetts, Maryland, Minnesota, Rhode Island, Vermont, and DC enacted virtual net metering policies. A virtual meter estimates flow rates instead of using a physical meter.

Virtual Power Plants (VPPs see also Distributed Energy Resource Management System): VPPs are characterized as a monitored network of de-centralized resources such as combined heat and power and other distributed energy resources (e.g., solar, wind, load management, batteries) that can respond to relieve expensive peak periods as well as provide frequency regulation and operating reserves. Proponents of VPPs contend that it minimizes costs, VPP is scalable and can be used to control the active power of DERs on a system-wide basis. It also prevents reverse power flow.

Virtual Purchased Power Agreements (VPPA): A VPPA allows a buyer to purchase a renewable resource in different regions, grids, or interconnections and is not, necessarily, physically transmitted to the buyer. These characteristics are in contrast to a traditional physical PPA. A *strike price* is typically determined for a long-term contract (e.g., 10 or more years). The generator sends / recieves settlements (settlement = wholesale price minus strike price) to / from the customer.

Virtual Transactions (see also Virtual Bids-INCs and Offers - DECs)**:** Virtual transactions are sets of offers (INCs), bids (DECs) and Up To Congestion Transactions (UTCs) submitted in the *Day Ahead Market* without the intention of delivering or consuming power in the *real-time markets.* These closely resemble financial transactions in other electricity commodity markets and share basic common elements with financially-settled, forward electricity contracts traded bilaterally or on electronic platforms and exchanges (such as the Intercontinental Exchange -ICE, New York Mercantile Exchange - NYMEX and Nodal Exchange). Virtual trading in wholesale energy markets such as Regional Transmission Organizations. Until about 2015, virtual transactions have been regarded as a valuable market feature because it: adds liquidity, opportunities for arbitrage that may result in price convergence and result in greater efficiencies, and gives participants with physical assets or load-serving obligations or participants with positions in related markets an opportunity to hedge those positions. Virtual bidding may also mitigate market power by allowing those without physical assets to compete with asset owners and load serving entities. More recently, concerns have been raised that can have adverse consequences. Some may skew transmission flows and congestion patterns which can result in inefficient performance of the Day-Ahead Market. These transactions may be profitable for traders but at the expense of consumers and suppliers.

Volatile Organic Compounds (VOCs**):** Organic compounds that participate in atmospheric photochemical reactions.

Volt Ampere (see also Apparent Power): A unit of measure of apparent power

Volt Ampere Reactive (VARs) (see also Reactive Power): A unit of measure of reactive power.

Voltage: The difference in electrical potential between any two conductors or between a conductor and ground. It is a measure of the electric energy per electron that electrons can acquire and/or give up as they move between the two conductors.

Voltage Collapse: An event that occurs when an electric system does not have adequate reactive support to maintain voltage stability. Voltage collapse may result in outage of system elements and may include interruption in service to customers.

Voltage Constraints: Primarily as a result of transmission line reactance, the voltage at the receiving end of a conductor will be less than the voltage applied on the sending end. Large voltage deviations either above or below the nominal value may damage utility or customer equipment. Therefore, operating voltage constraints are employed to preserve operating conditions that meet necessary voltage requirements. In general, voltage constraints are more typical in areas where transmission lines are sparse and long, such as in the Western Interconnection (Burgen 1986). It may be more economical to address voltage constraints by modifying existing lines, such as adding capacitance, rather than by adding new transmission capacity. Argonne National Labs, *The Design, Construction and Operation of High Voltage Electricity Transmission Technologies.*

Voltage Control: The control of transmission voltage through adjustments in generator reactive output and transformer taps, and by switching capacitors and inductors on the transmission and distribution systems.

Voltage Drop: The voltage drop increases as transmission line length increases. Similarly, the terminating voltage at the receiving end may vary above or below the recommended or nominal operating voltage, depending on the types of loads connected to the receiving end. Voltage constraints define the criteria needed to maintain receiving-end voltages within specified bounds (usually ± 5% of the nominal voltage). Customer and utility equipment operates most efficiently when operated near the nominal voltage level.

Voltage Drop Study: The Voltage Drop study is the most basic and commonly needed electrical study. The Voltage Drop analysis is part of a Power Flow study intended to show the power in kVA or Amperes on all of the individual electrical components – such as transformers, conductors – and their capabilities. Voltage Drop is defined as the amount of voltage loss that occurs through all or part of a circuit due to impedance. A common analogy used to explain voltage, current, and Voltage Drop is a garden hose. Voltage is analogous to the water pressure supplied to the hose. The voltage drop calculations for each bus and at all equipment will indicate if equipment supply voltages are at levels which will adversely affect equipment life or performance. Voltage Drop studies may cover conventional voltage drop analysis, loss analysis, power factor considerations, capacitor placement, long line charging effects, and co-generation analysis. A base-line Power Flow / Voltage Drop study should be performed any time major changes are made to the power distribution system. To better understand the concept of Voltage Drop, dam operations may be a helpful corollary. The water above the dam has greater potential energy than the water below the dam, and it releases that energy for other purposes as it descends. The amount of energy delivered by each bit of water is precisely proportional to the elevation change that bit of water experiences. 'Voltage drop' refers to a similar process that occurs in electrical circuits. In circuits, flowing water is replaced by flowing electrical charge, also known as current, and elevation change is replaced by voltage drop. Each point in a circuit can be assigned a voltage that's proportional to its 'electrical elevation,' so to speak. Voltage drop is simply the arithmetical difference between a higher voltage and a lower one. The amount of power (energy per second) delivered to a component in a circuit is equal to the voltage drop across that component's terminals multiplied by the current flow through the component: P = V*I where V is the voltage drop in volts, I is the current flow in amperes, and P is the power in watts. Obviously, if either V or I is zero, no power or energy is delivered to that component, so it can't fulfill any useful purpose. So voltage drop (along with current flow) is a vital feature of all electric circuits and is planned and controlled very carefully by the engineers that design those circuits.

Voltage Instability: Voltage instability occurs when the transmission system is exposed to large reactive power flows. As previously described, large reactive power flows on long transmission lines result in voltage drops at the receiving end of the line. Lower voltage causes increased current, which causes additional reactive losses. The end result is voltage collapse, which can damage equipment and cause additional outages, if left unresolved. In general, long transmission lines are stability limited, not thermally limited (Burgen 1986). Generally, depending on the system conditions, equipment enhancements to add more reactive power or additional transmission lines can relieve steady-state and voltage stability problem. Argonne National Labs, *The Design, Construction and Operation of High Voltage Electricity Transmission Technologies.*

Voltage Limits: A hard limit above or below which is an undesirable operating condition. Normal limits are between 95 and 105 percent of the nominal voltage at the bus under discussion.

Voltage Reduction: Any intentional reduction of system voltage by 3 percent or greater for reasons of maintaining the continuity of service of the bulk electric power supply system.

Voltage Reduction Warning: Synchronized Reserve capacity is less than the Synchronized Reserve requirement.

Voltage Ride Through (VRT see also Low Voltage Ride Through, Low Frequency Ride Through and Frequency Ride Through): Bulk transmission system faults result in voltage depression over an extended area, both during the duration of the fault, as well as during post-fault dynamic behavior. In the post-fault period, high voltages (NERC Integration of Variable Generation Task Force (IVFTF1-7) Report, ("Performance of Distributed Energy Resources During and After System Disturbance Voltage and Frequency Ride-Through Requirements ", December 2013) may also occur over a wide area due to dynamic "backswing". These voltage deviations at the bulk transmission level tend to propagate over a wide area to the distribution systems to which DR are connected. Without VRT requirements, and particularly with the present IEEE 1547 "must trip" requirements for voltage deviations, a potentially large amount of DR generation capacity could be tripped simultaneously as a result of a bulk grid event that stresses the grid. This has the potential for aggravating the bulk grid disturbance, and violates a fundamental principle of bulk system planning – generation should not be lost as a result of a grid fault that is within the planning criteria. The potential impacts of DR tripping on the bulk grid are a function of the aggregate DR capacity lost, and it makes no difference if the loss of 100,000 10kW DR units, or 100 10MW units. The net effect is the 8 same as if one 1,000 MW bulk generation plant is lost, a level of substantial significance to the bulk grid. Therefore, V/FRT requirements need to be applied to DR of all sizes, and irrespective of whether the units are single-phase or three-phase. Sandia National Laboratories April 2014.

Voltage Sag and Swell Studies: Short duration voltage variations are typically caused by fault conditions or energization of large loads that require high starting current (e.g., a very large motor starting, often resulting in a voltage sag). Voltage disturbances are generally temporary in nature and can either be temporary voltage reductions (denoted voltage sags), or increases in voltage (denoted voltage swells). Based on IEEE Standard 1159 (IEEE 2009), a voltage sag occurs when the root mean square voltage decreases to between 0.1 and 0.9 per unit of the nominal voltage level for a duration of 0.5 cycle to 1 minute. A *voltage swell* is defined as an increase in the root mean square voltage level to 1.1 to 1.8 per unit of the nominal voltage level for a duration of 0.5 cycle to 1 minute. The short voltage variations can disrupt or damage sensitive equipment, and thus have economic impacts on utility customers, and sometimes the utility itself. Power quality is not often examined by a utility unless there is a customer complaint. When a voltage sag and swell study is performed, it is often performed as an add-on to a protection or fault analysis study. Voltage sag and swell studies are usually conducted by reviewing results of power flow or fault analysis from a power quality perspective. During an interconnection study for DERs, voltage sag studies look at the step change in output of DERs from 100% to 0%. The step change in voltage will indicate the risk of sags or flicker. A true voltage sag study requires dynamics. Source: Grid Modernization Laboratory Consortium, U.S. Department of Energy.

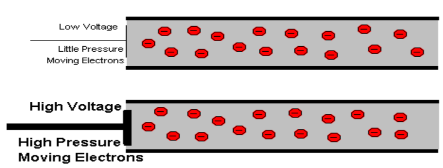
Voltage Sourced Converters (VSC): VSCs are capable of independent control of real and reactive power, voltage support to the connected AC system, and black-start capability.

Voltage Stability: The condition of an electric system in which the sustained voltage level is controllable and within predetermined limits.

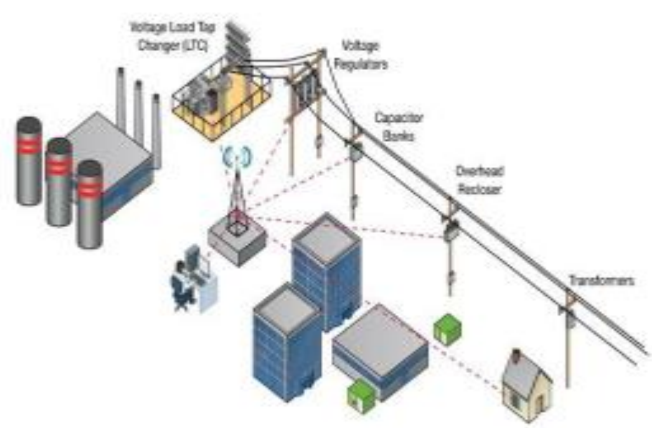
Voltage Support: An ancillary service that is required to maintain transmission and distribution voltages on the grid within acceptable limits.

Voltage Violations: A condition in the distribution system where voltage in any node is below or above an established limit, usually the America National Standard Institute's optimal and normal levels.

Volts: A Volt is a measure of the pressure forcing the current to flow. Notice that the number of electrons in both wires is the same. A flashlight battery with 1.5 volts is not very strong, but the 120 volts in your house is strong enough to run your refrigerator. The volt is the International System of Units (SI) measure of electric potential or electromotive force. A potential of one volt appears across a resistance of one ohm when a current of one ampere flows through that resistance. Reduced to SI base units, 1 V = 1 kg times m^2 times s^{-3} times A^{-1} (kilogram meter squared per second cubed per ampere).



Volt-Var Optimization (V.V.O. – sometimes referred to as Volt/Volt-Ampere Reactive Optimization)**:** A process that should be part of the Distribution System and Integrated Resource Planning to develop methods to optimally manage voltage levels and reactive power to achieve more efficient gird operation by reducing system losses, peak demand or energy consumption or a combination of the three. V V O considers changing feeder configurations, explicitly models voltage and thermal limits on primary, sub-transmission, and secondary circuits. Experts suggest that reductions in overall distribution line losses of 2%–5% are feasible through tight control of voltage and current fluctuations. "(NARUC) *encourages State public service commissions to evaluate the energy efficiency and demand reduction opportunities that can be achieved with the deployment of Volt-Var Optimization (VVO) technologies…and encourages State public service commissions to consider appropriate regulatory cost recovery mechanisms*." Distributed Energy Resources create significant challenges with VVO, because DERs, when exporting power, tend to raise voltage levels on a feeder line section when capacity penetration levels increase. Many utilities have required selected DER inverters, depending on the site and circuit, to absorb reactive power at a fixed power factor to mitigate voltage rise or voltage fluctuations. Other utilities have recently evaluated, and sometimes required, inverters to dynamically absorb or supply reactive power in response to voltage conditions, or even curtail real power output in iv response to high voltage. However, the use of such "smart inverter functions" in actual installations is not currently predominant in the utility industry. Because the applied sophisticated and integrated technology used, V V O is regarded as preferable to *Conservation Voltage Reduction* (CVR) The graphic below from Grid Modernization Laboratory Consortium of the U.S. Department of Energy illustrates the complex interrelationships.



Voluntary Emergency Demand Response (VEDR): Refers to voluntary customer load reductions during system emergencies. Customers may receive payments based on reductions achieved. It is important to note that reductions are not required and there are no penalties for non-performance. In response to alerts from RTOs / ISOs, utilities or aggregators typically notify customers of emergency conditions.

INDEX - W

Waste Confidence Rule (Nuclear): Waste Confidence Decision and Rule represented the generic determination by the U.S. Nuclear Regulatory Commission (NRC) that spent nuclear fuel can be stored safely and without significant environmental impacts for a period of time after the end of the licensed life of a nuclear power plant. On June 8, 2012, the U.S. Court of Appeals for the DC Circuit found that some aspects of the Decision did not satisfy the NRC's NEPA obligations and vacated the Decision and Rule. The NRC is currently revising its rule.

Waste Heat Boiler: A boiler that receives all or a substantial portion of its energy input from the combustible exhaust gases from a separate fuel-burning process.

Waste Heat Recovery: Any conservation system whereby some space heating or water heating is done by actively capturing byproduct heat that would otherwise be ejected into the environment. In commercial buildings, sources of water- heat recovery include refrigeration/ air-conditioner compressors, manufacturing or other processes, data processing centers, lighting fixtures, ventilation exhaust air, and the occupants themselves. Not to be considered is the passive use of radiant heat from lighting, workers, motors, ovens, etc., when there are no special systems for collecting and redistributing heat.

Water Pollution Abatement Equipment: Equipment used to reduce or eliminate waterborne pollutants, including chlorine, phosphates, acids, bases, hydrocarbons, sewage, and other pollutants. Examples of water pollution abatement structures and equipment include those used to treat thermal pollution; cooling, boiler, and cooling tower blowdown water; coal pile runoff; and fly ash waste water. Water pollution abatement excludes expenditures for treatment of water prior to use at the plant.

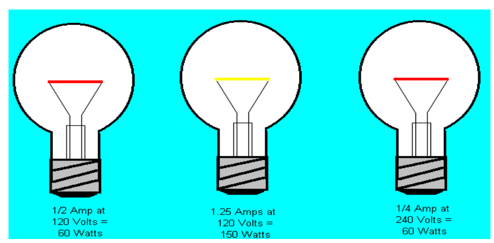
Watt: The electrical unit of real power or rate of doing work. The rate of energy transfer equivalent to one ampere flowing due to an electrical pressure of one volt at unity power factor. One watt is equivalent to approximately 1/746 horsepower or one joule per second.

SI multiples for watt (W)

Submultiples			Multiples		
Value	**Symbol**	**Name**	**Value**	**Symbol**	**Name**
10^{-1} W	dW	deciwatt	10^{1} W	daW	decawatt
10^{-2} W	cW	centiwatt	10^{2} W	hW	hectowatt
10^{-3} W	**mW**	**milliwatt**	10^{3} W	**kW**	**kilowatt**
10^{-6} W	**µW**	**microwatt**	10^{6} W	**MW**	**megawatt**
10^{-9} W	**nW**	**nanowatt**	10^{9} W	**GW**	**gigawatt**
10^{-12} W	**pW**	**picowatt**	10^{12} W	**TW**	**terawatt**
10^{-15} W	fW	femtowatt	10^{15} W	PW	petawatt
10^{-18} W	aW	attowatt	10^{18} W	EW	exawatt
10^{-21} W	zW	zeptowatt	10^{21} W	ZW	zettawatt
10^{-24} W	yW	yoctowatt	10^{24} W	YW	yottawatt

Common multiples are in **bold** face

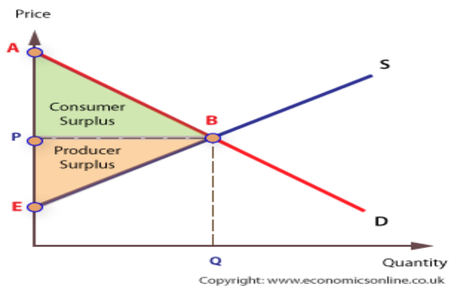
A Watt is a measure of electric power that depends on amps and volts. The bulb in the middle makes the most light because it uses more watts than the other two. But notice that the bulb on the right is using the same amount of power as the bulb on the left, even though it's using only half of the current. Watts = Volts x Amps.



Watthour (Wh): A unit of measure of electrical energy equal to 1 watt of power supplied to, or taken from, an electric circuit steadily for 1 hour.

Weather Diversity (see also Fuel Diversity, Load Diversity, and Resource Diversity)**:** Weather diversity can be regarded as an element of Load Diversity. That is, weather drives certain customer usage patterns and the utilities respond and plan resources to satisfy the potential changes in usage patterns. For example, utilities can realize substantial economies and greater reliability if there is an ability to transfer power during the summer to areas with heavy summer peaks from areas that are predominately winter peaking utilities and vice versa.

Welfare Economics (see also Consumer Surplus, and Producer Surplus): Economic welfare is the total benefit available to society from an economic transaction or situation. Total economic welfare is the combination of consumer and producer surplus. Total welfare is represented by the area ABE. Welfare economics considers whether economic decisions by individuals, companies / organizations, and the government increase or decrease economic welfare.

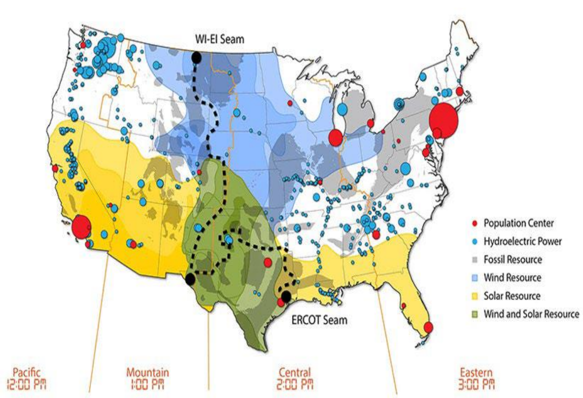


Wellhead: A wellhead is the control equipment which is placed at the top of the well casing.

Western Electricity Coordinating Council (WECC): One of the ten regional reliability councils that make up the North American Electric Reliability Corporation (NERC), formerly called the Western Systems Coordinating Council.

Western Energy Crisis of 2000-2001: Beginning in January 2001, disruptive rolling blackouts and brownouts affecting hundreds of thousands of consumers spread throughout California and affected neighboring states. The power supply crisis, in large measure, stemmed from a complex deregulation plan and market participants that exploited market design flaws. Some large electric utilities defaulted or went bankrupt. The state spent six billion dollars to buy electricity to keep the lights on in the region.

Western and Eastern Interconnections (NREL)



Wet Electrostatic Precipitator (ESP wet see also ESP dry): Uses multiple high-voltage fields to attract fine particulates to an electrode, which is washed with water to capture the constituents.

Wet Flue Gas Desulfurization (WFGD): Is a technology to reduce sulfur dioxide (SO_2) emissions. Wet scrubbers have removal efficiencies of greater than 90%. Newer dry scrubbers have efficiencies of about 90%,. Older dry scrubbers have efficiencies that may be less than 80%. Approximately 86% of the FGD (Flue Gas Desulfurization) systems are wet systems. 12% are spray dry, and 3% are dry systems. Capital costs for SO_2 have decreased by over 30% since the 1990s. Environmental Protection Agency "Fact Sheet."

Wet Natural Gas: A mixture of hydrocarbon compounds and small quantities of various non hydrocarbons existing in the gaseous phase or in solution with crude oil in porous rock formations at reservoir conditions. The principal hydrocarbons normally contained in the mixture are methane, ethane, propane, butane, and pentane. Typical non-hydrocarbon gases that may be present in reservoir natural gas are water vapor, carbon dioxide, hydrogen sulfide, nitrogen and trace amounts of helium. Under reservoir conditions, natural gas and its associated liquefiable portions occur either in a single gaseous phase in the reservoir or in solution with crude oil and are not distinguishable at the time as separate substances. *Note*: The Securities and Exchange Commission and the Financial Accounting Standards Board refer to this product as natural gas.

Wheeling: The contracted use of electrical facilities of one or more entities to transmit electricity for another entity.

Wheeling Charge: An amount charged by one electrical system to transmit the energy of, and for, another system or systems.

Wheeling Service: The movement of electricity from one system to another over transmission facilities of interconnecting systems. Wheeling service contracts can be established between two or more systems.

Wheel Through: An energy transaction flowing through a transmission grid whose origination and destination are outside of the transmission grid.

Wholesale Competition: A system whereby a distributor of power would have the option to buy its power from a variety of power producers, and the power producers would be able to compete to sell their power to a variety of distribution companies.

Wholesale Customer: An entity that purchases electric energy for resale, or uses transmission service for such transactions, within the PJM RTO.

Wholesale Electric Power Market: The purchase and sale of electricity from generators to resellers (retailers), along with the ancillary services needed to maintain reliability and power quality at the transmission level.

There are two main types of wholesale markets operating in the U.S. In the Southwestern, Southeastern and Northwestern regions of the U.S., vertically integrated utilities trade electricity through bilateral contracts and power pool agreements while in the rest of the U.S., RTOs / ISOs such as PJM and MISO use bid-based markets to determine the economic dispatch of resources.

Wholesale Market (Electric and Natural Gas): Electricity and natural gas, like other commodities (both are sold on commodity market exchanges), is bought and resold multiple times before being delivered to the end-use customer. These transactions form the wholesale electricity and natural gas markets. Suppliers that sell electricity and natural to retail consumers or other large-scale consumers purchase electricity and natural gas through the wholesale market.

Wholesale Sales: Energy supplied to other electric utilities, cooperatives, municipals, and Federal and state electric agencies for resale to ultimate consumers.

Wholesale Trading: The buying and selling of power between parties that are not ultimate end users

Wholesale Transmission Services: The transmission of electric energy sold, or to be sold, in the wholesale electric power market.

Wholesale Wheeling: An arrangement in which electricity is transmitted from a generator to a utility through the transmission facilities of an intervening system.

Wind Energy: Kinetic energy present in wind motion that can be converted to mechanical energy for driving pumps, mills, and electric power generators.

According to the Energy Information Agency, the average US household uses 888 kWh per month, or 10,656 kWh per year. An average 1.5-MW turbine (26.9% capacity factor) would produce the same amount of electric energy as that used by almost 332 households over a year. Of course, wind power is intermittent and variable, so a wind turbine produces power at or above its annual average rate only about 40% of the time. This is likely to change with storage and technolgoical advances.

Wind Power Density (WPD): A means of classifying *wind power classes* as measured in Watts per square meter (W/m^2).

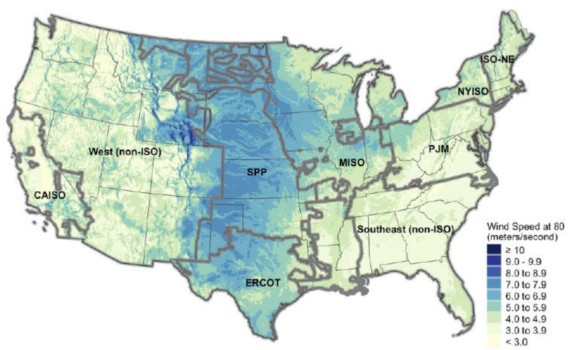
Wind Power Plant: A group of wind turbines interconnected to a common utility system through a system of transformers, distribution lines, and (usually) one substation. Operation, control, and maintenance functions are often centralized through a network of computerized monitoring systems, supplemented by visual inspection. This is a term commonly used in the United States. In Europe, it is called a generating station.

Wind Captured Energy Revenue. This Least Cost of Energy formulation (LCOE) seems to be intended to reflect that wind Purchased Power Agreements are sensitive to the Production Tax Credit. It is a reflection of the Wholesale Market Value.

Wind Resource Requirements: Generally, annual average wind speeds of greater than 9 miles per hour (mph), or 4 meters per second (m/s), are required for small electric wind turbines not connected to the grid, whereas utility-scale wind plants require a minimum wind speed of 10 mph (4.5 m/s). The power available to drive wind turbines is proportional to the cube of the speed of the wind. This implies that a doubling in wind speed leads to an eight-fold increase in power output. A measurement called the wind power density is used to classify sites into “wind power classes” [5]. Wind power density is measured in watts per square meter (W/m^2) and is calculated from annual observed wind speeds and the density of air. The Table below is from NREL and lists the wind class categories currently used.

	10 m (33 ft) Elevation		50 m (164 ft) Elevation	
Wind Power Class	Wind Power Density (W/m²)	Speed m/s (mph)	Wind Power Density (W/m²)	Speed m/s (m
1	0–100	0- 4.4 (9.8)	0-200	0-5.6 (12.5)
2	100 – 150	4.4 – 5.1 (9.8 – 11.5)	200 – 300	5.6 – 6.4 (12.5 – 14.3)
3	150 – 200	5.1 – 5.6 (11.5 – 12.5)	300 – 400	6.4 – 7.0 (14.3 – 15.7)
4	200 – 250	5.6 – 6.0 (12.5 – 13.4)	400 – 500	7.0 – 7.5 (15.7 – 16.8)
5	250 – 300	6.0 – 6.4 (13.4 – 14.3)	500 – 600	7.5 – 8.0 (16.8 – 17.9)
6	300 – 400	6.4 – 7.0 (14.3 – 15.7)	600 – 800	8.0 – 8.8 (17.9 – 19.7)
7	400 - 1000	7.0 – 9.4 (15.7 – 21.1)	> 800	8.8-11.9 (19.7-26.6)

Regional boundaries applied in this analysis include the seven independent system operators (ISO) and two non-ISO regions



Sources: AWS Truepower, NREL

Wind Synthetic Inertia: The potential for wind farms to emulate rotational inertia of conventional power plants to stabilize the bulk power system. This could entail programming power inverters attached to wind turbines.

Wind Turbine: Wind energy conversion device that produces electricity by converting the kinetic energy in the wind into mechanical energy and then into electricity by using the mechanical energy to turn an electricity generator. The most common wind turbine in use is horizontal axis one with three blades facing into the wind.

Wires Charge: A broad term referring to fees levied on power suppliers or their customers for the use of the transmission or distribution wires. Typically viewed as a "non-bypassable" charge could be viewed as a tax. A wires charge might be used to recover *stranded investment.* A state that instituted a wires charge might be applied to all electric customers regardless of whether the specific entities (utilities or generating companies) served those customers.

Working Capital: The term generally refers to those rate-base allowances, other than the utility plant in service, and may include material, fuels, supplies, etc. In the narrower use, commonly referred to as cash working capital, it relates to the investor-supplied funds necessary to meet operating expense or going-concern requirements of the business.

Working Gas: Working gas capacity is the amount of gas that is sold to markets and is beyond what may be reserved by the pipeline/operator to maintain system integrity and for load balancing.

Working *(Top Storage)* Gas: The volume of gas in the reservoir that is in addition to the cushion or base gas. It may or may not be completely withdrawn during any particular withdrawal season. Conditions permitting, the total working capacity could be used more than once during any season.

Worst CKAIDI (Circuits with the worst circuit – level Average Interruption Duration Index) Excludable Major Events are not included. Also see the following distribution system reliability indicies:

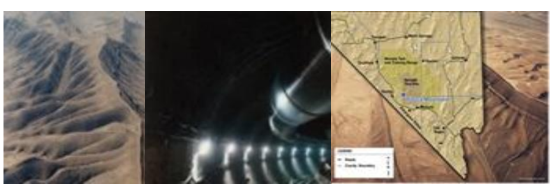
- Average Service Availability Index (ASAI),
- Customer Average Interruption Duration Index (CAIDI).
- System Average Interruption Duration Index (SAIDI),
- SAIFI (System Average Interruption Frequency Index)
- Customer Average Interruption Frequency Index (CAIFI),
- Average Amount of Time Electric Service is Available (ANSI),
- Worst CKAIFI (Circuits with the worst circuit–level Average Interruption Frequency Index),
- CELID-X — customers experiencing longest interruption durations; CELID-8 is the percentage of customers who experienced outages exceeding 8 hours,
- CEMI-X — customers experiencing multiple interruptions; a measure of the percentage of customers who experienced X interruptions,
- CEMMI-X — customers experiencing multiple momentary interruptions; a measure of the percentage of customers who experienced X momentary interruptions, and
- Momentary Average Interruption Frequency Index (MAIFI).
- Worst CKAIFI (Circuits with the worst circuit–level Average Interruption Frequency Index) Major Events are not included.

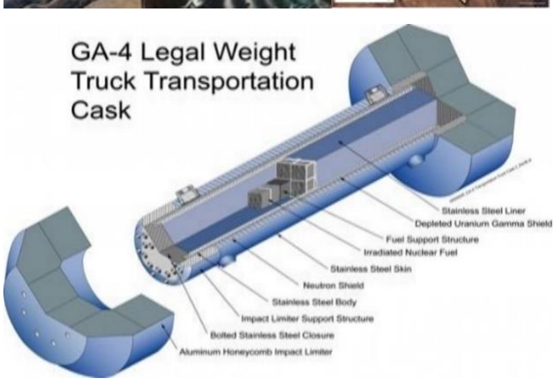
Wye configuration — A way of connecting three-phase electric lines, achieved by connecting three independent transformer windings at a common point.

X, Y, & Z

Yellowcake: A natural uranium concentrate that takes its name from its color and texture. Yellowcake typically contains 70 to 90 percent U_3O_8 (uranium oxide) by weight. It is used as feedstock for uranium fuel enrichment and fuel pellet fabrication.

Yucca Mountain Nuclear Waste Repository (see also Dry Cask Storage and Spent Fuel Pools): Designated by the Nuclear Waste Policy Act amendments of 1987, is to be a deep geological repository for spent nuclear fuel and other high-level radioactive waste. The site is located on federal land adjacent to the Nevada Test Site. The Department of Energy is currently reviewing other options. A Blue Ribbon Commission on America's Nuclear Future released its final report in January 2012. It expressed urgency to find a consolidated, geological repository, and said that any future facility should be developed by a new independent organization with direct access to the Nuclear Waste Fund, which is not subject to political and financial control as is the cabinet department of the Department of Energy. Until such time as a permanent site is available, most nuclear power plants in the United States have resorted to the indefinite on-site dry cask storage.





Zero Crossing Point: The sign of a mathematical function changes (e.g. from positive to negative), represented by an intercept of the axis (zero value) in the graph of the function. It is a commonly used term in electronics and mathematics.

Zero Emissions Credit (ZEC): Some states have implemented ZEC programs that are intended on maintaining nuclear generation by providing subsidies for not producing carbon dioxide emissions. Especially with projections for low natural gas prices and to a lesser extent renewable resources, nuclear power plants may not be able to operate at sufficient levels to recover their capital costs. The Illinois' program, for example, requires electric distribution companies in the state to pay ZECs to carbon-free facilities based on the amount of power they produce. ZEC proponents say the credits provide a crucial lifeline to a zero-carbon form of energy, but critics argue the subsidies distort the competitive power markets (e.g., PJM, MISO) that the FERC oversees. The market distortion issue was addressed in *Hughes v Talen Energy Marketing,* the Supreme Court held that the Maryland program intrudes on the FERC's jurisdiction because it conditioned subsidies based on a nuclear plant's participation in wholesale capacity and energy markets.

Zero Energy Building (ZEB): An energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.

Zero Intercept Method (One Cost of Service Method): The minimum-intercept method seeks to identify that portion of plant related to a hypothetical no-load or zero-intercept situation. This requires considerably more data and calculation than the minimum-system cost of service method. In most instances, it is considered to be more accurate, although the differences may be relatively small. The technique is to relate installed cost to current carrying capacity or demand rating, create a curve for various sizes of the equipment involved, using regression techniques, and extend the curve to a no-load intercept. The cost related to the zero-intercept is the customer component. The following describes the methodologies for determining the minimum intercept for distribution-plant Accounts 364, 65, 366, 367, and 368 (see Minimum System Studies). For example, determine the number, investment, and average installed book cost of distribution poles by height and class of pole. (exclude stub; for guying.), then determine minimum intercept of pole cost by creating a regression equation, relating classes and heights of poles, and using the Class 7 cost intercept for each pole of equal height weighted by the number of poles in each height category, finally, multiply minimum intercept cost by total number of distribution poles to get customer component. ELECTRIC UTILITY COST ALLOCATION MANUAL National Association of Regulatory Utility Commissioners (NARUC), January 1992.

Zero Liquid Discharge (ZLD see also Effluent Limitation Guidelines-ELG and Flue Gas Desulfurization - FGD): ZLDs are a compliance measure to meet the EPA's Effluent Limitation Guidelines and flue gas desulfurization requirements. A ZLD is a wastewater treatment process developed to completely eliminate all liquid discharge from a coal-fired power plant's cooling water system to reduce the volume of wastewater that requires further treatment. Evaporation of those liquid wastes in a zero liquid discharge system produces clean water that is recycled into the plant. The operations of electric generating facilities often produce wastewater containing salts (e.g., such as calcium and ammonium chlorides, and heavy metal salts which may not crystalize through evaporation. Traditionally, particularly in arid climates, natural evaporation of the cooling tower blowdown from holding ponds was cost-effective but it resulted in a permanent loss of water. In April 2017, EPA Administrator Scott Pruitt placed an *administrative stay* on the ELG regulations.

Zero-Sum: In game theory one person's gain is equivalent to another person's loss. As a result, there is no (zero) net change in wealth or benefits.

Z**eroth Law of Thermodynamics: I**f two thermodynamic systems are each in thermal equilibrium with a third, then they are in thermal equilibrium with each other. Accordingly, thermal equilibrium between systems is a transitive relation. Two systems are said to be in the relation of thermal equilibrium if they are linked by a wall permeable only to heat and they do not change over time. Systems are sometimes said to be in a relation of thermal equilibrium if they are not linked so as to be able to transfer heat to each other, but would not do so if they were connected by a wall permeable only to heat.

Zonal Capacity Price: The price charged to an LSE for their unforced capacity obligation in a zone. For PJM, these are based on the results of RPM Auctions for the Delivery Year. MISO also has Zones.

Zonal Transmission Limitations (ZTL): ZTL is equal to the capacity Import/Export Limits Capacity Import Limit (CIL) / Capacity Export Limit (CEL).

Zonal Unforced Capacity Obligation: RTOs / ISOs establish a zone's Reserve Requirement and Unforced Capacity Obligations.

Zones (MISO): *Local Reliability Requirement* LRR) and *Local Resource Zones* (LRZ)

ZONES (PJM)

ZZ-end....End of Industry Terms

Acronyms

A

3V0	Ground Fault (zero sequence) Overvoltage Protection
AAM	Advanced Asset Management
AACE	Association for the Advancement of Cost Engineering
AAQS	Ambient Air Quality Standards
AAR	Ambient Adjusted Ratings
Abs	Absorptance
ABCI	Advanced Batteries for Critical Infrastructure
AC	1. Air Conditioner 2. Alternating Current 3. Asset Class (Asset management Term) 4. Asset Condition (Asset Management Term) 5. Asset Criticality (Asset Management Term) 6. Average Cost
ACE	Area Control Error
	Affordable Clean Energy
ACEEE	American Council for an Energy Efficient Economy
ACESA	American Clean Energy and Security Act of 2009
ACH50	Air changes per hour at 50 pascals (Pa)- A determination of energy efficiency
ACI	Activated Carbon Injection
ACLM	Air Conditioning Load Management
ACOD	Transmission Circuit Outage and Duration
ACOSS	Allocated Cost of Service Study
ACP	Auction Clearing Price
ACR	Avoided Cost Rate
ACRS	Accelerated Cost Recovery System
AD	Administrative Docket (FERC)
ADIT	Accumulated Deferred Income Tax
ADMS	Advanced Distribution Management System
ADO	Advanced Distribution Operations
ADR	Automated Demand Response
	Alternative Dispute Resolution
ADS	Alternative Depreciation System
ADT	Advanced Transmission Operations
AEO	Annual Energy Outlook -U.S. Energy Information Administration (EIA)
AES	Alternative Electric Supplier
AESC	Avoided Energy Supply Component
AFC	Automated Frequency Coordination
AFUDC	Allowance for Funds Used During Construction
AFUE	Annual Fuel Efficiency
AFV	Alternative Fuel Vehicle
AGC	Automatic Generation Control
AGE	Adaptive Generation Resources
AGIR	Authority Governing Interconnection Requirements (NERC)
AH	Available Hours
AHAM	Association of Home Appliance Manufacturers

AHI	Asset Health Index (Asset Management Term)
AHJ	Authority Having Jurisdiction
AHP	Analytic Hierarchy Process
AI	Artificial Intelligence
AICT	Advanced Information and Communications Infrastructure
AIFI	Average Interruption Frequency Index
ALCP	Asset Life Cycle Plan (Asset Management Term)
ALR	Adequate Level of Reliability
ALT	Accelerated Life Testing
AM	Asset Management
AMI	Advanced Metering Infrastructure
AMR	Automated Meter Reading
AMSL	Above Mean Sea Level
AMY	Actual Meteorological Year
ANI	Adjusted Net Interchange
ANL	Argonne National Laboratory
ANM	Active Network Management
ANN	Artificial Neural Network
ANOPR	Advanced Notice of Proposed Rulemaking
ANS	American Nuclear Society
ANSI	American National Standards Institute
AO	Asset Owner
AP	Achievable Potential (generally applied to Energy Efficiency and Demand Response)
APA	Administrative Procedures Act
APC	Adjusted Production Cost
APEX	Internal Continuous Improvement Program
API	American Petroleum Institute
APPA	American Public Power Association
APWR	Advanced Pressurized Water Reactor
AQCR	Air Quality Control Region
ARC	1. Aggregators of Retail Customers 2. Anti-Reflection Coating
ARCH	Autoregressive Conditional Heteroscedasticity
ARCSi	Anti-Reflective Crystalline Silicon
ARI	Asset Risk Index (Asset Management Term)
ARIMA	Autoregressive Integrated Moving Average (statistical modeling technique)
ARL	Average Remaining Life
ARM	Asset Risk Management (Asset Management Term)
ARIMA	Auto Regressive Integrated Moving Average (statistical modeling technique)
ARR	1. Asset Renewal Rate (Asset Management Term) 2. Auction Revenue Rights 3. Automatic Response Rate 4. Ambient Adjusted Ratings (Transmission – compared to static ratings)
ARRA	American Recovery and Reinvestment Act of 2009
ART	Average Run Time
ASAI	Average Service Availability Index
ASC	Accounting Standard Codification
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
ASIDI	Average System Interruption Duration Index (Total Connected kVA served)

ASIFI	Average System Interruption Frequency Index (Total Connected kVA of Load Interrupted)
A/S	Ancillary Services
ASM	Ancillary Services Market
ASTM	American Society for Testing and Materials
ASU	Air Separation Unit
ATB	Annual Technology Baseline (DOE/NREL)
ATC	1. Available Transmission Capability or Capacity 2. Available Transfer Capability 3. Around the Clock
ATO	Advanced Transmission Operations
ATWACC	After Tax Weighted Cost of Capital
AUPC	Average Use Per Customer
Auto DR	Automated Demand Response
AV	Availability Factors
AVE	All Electric Vehicles
AVERT	Avoided Emissions and generation tool (EPA)
AVG	Average or Mean
AVR	Automatic Voltage Regulator

B

BA	1. Balancing Authority or Balancing Area 2. Bottom Ash
BACT	Best Available Control Technology
BANC	Balancing Area of Northern California
BART	Best Available Retrofit Technology
BAS	Building Automation System
BASA	Buy All, Sell All
BAT	Best Available Technology
BAU	Business as Usual (a/k/a Base Case & Reference Case)
Bbl	Barrels (oil)
BPS	Basis Points
BCA	Benefit Cost Analysis
Bcf	Billion Cubic Feet
Bcf/d	Billion Cubic Feet Per Day
BCP	Black Start Capability Plan
BEM	Building Energy Modeling
BES	1. Bulk Electric System 2. Basic Energy Services (DOE's Office of Science)
BESS	Battery Energy Storage System
BEV	Battery Electric Vehicle
BEWT	Built Environment Wind Turbine
BFB	Bubbling Fluidized Bed Reactor
BGSS	Basic Gas Supply Service
BLM	Bureau of Land Management
BLR	Baseline Reliability Projects
BM	Balancing Mechanism
BMP	Best Management Practices
BNEF	Bloomberg New Energy Finance
BNL	Brookhaven National Laboratory

BPD	Barrels Per Day Equivalent
	Building Performance Database
BPL	Broad Band over Power Lines
BPR	Base to Peak Ratio
BPS	Bulk Power System
BPT	1. Benefit–per-Ton 2. Best Practicable Technology
BRA	Base Residual Auction
BRP	Baseline Reliability Projects (MISO)
BSER	Best System of Emissions Reduction
BSM	Building Stock Models (DOE)
BTMs	Behind-the-Meter Storage
BTMG	Behind the Meter Generation
BTMPV	Behind the Meter Photovoltaics
BMO	Building Technology Office
BTU	British Thermal Unit
BWR	Boiling-Water Reactor

C

C&I	Commercial and Industrial
C2M2	Cybersecurity Maturity Mode
CA	Control Area
CAC	Citizens Action Coalition
CA CEUS	California Commercial End-Use Survey
CA RASS	California Residential Appliance Saturation Study
CAA	Clean Air Act – EPA issued initial rules in 1970
CAAA	Clean Air Act Amendments – 1990
CAES	Compressed Air Energy Storage
Café	Corporate Average Fuel Economy
CAGR	Compound Annual Growth Rate
CAIDI	Customer Average Interruption Duration Index (reliability see also SAIDI, and SAIFI)
CAIFI	Customer Average Interruption Frequency Index
CAIR	Clean Air Interstate Rule
CAMR	Clean Air Mercury Rule
CANDU	Canadian Deuterium Uranium Reactor
CapEx	Capital Expenditures
CAPM	Capital Asset Planning Model
CARP	Cost Allocation and Resource Planning
CASIO	California ISO a/k/a California Independent System Operator
CaSPM	California Standard Practice Manual
CATR	Clean Air Transport Rule
CAZ	Cost Allocation Zone (MISO)
CBA	Consolidated Balancing Authority
CBD	Central Business District
CBECS	Commercial Building Energy Consumption Survey
CBI	Confidential Business Information
CBL	Customer Base Line
CBM	Capacity Benefit Margin
CBP	County Business Patterns

CBR	Close by Removal (Coal Combustion Residual rule)
CC	Combined Cycle
CCA	Critical Cyber Assets
CCAs	Community Choice Aggregators
CCCGT	Combined Cycle Combustion Gas Turbine
CCGT	Combined Cycle Gas Turbine
CCHP	Combined Cooling, Heat, and Power
CCP	Capacity Commitment Period
CCR	Coal Combustion Residuals – EPA issued rules June 2010
CCS	Carbon Capture and Sequestration or Carbon Capture and Storage
CCSP	Climate Change Science Program
CCT	Clean Coal Technology
CDC	Cost Duration Curve
CDD	Cooling Degree Days
CDD/HDD	Cooling/Heating Degree Days
CDE	Carbon Dioxide Equivalent
CDF	Cumulative Distribution Functions
CDS	Circulating Dry Scrubber
CDG	Community Distributed Generation
CDIAC	Carbon Dioxide Information Analysis Center (see also Environmental Systems Science)
CEATI	Center for Energy Advancement through Technological Innovation
CEED	Center for Electric End-Use Data (EPRI)
CEI	Climate Extreme Index
CEII	Critical Energy Infrastructure Information
CEIP	Clean Energy Incentive Program (environmental)
CEL	Capacity Exports Limits
CELID	Total Number of customers experiencing more than 8 interruptions in a year
CEM	Capacity Expansion Model
CEMI	Total Customers Experiencing More than n sustained Interruptions
CEMS	Continuous Emission Monitoring Systems
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CETL	Capacity Emergency Transfer Limit
CETO	Capacity Emergency Transfer Objective
CF	Capacity Factor
CFB	Circulating Fluidized Bed Boiler
CFC	Chlorofluorocarbons of Chlorinated Fluorocarbons
CFD	1. Computational Fluid Dynamics 2. Contract for Difference
CFF	Construction Finance Factor
CFL	Compact Fluorescent Lighting
CH_4	Methane
CHP	Combined Heat and Power
CI	1. Confidence Interval 2. Customers Interrupted
CIAC	Contribution in Aid of Construction
CIKR	Critical Infrastructure and Key Resources
CIL	Capacity Imports Limit

CIP	1. Critical Infrastructure Protection 2. Close in Place (see Coal Combustion Residual rule)
CIS	Customer Information System
CIS	Center for Internet Security
CISSP	Certified Information Systems Security Professional
CM	Capacity Margin (see also Reserve Margin and Resource Adequacy)
CMI	Customer Minutes Interrupted
CMVE	Competitive Market Value Estimate
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CO_2 E	Carbon Dioxide Equivalent
COD	Commercial Operation Date
COF	Confidence Interval Equations
COL	Construction and Operating License (NRC)
CONE	Cost of New Entry
COP	Coefficient of Performance
COS	Cost of Service
COSS	Cost of Service Study
Covid19	SarsCovid19 began in the United States in 2019
CP	1. Coincident Peak 2. Capacity Performance – PJM 3. Certificate Proceeding (FERC)
CPCN	Certificate of Public Convenience and Necessity
CP/DRP	Contingency Planning and Disaster Recovery Planning
CPI	Consumer Price Index
CPM	Critical Path Method
CPNodes	Commercial Pricing Nodes
CPP	1. Clean Power Plan–EPA issued draft proposed rules June 2014 - Green House Gasses 2. Critical Peak Pricing
CPS	Control Performance Standard (NERC standards 1 and 2) Cycles Per Second
CPT	Cone Penetration Tests (Coal Combustion Residuals)
CPV	Concentrated Photovoltaic
CPW	Cumulative Present Worth
CR	1. Contingency Reserve (NERC) 2. Capacity Requirement
CRF	Capital Recovery Factor (see also Annual Capital Recovery Factor)
CRO	Control Room Operator
CRPS	Continuous Ranked Probability Score
CRR	Congestion Revenue Rights (CASIO)
CRREQ	Contingency Reserve Requirement
CS	Community Solar
CSA	Coordinated Seasonal Assessments
CSAPR	Cross State Air Pollution Rule – EPA issued rules July 2011
CSC	Convertible Static Compensator
CSE	Cost of Saved Energy
CSP	1. Concentrating Solar Power 2. Curtailment Service Provider 3. Coordinated System Planning
CSPAR	Cross State Air Pollution Rule (EPA July 2011)

CSRP	Commercial System Relief Program (NYISO)
CSS	Critical Spares Strategy (an Asset Management Term)
CT	1. Combustion Turbine 2. Current Transformers
CTR	Capacity Transfer Rights
CTS	Coordinated Transaction Scheduling
CV	Capacity Value
CV (aka COV)	Coefficient of Variation (statistical)
CVR	Conservation Voltage Reduction
CWA	Clean Water Act
CWI	Clean Water Intake Structures – August 2014
CWIP	Construction Work in Progress

D

D_2O	Deuterium Oxide or Heavy Water
D4	Maintenance Derating
DA	1. Distribution Automation and Day Ahead Scheduling 2. Distribution Automation, or Day Ahead Scheduling
DADS	Demand Response Availability Data System
DART	Day-Ahead Real Time System
DAS	Distributed Acoustic Sensing
DBB	Design, Bid, Build
DC	Direct Current
DCF	Discounted Cash Flow
DCFC	Direct Current Fast Charging
DCLM	Direct Control Load Management
DCS	1. Distributed Control System 2. Disturbance Control Standard
DEB	Default Energy Bid (CASIO)
DECs	Decrement Bids (customer bids)
DEIS	Draft Environmental Impact Statement
DELI	Total Distribution Equipment Experiencing Long Outages
DEMI	Length of Interruption by Equipment Type
DER	Distributed Energy Resources (DSM plus, customer-owned resources, including batteries)
DERa	Distributed Energy Resources aggregation
DERMS	Distribution Energy Resource Management System
DES	Distributed Energy Storage
DESS	Distributed Energy Storage System
DF	1. Distribution Factor 2. Diversity Factor 3. Degrees of Freedom
DG	Distributed Generation
dGEN	Distribution Generation Market Demand Model
DGUI	Distributed Generation Unavailability Index
DICE	Direct Injection Carbon Engine
DIR	Dispatchable Intermittent Resources
DLC	Direct Load Control
DLPR	Distribution Load Relief Program (NYISO)
DLR	Dynamic Line Rating (see also Real Time Thermal Rating and Ambient Adjusted Ratings)

DLTS	Deep Level Transient Spectroscopy
DMGC	Dependable Maximum Gross Capability
DMNC	Dependable Maximum Net Capability
DMS	1. Data Management System 2. Distribution Management System
DO	Dissolved Oxygen
DOE	U.S. Department of Energy
DOJ-AD	Department of Justice – Antitrust Division
DP	Dynamic Programming
DPP	Distribution Planning Process
DPR	Digital Protective Relays
DPT	Delivered Price Test (antitrust)
DPV	Distributed Photovoltaic
DR	Demand Response
DR Factor	Demand Response Factor (PJM to calculate Unforced Capacity value)
DR Mod	Demand Response Modification (PJM to track increases / decreases in demand resource
DRIPE	Demand Reduction Induced Price Effect
DRP	Distributed Resource Plan
DRQAT	Demand Response Quick Assessment Tool
DRR	Demand Response Resource
DRV	Demand Reduction Value
DSA	Distribution System Analysis
DSBR	Demand-Side Balancing Reserve
DSC	Debt Service Coverage
DSCADA	Distribution System Supervisory Control and Data Acquisition (dSCADA)
DSCC	Dye Sensitive Solar Cells
DSI	Dry Sorbent Injection
DSIRE	Database of State Incentives for Renewables and Efficiency
DSM	Demand-Side Management (energy efficiency, demand response, all forms of DERs)
DSM	Distribution System Management
DSO	Distribution System Operator
DSP	Distribution Systems Planning
DSPP	Distributed System Platform Provider
DSRP	Distribution System Relief Program
DSSE	Distribution System State Estimation
D Statcom	Distribution Static Synchronous Compensator
D SVC	Distribution Static Var Compensatory
Dth	Dekatherm
DTS	Distributed Temperature Sensing
DVAr	Dynamic VArs Device
DVER	Dispatchable Variable Energy Resources
DWS	Durbin-Watson Statistic

E

EA	Environmental Assessment
EAF	Equivalent Availability Factor
EAS	Energy and Ancillary Services
Eaton	Electric utility/Distribution System Incident Data
EBB	Electronic Bulletin Board

EBIT	Earnings Before Interest and Taxes
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortization
ECA	Energy Cost Adjustment
ECAR	East Central Area Reliability Coordination Agreement
ECCP	Emergency Coordination and Control Plan
FCEV	Fuel Cell Electric Vehicles
ECMPS	Emissions Collection and Monitoring Plan System
ECP	Energy Clearing Price
ECPC	U.S. Economic Classification Policy Committee
ECS	Energy Control System
Ed	Price Elasticity
ED	Economic Dispatch
EDAM	Extended Day Ahead Market (CASIO)
EDC	Electric Distribution Company
EDP	Electric Distribution Planning
EDR	Emergency Demand Response
EDRP	Emergency Demand Response Program
EE	Energy Efficiency
EEA	Energy Emergency Alert
EEFORd	Effective Equivalent Forced Outage Rate demand
EEI	Edison Electric Institute
EEPS	Energy Efficiency Portfolio Standard
EER	Energy Efficiency Rider
EERS	Energy Efficiency Resource Standard
EES	Energy Efficiency Standard
EF	EF energy factor
EFDH	Equivalent Forced Derated Hours
EFDHRS	Equivalent Forced Derated Hours During Reserve Shutdowns
EFLH	Equivalent Full Load Hours
EFOF	Equivalent Forced Outage Factor
EFOH	Equivalent Forced Outage Hours
EFORd	Equivalent Forced Outage Rate demand
EFORd-5	Equivalent Forced Outage Rate demand based on 5 years of data
EFORp	Peak-Period Equivalent Forced Outage Rate Peak
EG	1. Emissions Guidelines 2. Steam Electric Power Generating Effluent Guidelines and Standards
EGR	Enhanced Gas Recovery (natural gas)
EGU	Electric Generating Unit
EHV	Extra High Voltage
EI	1. Eastern Interconnection 2. Energy Intensity (see Unit Energy Consumption)
EIA	Energy Information Administration of the U.S. Department of Energy
EIEA	Energy Improvement and Extension Act of 2008
EIPC	Eastern Interconnection Planning Collaborative
EIS	Environmental Impact Study or Statement
EISA	Energy Independence and Security Act of 2007
E-ISAC	Electricity Information Sharing and Analyses Center
EISPC	Eastern Interconnection States' Planning Council

ELCC	Effective Load Carrying Capability
ELCON	Electric Consumers Resource Council
ELG	1. National Effluent Limitation Guidelines 2. Equal Life Group (Depreciation method)
ELMP	Convex-Hull Pricing (a/k/a Extended LMP)
EM	Electro Magnetic Field
EM&V	Evaluation, Measurement, and Verification
EMCS	Energy Management And Control System
EMDH	Equivalent Maintenance Derated Hours
EMDHRS	Equivalent Maintenance Derated Hours During Reserve Shutdowns
EMF	Electromagnetic Field
EMHSD	Emergency Management and Homeland Security Division
EMOF	Equivalent Maintenance Outage Factor
EMOH	Equivalent Full Maintenance Outage Hours
EMOR	Equivalent Maintenance Outage Rate
EMP	Electromagnetic Pulse
EMPAC	Work Management System
EMPOH	Equivalent Maintenance Partial Outage Hours
EMS	Energy Management System
EMTP	Electromagnetic Transient Program
ENS	Energy Not Supplied
EOH	Equivalent Outage Hours
EOL	End of Life (e.g., transmission or other equipment)
EOP	Emergency Operating Procedure
EP Node	Elemental Pricing Node (based on specific equipment)
EPA	1. Energy Efficiency Potential – assessment methods 2. U.S. Environmental Protection Agency
EPAct	Energy Policy Act 1992 and 2005
EPC	Engineering, Procurement, and Construction Contractor
EPDH	Equivalent Planned Derated Hours
EPDHRS	Equivalent Planned Derated Hours During Reserve Shutdowns
EPOEF	Equivalent Planned Outage Extension Factor
EPOF	Equivalent Planned Outage Factor
EPOH	Equivalent Full Planned Outage Hours
EPOR	Equivalent Planned Outage Rate
EPPOH	Equivalent Planned Partial Outage Hours
EPS	1. Electric Power System 2. Earnings Per Share
ERAG	Eastern Interconnection Reliability Assessment Group
ERC	Emission Rate Credit
ERCOT	Electric Reliability Council of Texas
ERIS	Energy Resource Interconnection Service
ERO	Electric Reliability Organization
ERP	Emergency Restoration Plan
ERPI	Electric Power Research Institute
ERS	Essential Reliability Services (NERC)
ERT	Emergency Response Timing
ERT	Estimated Time of Restoration for Reported Outages

ESA	Endangered Species Act Energy Storage Association
ESCO	Energy Service Company or Efficiency Service Company
ESDH	Equivalent Scheduled Derated Hours
ESEDH	Equivalent Seasonal Derated Hours
ESI	Energy Security Improvements
ESIF	Energy Systems Integration Facility (NREL)
ESOF	Equivalent Scheduled Outage Factor
ESP	1. Electrostatic Precipitator 2. Energy Services Provider
ESR	Energy Storage Resource
ESS	Energy Storage Systems
EUDH	Equivalent Unplanned Derated Hours
EUE	Expected Unserved Energy
EUF	Equivalent Unavailability Factor
EUI	Energy Usage Intensity
EUL	Estimated Useful Life
EULP	End-Use Load Profile
EUOF	Equivalent Unplanned Outage Factor
EUOR	Equivalent Unplanned Outage Rate
EUR	Estimated Ultimate Recovery
EUT	Equipment Under Test
EV	1. Electric Vehicles 2. Expected Value
EWG	Exempt Wholesale Generator
EWR	Energy Waste Reduction (Michigan statute)
EWS	Efficiency increases with Wind and Solar Build-Out

F

FA	1. Failure Analysis (Asset Management Term) 2. Fly Ash
FAC	1. Facility Ratings Standards 2. Fuel Adjustment Clause
FACTS	Flexible Alternative Current Transmission System
FASB	Financial Accounting Standards Board
FBC	Fluidized Bed Combustion
FBR	Fast Breeder Reactor
FCA	1. Forward Capacity Auction 2. Facilities Construction Agreement
FCEV	Fuel Cell Electric Vehicles
FCITC	First Contingency Incremental Transfer Capability (Linear FCITC)
FCL	Fault Current Limiting
FCM	Forward Capacity Market
FCP	Fuel Cell Power
FCV	Fuel Cell Vehicles
FEED	Front End Engineering Design
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission

FF	1. Fabric Filter 2. Full f-Factor
FFE	Firm Flow Entitlements (MISO)
FFL	Firm Flow Limitations (MISO)
FFR	Fast Frequency Response (NERC)
FFV	Flexible Fuel Vehicle
FGD	Flue Gas Desulfurization
FGDT	Fuel Gas Drain Tank
FGMC	Flue Gas Mercury Control
FICS	Flexible Interconnect Capacity Solution
FIP	Federal Implementation Plan (environmental)
FiT	Feed-In Tariff.
FLE	Full Load Equivalent
FLISR	Fault Location, Isolation, and Service Restoration
FLPMA	Federal Land Policy and Management Act
FMOF	Maintenance Outage Factor
FMU	Frequently Mitigated Units
FOB	Free On board
FOF	Forced Outage Factor
FOH	Forced Outage Hours sometimes Full Forced Outage Hours
FOHMY	Outages per hundred miles per year
FOIA	Freedom of Information Act
FOM	Fixed Operating and Maintenance Costs
FOR	Forced Outage Rate
FP	Partial f-Factor
FPA	Federal Power Act (1935 and subsequent amendments)
FPI	Fault Passage Indicators
FPM	Filterable Particulate Matter
FPOH	Forced Partial Outage Hours
FR	Federal Register
FRAP	Fixed Resource Adequacy Plan (MISO)
FRB	Federal Reserve Bank
FRCC	Florida Reliability Coordinating Council
FRM	Forward Reserve Market
FRR	Fixed Resource Requirement
FRT	Frequency Ride Through
FSA	Fuel Security Analysis (ISO NE)
FSS	Fixated Scrubber Sludge (Coal Combustion Residuals)
FTC	Federal Trade Commission
FTE	Full Time Equivalent
FTR	Financial Transmission Rights
FUA	Fuel Use Act
FUCO	Foreign Utility Company
FV	Future Value

G

G&I	Generation and Interchange
G&T	Generation and Transmission

GAAP	Generally Accepted Accounting Principles
GADS	Generation Availability Data System
GAPP	Generally Accepted Accounting Practices
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
GATT	General Agreement of Trade and Tariffs
GCF	Gross Capacity Factor
GDP	Gross Domestic Product
GDS	General Depreciation System
GEB	Grid Interactive Efficient Building
GEFCom	Global Energy Forecasting Competitions in 2012, 2014, 2017…
GET	Grid Enhancing Technologies
GFOV	Ground Fault Over Voltage
GHC	Grid Hosting Capacity
GHG	Green House Gas
GEB	Grid-Interactive Efficient Buildings (DOE)
GHI	Global Horizon Irradiance
GIA	Generator Interconnection Agreement
GIC	Geomagnetic Induced Currents
GIEB	Grid Interactive Efficient Building
GIP	Generator Interconnection Procedures
GIR	Generator Interconnection Requests
GIS	Geographic Information System
GISB	Gas Industry Standards Board (NAESB)
GJ	Gigajoule (1 Mcf ≈ 1 MMBtu = 1 Dth ≈ 1 GJ)
CKT	Circuit
GLDF	Generation-to-Load Distribution Factor
GLT	Generation Limited Transfer
GML	Grid Modernization Laboratory
GMP	Gross Metropolitan Product
GMT	Greenwich Mean Time
GNA	Grid Needs Assessment
GOF	Gross Output Factor
GPM	Gallons Per Minute
GPS	Global Positioning System
GRC	1. Governance, Risk, and Compliance
	2. General Rate Case
GSF	Generation Shift Factor or Generation to Load Distribution Factor
GSP	Gross State Product
GSU	Generator Step-Up transformer
GT	Gas Turbine
GTECH	Geographic Information System
GUI	Graphical User Interface
GVTC	Generation Verification Test Capacity
GW	Gigawatt
GWe	Gigawatt-Electric
GWh	Gigawatt Hour
GWP	Global Warming Potential

H

$H_2 S0_4$	Sulfuric Acid
HAEMP	High Altitude Electromagnetic Pulse
HAN	Home Area Network
HAP	Hazardous Air Pollutant
HAWT	Horizontal-Axis Wind Turbine
HDD	Heating Degree Days
HEATCAP	Heating Capacity
HELE	High Efficiency, Low Emissions Coal-Fired Power Plants
HEMS	Home Energy Management System
HES	Hybrid Energy System
HESS	Hydrogen Energy Storage Systems
HEV	Hybrid Electric Vehicles
HFC	Hydrofluorocarbons
Hg	Mercury
HGL	Hydrocarbon Gas Liquids
HHI	Herfindahl-Hirschman Index
HHV	Higher Heating Value
HID	High Intensity Discharge Lamps
HILF	High Impact Low Frequency Events
HIS	Hyperspectral Imagery
HPC	High Performance Computing
HPS	High Pressure Sodium (e.g., street lights)
HPTC	High Performance Transmission Conductor
HRSG	Heat Recovery Steam Generators
HRTG	High Resistivity Toughened Glass
HSPF	Heating Season Performance Factor
HTS	High-Temperature Superconductor
HVAC HVAC&R	1. Heating, Ventilation, and Air Conditioning 2. High Voltage Alternating Current 3. Heating, Ventilating, Air Conditioning, and Refrigeration
HVDC	High Voltage Direct Current
Hz	Hertz

I

IA	Interconnection Agreement
IAIP	Information Analysis and Infrastructure Protection
IARR	Incremental Auction Revenue Rights (MISO and PJM)
IBC	Internal Bilateral Transaction
ICA	Integrated Capacity Analyis
ICAP	Installed Capacity
ICCP	Internal Control Center Protocol
ICCT	International Council on Clean Transportation analysis
ICE	Internal Combustion Engine Interruption Cost Estimator (DOE)
ICR	Installed Capacity Requirement
ICU	Inverter Charger Unit
IDC	Interchange Distribution Factor

IDER	Integrated Distributed Energy Resource
IDR	Interval Data Recorder (electric meter)
IDSM	Integrated Demand-Side Management
IDSO	Independent Distribution System Operator
IEA	International Energy Agency
IEDs	Intelligent Electronic Devices
IEEE	Institute of Electrical and Electronics Engineers
IEMI	Intentional Electromagnetic Interference
IEN-P	Integrated Energy Network Planning
IEP	Interregional Economic Projects
IFRO	Interconnection Frequency Response Obligations (NERC)
IGBT	Insulated-Gate Bipolar Transistor
IGCC	Integrated Gasification Combined Cycle
IGT	Institute of Gas Technology
IHR	Incremental Heat Rate
ILFA	Incremental Load Flow Approach
ILR	Inverter Loading Ratio
IMM	Independent Market Monitor
INCs	Incremental Offers (resources)
INGAA	Interstate Natural Gas Association of America
IoT	Internet of Things
IOU	Investor-Owned Utility
IPAA	Independent Petroleum Association of America
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Planning Model
IPMVP	International Performance Measures Verification Protocol (energy efficiency)
IPP	Independent Power Producer
IQR	Inter-Quartile Range
IR	Interconnection Request
IRC	1. Instantaneous Reserve Check 2. ISO / RTO Council
IRM	Installed Reserve Margin
IRO	Interconnection Reliability Operations Coordination
IROL	Interconnection Reliability Operating Limit
IRP	Integrated Resource Planning
IRR	Internal Rate of Return
ISAC	Information Sharing and Analysis Center
ISL	In Situ Leach Mining
ISN	Interregional Security Network
ISO	Independent System Operator (see also RTO)
ISO-NE	Independent System Operator-New England
ISS	Interruptible Sales Service
ITC	Investment Tax Credit
ITIL	Information Technology Infrastructure Library
IVARA	Asset Performance Management Systems
IVVC	Integrated Volt / Var Control

J

JCSP	Joint Coordinated System Planning

JIT	Just in Time
JOA	Joint Operating Agreement
JST	Jurisdiction Specific Test

K

KPI	Key Performance Indicators
kV	(Units) kilovolt
kVA	Kilovolt-Ampere
kW	Kilowatt
kWe	Kilowatt Electric
kWh	Kilowatt-Hour

L

LACE	Levelized Avoided Cost of Electricity
LAER	Lowest Achievable Emission Rate
LAES	Liquefied Air Energy Storage
LANL	Los Alamos National Laboratory
LBA	Load Balancing Authority
LB CO2/MWh	Pounds of CO2 per Megawatt-hour
LBNL	Lawrence Berkeley National Laboratory
LBO	Leveraged Buyout
LC	Load Curve
LCC	1. Load Carrying Capacity 2. Line Commutated Converter
LCM	Life Cycle Management
LCO	Limiting Conditions of Operations (NRC)
LCOE	Levelized Cost of Electricity or Energy
LCP	Least Cost Planning
LCR	Locational Capacity Requirement Local Clearing Requirement
LCV	Light Commercial Vehicles
LCSE	Levelized Cost of Saved Energy
LDA	Locational Deliverability Areas
LDC	1. Load Duration Curve 2. Local Distribution Company (primarily natural gas)
LDES	Long Duration Energy Storage
LDEV	Light Duty Electric Vehicle
LDRD	Laboratory Directed Research and Development
LF	1. Load Factor 2. Load Following
LFG	Landfill Gas
LFRT	Low Frequency Ride Through
LFU	Load Forecast Uncertainty
LGIA	Large Generator Interconnection Agreement (FERC)
LHV	Lower Heating Value
LIB	Lithium-ion Battery
LID	Light Induced Degradation
LIDAR	Light Imaging, Detection, and Ranging

LiDR	Light Detecting and Ranging
LiFP	Lithium Iron Phosphate
LIHEAP	Low-Income Home Energy Assistance Program
Li-ion	Lithium-ion Battery
LIO	Lithium Cobalt Oxide Battery
Li-S	Lithium Sulfur Battery
LLR	Largest Loss Reserve
LMH	Nickle-Metal Hybrid Battery
LMI	Low Moderate Income
LMO	Lithium Manganese Oxide Battery
LMP	Locational Marginal Cost Pricing
LMPM	Local Market Power Mitigation (CASIO)
LMR	Load Modifying Resource
LNB	Low NOx Burner
LNBA	Locational Net Benefit Analysis
LNG	Liquefied Natural Gas
LNMC	Lithium Nickel Manganese Cobalt Oxide Battery
LOC	Line of Credit
	Lost Opportunity Cost
LODF	Line Outage Distribution Factor
LOLE	Loss of Load Expectation
LOLEV	Loss of Load Events
LOLH	Loss of Load Hours
LOLP	Loss of Load Probability
LPF	Load Power Factor
LPG	Liquefied Petroleum Gases
LPWA	Low Power Wide Area
LRD	Load Research Data
LRAM	Lost Revenue Adjustment Mechanism
LRR	Local Reliability Requirements
LRRM	Lost Revenue Recovery Mechanism
LRRucap	Local Reliability Requirements Unforced Capacity
LRS	Load Ratio Share
LRZ	Local Resource Zone
LS	Load Shape
LSE	Load Serving Entity
LSF	Load Shift Factor
LSRV	Locational System Relief Value
LTC	Load Tap Changer
LTLF	Long Term Load Forecasting
LTO	Lithium Titanate Battery
LTRA	Long-Term Reliability Assessments
LTS	Low-Temperature Superconductor
LTT	Light-Triggered Thyristor
LVD	Low Voltage Distribution
LVDT	Linear Variable Differential Transformer
LVEP	Low Voltage Economic Project
LVRT	Low Voltage Ride Through

LWR	Light Water Reactor

M

M2M	Market to Market
MAAC	Mid Atlantic Area Council
MACH	Modular Advanced Control for High Voltage Direct Current
MACRS	Modified Accelerated Cost Recovery System
MACT	Maximum Achievable Control Technology
MAIF	Momentary Average Interruption Frequency Index
MAIN	Mid America Interconnection Network
MAOP	Maximum Allowable Operating Pressure
MAPE	Mean Absolute Percentage Error
MARS	Multi-Area Reliability Simulation
MATS	Mercury and Air Toxics Standard
MAUT	Multi-Attribute Utility Theory
MaxGen	Maximum Generation Emergency
MBRA	Market Based Rate Authority (FERC)
MBR	Market Based Rate
MC	Marginal Cost (Incremental Cost)
MCDM	Multi-Criteria Decision Making
MCF	Metric Cubic Foot
MCP	Market Clearing Price
MCS	Marginal Cost of Service
MHDV	Medium and Heavy Duty Vehicles
MDMS	Meter Data Management System
MDQ	Maximum Daily Quantity
MDth	Thousand dekatherms
MDth/d	Thousand dekatherms per day
MEA	Midwest Energy Association
MECS	Manufacturing Energy Consumption Survey
MECT	Module E Capacity Tracking tool (MISO)
MED	Major Event Days (used in reliability analysis)
MEDSIS	Modernizing the Energy Delivery System for Increased Sustainability
MEL	Minimum Export Limit
MEP	Market Efficiency Projects (transmission)
MER	Maximum Efficiency Rate
MFO	Maximum Facility Output
MFV	Modified Fixed Variable rate
MGY	Million Gallons per Year
MILP	Mixed Integer Linear Programming
MinGen	Minimum Generation Emergency
MISO	Midcontinent Independent System Operator
MLR	Multiple Linear Regression
MLR	Multiple Linear Regression (statistical modeling technique)
MMBTU	Million British Thermal Units 3412 BTUs = 1 kWh and 1 MCF of gas = 1 MBTU
MMC	Modular Multilevel Converter
MMSCFD	Million Standard Cubic Feet per Day
MNDC	Maximum Net Dependable Capacity

MNL	Maximum Net Load
MO	Maintenance Outage
MOD	Modeling, Data, and Analysis (Power System Modeling and Analysis -NERC)
MOH	Maintenance Outage Hours
MP	Market Participant
MOPR	Minimum Offer Pricing Rule
MOR	Thirty Minute Operating Reserve
MPCP	Multi-Pollutant Compliance Plan
MPE	Mean Percent Error
MPFCA	Multi Party Facilities Construction Agreement
MPLS	Multiprotocol Label Switching
MPS	Market Potential Study
MRJD	Mean Reverting Jump Diffusion
MRN	Multi-Region National
MRO	Midwest Reliability Organization
MSA	Metropolitan Statistical Area
MSSC	Most of Severe Single Contingency
MT	Metric Ton
MTLA	Marginal Transmission Loss Approach
MTU	Master Terminal Unit
MTEP	Midcontinent ISO Transmission Expansion Planning Study
MTLF	Middle Term Load Forecasting
MVA	1. Mega Volt Ampere 2.Mega Volt Amplifier 3.Multivariate Analysis
MVAr	Megavars
MVP	Multi-Value Projects (transmission for both reliability and economic benefits)
MW	Megawatt
mw	Molecular Weight
MWh	Megawatt hour

N

N_2O	Nitrous Oxide
NAAQS	National Ambient Air Quality Standard – EPA issued rules January 2013
NAESB	North American Energy Standards Board
NAI	Net Area Interchange
NAICS	North American Industry Classification System (formerly SIC Codes)
NAM	Nuclear Asset Management
NARUC	National Association of Regulatory Utility Commissioners
NAS	National Academy of Sciences
NaS	Sodium Sulfur
NATCARB	National Carbon Sequestration Database and Geographic Information System
NCA	Narrowly Constrained Area
NCDC	National Climatic Data System
NCF	Net Capacity Factor
NCP	Non-Coincident Peak Demand
NCPV	National Center for Photovoltaics
NCRA	National Coal Resource Assessment

NDC	Net Dependable (Demonstrated) Capacity
NDR	Non-Dispatchable Resources (NERC)
NDVER	Non-Dispatchable Variable Energy Resources
NE & AS	Net Energy & Ancillary Services offset
NEB	1. Non-Energy Benefits (e.g., from DSM) 2. National Energy Board (Canada)
NEC	National Electric Code
NEEDS	National Electric Energy Data System
NEEM - NEEM &	Model combines the North American Electricity and Environment Model
NEEP	Northeast Energy Efficiency Partnerships
NEM	Net Energy Metering
NEMS	National Energy Modeling System
NEPA	National Environmental Policy Act (EPA – enacted January 1, 1970)
NERC	North American Electric Reliability Corporation (formerly Council)
NESC	National Electric Safety Code
NESHAPs	National Emissions Standards for Hazardous Air Pollutants
NETL	National Energy Technology Laboratory
NFCRC	National Fuel Cell Research Center
NGCC	Natural Gas Combined Cycle
NGL	Natural Gas Liquids
NGPA	Natural Gas Policies Act of 1978
NGPL	Natural Gas Plant Liquids
NGSI	Natural Gas Sustainability Initiative (EEI and AGA to address methane)
NGV	Natural Gas Vehicle
NH_3	Amonia – as used in scrubbers
NHTSA	National Highway Traffic Safety Administration
NID	Net Internal Demand
NIPP	National Infrastructure Protection Plan
NIST	National Institute of Standards and Technology
NITC	Normal Incremental Transfer Capability
NITS	Network Integration Service
NMBE	Normalized Mean Bias Error
NMC	Equivalent Seasonal Net Maximum Capacity
NMS	Network Management Systems
NN	Neural Network
NNL	Native and Network Load
NNSR	Nonattainment New Source Reviews
NOAA	National Oceanic and Atmospheric Administration
NOAK	Next of a Kind or Nth of a Kind
NOF	Net Output Factor
NOI	Net Operating Income
NOM	Nominal
NOx	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NPVRR	Net Present Value of Revenue Requirements
NR	Network Resource
NRC	1. National Research Council 2. Nuclear Regulatory Commission

NRECA	National Rural Electric Cooperatives Association
NREL	National Renewable Energy Laboratory
NRIS	Network Resource Interconnection Service
NRTC	Non Recallable Available Transfer Capability
NS	Network Service
NSCR	Non Selective Catalytic Reduction
NSF	NERC Summary Forecasts
NSI	Net Scheduled Interchange
NSPL	Network Service Peak Load
NSPM	National Standard Practice Manual for Assessing Cost-Effectiveness for EE May 2017
PM	National Standard Practice Manual for Assessing Benefit Cost Analysis for DERs 2020
NSPS	New Source Performance Standard
NSR	New Source Review
NSRDB	National Solar Radiation Data Base
NTA	Non Transmission Alternatives
NTG	Net-to-Gross Ratio
NTTAA	National Technology Transfer and Advancement Act
NUG	Non-Utility Generator
NWA	Non-Wires Alternative
NWPCC	North West Power and Conservation Council
NYISO	New York Independent System Operator
NYMEX	York Mercantile Exchange

O

O&M	Operations and Maintenance Expense
OASIS	Open Access Same Time Information Service (as defined by FERC Order 888 /889)
OATT	Open Access Transmission Tariff
OCD	Original Cost Depreciated
OCGT	Open Cycle Gas Turbine
OCPP	Open Charge Point Protocol
OECD	Organization for Economic Cooperative Development
OEM	Original Equipment Manufacturer
OFA	Over-Fire Air
OFO	Operational Flow Order (natural gas)
OH	Overhead
OLS	Ordinary Least Squares
OLTC	On-Load Tap Changers
OMB	Office of Management and Budget
OMS	1. Organization of MISO States 2. Outage Management System
OPA	Operation Planning Analysis
OPEC	Organization of Petroleum Exporting Countries
OpenADR	Open Automated Demand Response
OPEX	Operations and Maintenance Expenditure
OPGW	Optical Ground Wire
ORD	Operating Reliability Dynamic
ORDC	Operating Reserve Demand Curve
ORM	Operating Reserve Margin

ORNL	Oak Ridge National Laboratory
ORSS	Operating Reliability Steady State
OSM	Office of Surface Mining
OSW	Offshore Wind
OSWinDI	Offshore Wind Innovation and Demonstration Initiative
OTC	1. Operating Transfer Capability 2. Over-the-Counter
OTDF	Outage Transfer Distribution Factor
OTR	Ozone Transport Region
OWT	Off-Shore Wind turbine

P

P	Real Power
PA	Planning Authority (a/k/a Planning Coordinator)
PAC	Programmable Automation Controller
PACE	Internally Developed Prioritization Tool
PAGE	Policy Analysis of the Greenhouse Gas Effect Model
PAM	Partitioning Around Meldoids
PAR	Phase Angle Regulator
PbA	Advanced Lead Acid
PBR	Performance Based Regulation (or Ratemaking)
PC	Pulverized Coal
PCA	Principle Component Analysis
	Paris Climate Accord
PCAF	Peak Capacity Allocation Factor
PCB	Polychlorinated Biphenyl
PCC	Point of Common Coupling
PCT	1. Participant Cost Test (see EM&V) 2. Programmable Communicating Thermostat
PDF	Probability Density Function
PdM	Predictive Maintenance (an Asset Management Term)
PDR	Probability Density Function
	Passive Demand Resources
PF	Power Factor
PFC	Perfluorocarbons
PFR	Primary Frequency Response
PH	Period Hours
PHES	Pumped Heat Electrical Storage
PHEV	Plug-In Hybrid Electric Vehicle
PHFFU	Plant Held for Future Use
PHMSA	Transportation
PI	Historian for storing time series data used in applications such as Asset Management.
PIFUA	Powerplant and Industrial Fuel Use Act of 1978
PILOT	Payment in Lieu of Taxes
PIM	Performance Incentive Mechanisms
PISCC	Post In-Service Carrying Costs
PJM	PJM LLC (Regional Transmission Organization)
PLC	Power Line Carrier

PM	1. Preventative Maintenance (an Asset Management Term) 2. Particulate Matter 3. Peak Load Contributions
PM2.5	Fine Particulate Matter
PMA	Power Marketing Administration
PMU	Phasor Measurement Unit
Pnode	Pricing Node
PNNL	Pacific Northwest National Laboratory
PO	Planned Outages which occur from in-service state only
POA	Principles of Access
PoC	Point of Connection (for DERs)
POD	1.Points of Delivery 2.Power Oscillating Damping
POH	Planned Outage Hours
POI	Point of Interconnection
POLR	Provider of Last Resort – or Default Provider - A term applied to Load Serving Entities in retail competition states.
PONM	Probability of Negative Margin
POR	Points of Receipt
POU	Publically Owned Utilities
PPA	Purchase Power Agreement
PPI	Producer Price Index
Ppm	Parts per Million – Ppb – Parts per billion and Ppt – Parts per trillion
Ppmvd	Parts per million by volume on a dry basis
PQ	Power Quality
PRA	1. Planning Resource Auction (MISO) 2. Paperwork Reduction Act 3. Probabilistic Risk Assessment
PRB	Powder River Basin Coal
PRC	Protection and Control (NERC)
PRD	Price Responsive Demand
PRF	Primary Frequency Response
PRM	Planning Reserve Margin
PRMR	Planning Reserve Margin Requirement
PRMucap	Planning Reserve Margin on UCAP (Unforced Capacity)
PSB	Public Service Board
PSC	Public Service Commission
PSCAD	Power System Computer Aided Design
PSD	Prevention of Significant Deterioration
Psig	Pounds per Square Inch Gauge
PSS	1. Power System Stabilizers 2. Physical Scheduling System
PT	Potential Transformer
PTC	1. Production Tax Credit 2.Price to Compare
PTDF	Power Transfer Distribution Factor
PTH	Period Turbine-Hours
PUC	Public Utilities Commission
PUHCA	The Public Utility Holding Company Act of 1935

PURPA	Public Utility Regulatory Policies Act (1978 and amendments)
PV	1. Photovoltaic 2. Present Value
PVC	Photovoltaic Cell
PVRR	Present Value of Revenue Requirement
PVWatts	Photovoltaic Calculation Tool Developed by NREL
PWR	Pressurized Water Reactor
PX	Power Exchange

Q

Q	Reactive Power
QD	Quantum Dot Solar Technology
QER	Quadrennial Energy Review (Department of Energy)
QF	Qualifying Facility
QP	Queue Position
QSTS	Quasi-Static Time Series
QTU	Qualifying Transmission Upgrade
QUAD	Quadrillion Btu 1015 Btu.

R

R	Correlation Coefficient (see R^2) also a statistical programming language
R^2	R Squared is also referred to as the Coefficient of Determination
RA	1. Reliability Authority (sometimes referred to as Reliability Coordinator) 2. Resource Adequacy (see also Reserve Margin and Capacity Margin)
RAC	Reliability Assessment Commitment
RACI	An Asset Management Term that is usually a form of a matrix
RAN	Resource Availability and Need
RAR	Resource Adequacy Requirements
RAS	Remedial Action Scheme
RASS	Residential Appliance Saturation Survey
RATC	Recallable Available Transmission Capability
RBSA	Residential Building Stock Assessment
RBSAM	Residential Building Stock Assessment Metering
RC	Reliability Coordinator
RCA	Root Cause Analysis
RCC	Resource Contingency Criteria (NERC)
RCIS	Reliability Coordinator Information System
RCO	Resource Carve Out (PJM)
RCRA	Resource Conservation and Recovery Act (CCR- Coal Ash Disposal Regulations)
RCS	Remote Controlled Switches
RE	Renewable Energy
REC	Renewable Energy Credit
RECB	Regional Expansion Criteria and Benefits
RECS	Residential Energy Consumption Survey
REE	Rare Earth Elements
REMC	Rural Electric Cooperative Association
REP	Renewable Energy Production
RES	Renewable Energy Standards
RESA	Retail Electric Suppliers Act

RF	Radio Frequency
RFA	Regulatory Flexibility Act
RFC	Reliability First Corporation
RFP	Request for Proposals
RGGI	Regional Greenhouse Gas Initiative (Northeastern United States)
RI	The Reliability Index
RIA	Regulatory Impact Analysis
RICE	Reciprocating Internal Combustion Engines
RIIA	Renewable Integration Impact Assessment (MISO)
RIM	Rate Payer Impact Measure (see Evaluation, Measurement, &Verification)
RLR	Retail Load Responsibility
RM	Reserve Margin (see also Resource Adequacy and Capacity Margin) Rulemaking (FERC)
RMAG	Regional Mutual Assistance Groups
RMCCP	Regulation Market Capability Clearing Price
RMCP	Regulation Market Clearing Price
RMPCP	Regulation Market Performance Clearing Price
RMR	Reliability Must Run
RMSE	Root Mean Square Error
RNG	Renewable Natural Gas
RO	Reverse Osmosis
ROA	Return on Assets
ROCOF	Rate of Change of Frequency (NERC)
ROE	Return on Equity
ROFR	Right of First Refusal
ROR	Rate of Return
ROW	Rights of Way
RPC	Revenue Per Customer
RPM	Reliability Pricing Model
RPS	Renewable Portfolio Standards
RRaR	Revenue Requirement at Risk
RRM	Reliability Risk Measure (NERC)
rRMSE	Relative Root Mean Square Error
RRO	Regional Reliability Organization (e.g., Reliability First with standards approved by NERC and, ultimately, FERC.)
RSC	Regional State Committee
RSDER	Retail Scale Distributed Energy Resource
RSG	1. Reserve Sharing Group 2. Revenue Sufficiency Guarantee
RSP	Reserve Scarcity Price
RTA	Real Time Analysis
RTC	Real Time Co-Optimization
RTCA	Real Time Contingency Analysis
RTEP	Regional Transmission Expansion Planning
RTG	Regional Transmission Group
RTM	Real-Time Market
RTO	Regional Transmission Organization (Independent System Operator)
RTP	Real Time Pricing

RTTR	Real Time Thermal Rating (see also Dynamic Rating)
RTU	Remote Terminal Unit Roof Top Unit
RTUS / RTWIN	Real-Time Summer and Real-Time Winter resource ratings used for outage coordination
RUM	Reliability Unit Commitment
RUS	Rural Utilities Service (formerly Rural Electrification Administration or REA)

S

S∑	(Six Sigma) An Asset and Project Management term
SAB-CASAC	Science Advisory Board Clean Air Scientific Advisory Committee
SAE	Statistically Adjusted End-Use Model
SAIDI	System Average Interruption Duration Index (reliability-see also SAIDI and CAIDI)
SAIFI	System Average Interruption Frequency Index (reliability-see also SAIDI and CAIDI)
SARI	Circuit Outage Number and Duration
SARs	Standards Authorization Requests (NERC)
SATA	Storage-as-Transmission Assets
SBA	Small Business Administration
SBC	System Benefits Charge
SBS	Sodium Based Sorbents
SC	Shading Coefficient
SCADA	Supervisory Control and Data Acquisition
SCC	Social Cost of Carbon
SCED	Security Constrained Economic Dispatch
SCF	Standard Cubic Feet
SCGT	Simple Cycle Gas Turbine
SCPC	Super Critical Pulverized Coal
SCR	1. Selective Catalytic Reduction (pollution control) 2. Special Case Resources (NYISO) 3. Short Circuit Ratio
SCT	Societal Cost Test
SCUC	Security Constrained Unit Commitment
SD	Standard Deviation (statistical)
SDX	System Data Exchange (NERC) –Communication of outages among Reliability Coordinators
SEDF	Seasonal Derating Factor
SEER	Seasonal Energy Efficiency Rating
SEIA	Solar Energy Industry Association
SEM	Strategic Energy Management
SEPA	Smart Electric Power Alliance
SER	1. Stored Energy Resources 2. Standards Efficiency Review (NERC)
SERVM	Strategic Energy Risk Valuation Model (for loss of load analysis)
SF	1. Service Factor 2. Start-Up Failures
SFC	Secondary Frequency Control
SFEIS	Supplemental Final Environmental Impact Statement
SFT	Simultaneous Feasibility Test
SFVC	Straight-Fixed Variable Cost
SGC	Syngas Clean Up

SGIA	Small Generation Interconnection Agreement (FERC)
SGICH	Smart Grid Information Clearinghouse
SGIP	Small Generator Interconnection Procedures
SGIRM	Smart Grid Interoperability Reference
SH	Service Hours
SHEMS	Smart Home Energy Management System
SHGC	Solar Heat Gain Coefficient
SHP	Separate Heat and Power
SIC	Standard Industrial Classification Code
SIC Code	Standard Industrial Classification Code (replaced by NAICS)
SIL	Simultaneous Transmission Import Limit
SIP	State Implementation Plan (environmental)
SIR	Synchronous Inertial Response (NERC)
SLARC	Single Layer Anti-Reflective Coating
SMCRA	Surface Mining Control and Reclamation Act of 1977
SMD	Standard Market Design
SMR	Small and Modular Nuclear Reactors
SNCR	Selective Non-Catalytic Reduction
SND	Summer Net Dependable rating
SNG	Synthetic Natural Gas
SNL	Sandia National Laboratory
SO_2	Sulfur Dioxide
SO_3	Sulfur Trioxide
SOF	Scheduled Outage Factor
SOH	Scheduled Outage Hours
SOL	System Operating Limits
Solar ABCs	Solar American Board for Codes and Standards
Sol Abs	Solar Absorbance
SPA	Solar Parameter Analysis
SPE	Special Purpose Entity
SATOA	Storage As Transmission Only Assets (MISO)
SPIDERWG	System Planning Impacts of Distributed Energy Resources Working Group (NERC)
SPP	Southwest Power Pool (RTO / ISO)
SPR	Strategic Petroleum Reserve
SPS	Special Protection System / Scheme
SPT	Standard Penetration Tests (Coal Combustion Residuals)
SPV	Special Purpose Vehicle
SR	Starting Reliability
SREC	Solar Renewable Energy Credit
SRM	Spinning Reserve Margin
SSR	1.System Support Resource (MISO)
	2.Sub Synchronous Resonance
STD	Standards Draft Team (NERC)
STE	Short Term Emergency
STLF	Short Term Load Forecasting
STMP	Short Term Market Purchases
STOR	Short Term Operating Reserve
SVC	Static VAR Compensator

T

T&D	Transmission and Distribution
TACS	Total Amount of Equipment that have more than n interruptions in a year
TADS	Transmission Availability Data System
TAG	Technical Assessment Guide (the Electric Power Research Institute – EPRI)
TBEL	Technology Based Effluent Limits
tBtu	Trillion British Thermal Units
TCC	Transmission Constraint Contacts
TCDC	Transmission Constraint Demand Curve
TCF	Trillion Cubic Feet
TCP	Transmission Control Protocol
TCSC	Thyristor Controlled Series Capacitor
TDC	Transmission Delivery Charge
TDF	Transfer Distribution Factor
TDSIC	Transmission, Distribution and Storage System Improvement Charge (Indiana Commission)
TDU	Transmission Dependent Utility
TE	Transactive Energy
TES	Thermal Energy Storage
TFC	Total Flow-Gate Capability
TFP	Total Factor Productivity
TFR	Transmission Formula Rates
Tg	Teragram (one trillion (1012) grams)
TH	Turbine-Hours
THD	Total Harmonic Distortion
THERM	One hundred thousand (100,000) Btu.
THI	Temperature-Humidity Index
TI	Turbulence Intensity
TIER	Times Interest Earned Ratio
TLARC	Triple Layer Anti Reflective Coatings
TLR	Transmission Line Loading Relief
TMEP	Targeted Market Efficiency Project (MISO)
TMNSR	Ten Minute Non-Spinning Reserve
TMOR	Thirty Minute Operating Reserve
TMSR	Ten Minute Spinning Reserve
TMY	Typical Meteorological Year
TO	Transmission Owner
TOD	Time of Day such as Time of Day Rates
TOP	1. Transmission Operations 2. Transmission Operator
TOTEX	Total Expenditure
TOU	Time of Use
TPES	Total Primary Energy Supply
TPL	Transmission System Planning Performance Requirements (NERC Standards)
TPO	Third Party Ownership
TPS	Three Pivotal Suppliers Test (PJM Market Mitigation)
TPY	Tons Per Year
TPZ	Transmission Pricing Zone

TRANSCO	Transmission Company
TRC	Total Resource Cost Test (see Evaluation, Measurement and &Verification)
TRM	1. Transmission Reliability Margin 2. Technical Reference Manual (DSM)
TSD	Technical Support Document
TSEE	Time Sensitive Energy Efficiency
TSI	Total Solar Irradiance
TSO	Transmission System Operator
TSP	Transmission Service Provider
TSR	1. Transmission Service Requests 3. Total Shareholder Return
TSPFA	Time-Series Power Flow Analysis
TSS	Total Suspended Solids (Coal Combustion Residuals)
TSVE	Time Sensitive Value of Efficiency
TTC	Total Transfer Capability
TTN	Technology Transfer Network
TUC	Transmission Usage Charge
TW	Terawatt
TX	Transmission Expansion

U

UA	Thermal Conductance
UC	Unit Commitment
UCAP	Unforced Capacity (the amount of installed capacity that is actually available)
UCED	Unit Commitment Economic Dispatch
UCM	Unobserved Components Model
UCT	Utility Cost Test (see EM&V)
UD	Uninstructed Deviation
UDF	Unit Derating Factor
UDS	Unit Dispatching System
UE	Unit Energy Consumption (see Energy Intensity)
UEC	Unit Electricity Consumption
UESC	Turbulence Intensity
UF	Unavailability Factor
UG	Underground
UFLS	Under-Frequency Load Shedding (NERC)
UH	Unavailable Hours
UHV (AC or DC)	Ultra-High Voltage Alternating Current or Ultra High Voltage Direct Current.
UL	Underwriters Laboratory
ULSD	Ultra-Low Sulfur Diesel Fuel
Ultra SCPC	Ultra-Super Critical Pulverized Coal
UMP	Uniform Methods Project (DOE - Energy Efficiency)
UMRA	Unfunded Mandates Reform Act of 1995
UNFCCC	United Nations Framework Convention on Climate Change
UOF	Unplanned Outage Factor
UOH	Unplanned Outage Hours
UPC	Use Per Customer
UPV	Utility Scale Photovoltaic

UQ	Uncertainty Quantification
URD	Underground Residential Distribution
URRM	Upward Response Reserve Multiplier
USDA	United States Department of Agriculture
USGCRP	U.S. Global Change Research Program
USGS	United States Geological Survey
USOA	Uniform System of Accounts
UTC	Up to Congestion Transactions
Utility MACT	Utility Maximum Achievable Control Technology
UV	Ultraviolet
UVLS	Under Voltage Load Shedding

V

V	Volt
V2G	Vehicle to Grid
VAR	1) Volt Ampere Reactive, Variance 2) Variance 3) Value at Risk
VAWT	Vertical Axis Wind Turbine
VCS	Voluntary Consensus Standard
VDC	Volts of Direct Current
VDER	Value of Distributed Energy Resources (NY)
VEDR	Voluntary Emergency Demand Response
VER	Variable Energy Resources
Vermont TRM	Vermont Technical Reference User Manual
VFD	Variable Frequency Drives
VMT	Vehicle Miles Traveled
VNM	Virtual Net Metering
VOC	Volatile Organic Carbon
VOLL	Value of Lost Load
VOM	Variable Operating and Maintenance Costs
VoS	Value of Solar
VPP	Variable Peak Pricing
VPPs	Virtual Power Plants
VPPA	Virtual Purchased Power Agreement
VRE	Variable Renewable Energy
VRegs	Voltage Regulators
VSC	Voltage Sourced Converters
VSR	Variable Shunt Reactors
VSS	Voltage Support Service
VRT	Voltage Ride Through
VVO	Volt-Var Optimization
VVUQ	Verification, Validation, and Uncertainty Quantification

W

WACC	Weighted Average Cost of Capital
WACOG	Weighted Average Cost of Gas
W_{AC}	Watt Alternating Current
W_{DC}	Watt Direct Current

WECC	Western Electricity Coordinating Council
WECS	Wind Energy Conversion System
WFGD	Wet Flu Gas Desulfurization
WHP	Waste Heat to Power
WLIO	Wet Lime Inhibited Oxidation – used in Flue Gas Desulfurization
WLR	Wholesale Load Responsibility
WMIS	Work Management System
WOTUS	Waters of the United States
WPD	Wind Power Density
WPI	Wholesale Price Index
WQBEL	Water Quality Based Effluent Limits
WSCC	Western States Coordinating Council
WSPP	Western States Power Pool
WSR	Winter to Summer Ratio
WTE	Waste to Energy

X-Y-Z

xEFORd	The Equivalent Forced Outage Rate (demand) subject to exclusion of events outside management control (OMC)
ZCP	Zero Crossing Point
ZCPR	Zero Crossing Point Ratio
ZEA	Zonal Export Ability
ZEC	Zero Emissions Credit
ZEV	Zero Emissions Vehicle
ZIA	Zonal Import Ability
ZSWPRMR	Zone's System Wide Planning Reserve Margin Requirement (forecasted peak + planning reserve)
ZRC	Zonal Resource Credit

THE "PUBLIC INTEREST": WHO HAS A DEFINITION?

September 2017, Scott Hempling, Attorney at Law LCC

Regulatory statutes direct commissions to act in the "public interest." Rarely do statutes, commissions or applicants define the term. Lacking definition, this statutory phrase risks becoming, in utility applications, a label attached to an applicant's desires rather than a discipline on those desires; and in regulatory decisions, a label attached to a commission's preferred outcome rather than principles that produce the right outcome.

Without a common definition we cannot have a common purpose. I suggest defining "public interest" as a composite of five goals: economic efficiency, alignment of shareholder and ratepayer interests, replication of competitive outcomes, respect for legitimate expectations, and diversity among each utility's employees. The first four are entirely conventional, rooted in the elementary economic principles and longstanding regulatory practice. The fifth is an immediate necessity because of our national emergency. All five are mutually consistent and mutually reinforcing.

Economic efficiency: Economic efficiency means biggest bang for the buck. It means no waste. Investors seek the highest return for a given level of risk. Consumers seek the lowest price for a given quality of product. Business managers seek the highest possible output for a given level of input. As long as all bear the costs they cause, these rational actions lead to these results: benefits go to benefit-creators, costs are borne by cost-causers, and rewards repay risks. Each action makes someone better off and no one worse off; no benefit-creating opportunity is foregone.

Alignment of the shareholder and ratepayer interests: Shareholder and ratepayer interests, if legitimate, are not opposites. Shareholders want satisfied customers; customers want healthy companies. In regulating public utilities, the public interest is served when shareholder and ratepayer interests are aligned; that is, when pursuit of the shareholder interest simultaneously advances the consumer interest. That is how competition works: When a market has low entry barriers and no anticompetitive behavior, the most successful businesses have the most satisfied customers.

Replication of competitive outcomes: Economic regulation seeks to replicate the outcomes of effective competition. This goal is necessarily aspirational, because in the real world both competition and regulation are imperfect. Entry barriers, externalities, oligopolistic and monopolistic market structures, customer inertia, and imperfect information make effective competition difficult to achieve, let alone measure so as to replicate. Despite these difficulties, regulation aims to replicate competition because competition, ideally, is objective. It ranks players ruthlessly, based on their merits. Regulation must do the same.

Respect for legitimate expectations: In a competitive market, customers expect products to have the quality and price levels reflecting the best practices of the best competitor. Shareholders expect profit levels consistent with their company's performance for customers. Under regulation, the expectations should be similar. In both competition and regulation, customers have no legitimate expectation of superlative service at bargain-basement prices; investors have no legitimate expectation of superlative returns at below-average risks. In regulation, those legitimate expectations are protected, for shareholders and customers, by regulatory statutes; and for shareholders, by the Constitution's Takings Clause ("nor shall private property be taken without just compensation"). All other expectations are only aspirations; regulators are not bound by them.

The necessity of diversity: Fear, hatred, ignorance and political opportunism, abetted by so many of us lucky enough to look the other way, are soiling our national nest. May this period not last past January 20, 2021. Meanwhile, what is regulation's responsibility?

Utility executives are rightly assessing ways to protect our physical infrastructure from foreign terrorists. They need also to consider less costly protections against domestic terrorists. One way is to make utility personnel—from leadership to lineworkers—look like the populations they serve.

Diversity is not some "add-on," rolled out by merger applicants or rate increase-seekers looking to gain favor with their regulator. Diversity is who we are. Thomas Friedman wrote recently in the New York Times of his trip to Afghanistan with leaders of the U.S. Air Force. The chief is Jewish, his civilian boss a woman, her top aide an African American woman. The base commander and his aide were of Armenian and Lebanese descent; the combat innovation team commander had parents from Cuba and Mexico. Running the control center were two servicemen who had emigrated from Russia and Ukraine; the intelligence briefer was a Captain Yang. America had the region's most powerful force, Friedman writes, because our military "can take all of those different people and make them into a fist." See "Charlottesville, ISIS and Us."

What the Air Force has accomplished, our utilities have not. If diversity is central to success, why is progress by U.S. utilities optional rather than obligatory? In any utility financial report, read the sections on executive compensation plans. They all come from the same playbook: Rewards are based on earnings and share price. What utility board bases executive compensation on diversity? What regulatory commission disallows executive compensation costs, or lowers the authorized return on equity, for failure to create and carry out a plan for diversity?

Three score years after *Brown v. Board of Education*, the lack of progress—in utilities' C-suites, board rooms, management corps and work forces—is inexcusable. It arises from lack of commitment, lack of plans, lack of discipline and lack of regulatory muscle. "Good faith efforts," "outreach," scattered appointments to the vice presidency for community outreach, will not make up for decades of indifference. The pipeline is 15-20 years long—elementary school, middle school, high school, trade school, business school. But the pipeline is there. We need utilities motivated and obligated to fill it—with people who look like the community. And that need is matched by opportunity as thousands of baby boomers retire. We can't fix this overnight. But we can over a decade, if there are annual obligations connected to each of pipeline segment. (For more discussion of diversity, see my essay "Promoting Diversity and Prohibiting Discrimination: Is There a Regulatory Obligation to Society?"

We don't need to make America great again. America is already great, because of its diversity. If our utilities want to be great, they need to start the hard work, the long-term work: the 10-year accountable plans with real executive accountability to commissions prepared to penalize those who fail to progress. Our utilities need to catch up with the customers they are privileged to serve—or have their regulators find companies that will.

Brief Biographies of Pioneers in the Electric Industry

Ampère, Andre-Marie (1775-1836): Discovered wire carrying electric current can attract or repel an adjacent wire that is also carrying electric current. The attraction is magnetic, but no magnets are necessary for the effect to be seen. He went on to formulate Ampere's Law of electromagnetism and produced the best definition of electric current of his time. Ampère also proposed the existence of a particle we now recognize as the electron.

Ayrton, Hertha (1854 -1923): Ms. Aytron was a mathematician, physicist and inventor, and suffragette. In 1895, Hertha Ayrton wrote a series of articles for *the Electrician*, explaining that electric arcs were the result of oxygen coming into contact with the carbon rods used to create the arc. In 1899, she was the first woman ever to read her own paper- "The Hissing of the Electric Arc" - before the Institution of Electrical Engineers (IEE). Ms. Ayrton was elected the first female member of the IEE; the next woman to be admitted to the IEE was in 1958. She petitioned to present a paper before the Royal Society but was not allowed because of her sex and "The Mechanism of the Electric Arc." Ayrton was also the first woman to win a prize from the Society, the Hughes Medal, awarded to her in 1906 in honor of her research.

Babbage, Charles (1791-1871): Considered by some to be a "father of the computer," Babbage is credited with inventing the first mechanical computer that eventually led to more complex electronic designs. Reference to Lagrange in calculus terms marks out the application of what are now called formal power series. British mathematicians had used them from about 1730 to 1760. As re-introduced, they were not simply applied as notations in differential calculus. They opened up the fields of functional equations (including the difference equations fundamental to the difference engine) and operator (D-module) methods for differential equations.

Bardeen, John (1908-1991): Twice awarded the Noble Prize but particularly noted for the invention of the transistor.

Clark, Edith (1883-1959): The first female electrical engineer and the first female professor of electrical engineering at the University of Texas at Austin. She specialized in electrical power system analysis and wrote Circuit Analysis of A-C Power Systems.

Conwell, Esther (1923-2014): Esther Marley Conwell was an American chemist and physicist who studied properties of semiconductors and organic conductors, especially transport. Ms. Conwell's work elucidating how electrons travel through semiconductors helped revolutionize modern computing.

Coulomb, Charles-Augustine de (1736-1806): Formulated Coulomb's law, that the force between two electrical charges is proportional to the product of the charges and inversely proportional to the square of the distance between them. Coulombic force is a factor in atomic reactions.

Curie, Pierre (1859–1906): Shared the Noble Prize with his wife Marie Curie in 1903 for their discovery of radium and polonium in their investigation of radioactivity. Curie was a pioneer in crystallography, magnetism, and piezoelectricity. discovered the existence of transitions among the three types of magnetism specifically ferromagnetism, paramagnetism, and diamagnetism). In order to measure the magnetic coefficients, Curie constructed a torsion balance that measured 0.01 mg, which is still used and called the Curie balance. Curie's Law states that magnetic coefficients of attraction of paramagnetic bodies vary in inverse proportion to the absolute temperature. He then established an analogy between paramagnetic bodies and perfect gases and, as a result of this, between ferromagnetic bodies and condensed fluids.

Descartes, Rene (1596-1650): "I think therefore I am." Descartes developed Cartesian or analytic geometry. Cartesian geometry uses algebra to describe geometry. His work on algebra was influential in the later work of Isaac Newton (on calculus and cubic equations) and Gottfried Leibniz (infinitesimal calculus).

Dirac, Paul Adrian Maurice (1902-1984): Noted for his contribution to quantum mechanics and quantum electrodynamics. The Dirac Equation which explained the behavior of electrons and postulated the existence of antimatter. In Dirac's exposition of electrodynamics using the Lagrangian formulation of quantum mechanics to account for the creation and annihilation of photons of light within atoms. Dirac also demonstrated that quantization of electric charge occurs naturally if a magnetic monopole exists in the universe.

Edison, Thomas Alva (1847-1931): Thomas Alva Edison exerted a tremendous influence on modern life, contributing inventions such as the incandescent light bulb, the phonograph, and the motion picture camera, as well as improving the telegraph (i.e., innovation of the quadruplex for sending four simultaneous telegraph messages simultaneously) and telephone. In his 84 years, he acquired an astounding 1,093 patents.

Faraday, Michael (1791-1867): Contributions to electromagnetism and electro-chemistry. In 1831, Faraday discovered electromagnetic induction, the principle behind the electric transformer and generator. This discovery was crucial in allowing electricity to be transformed from a curiosity into a powerful new technology. During the remainder of the decade he worked on developing his ideas about electricity. He was partly responsible for coining many familiar words including 'electrode', 'cathode' and 'ion'.

Ferraris, Galileo (1847-1897): A prominent engineer in the development of the alternating current (AC) power system and inventor of the three-phase induction motor which is the principal device for the conversion of electric power to mechanical power.

Fleming, John Ambrose (1849-1945): Fleming's invention of the thermionic valve allowing electric current to flow in one direction only (a diode) which could convert alternating current to direct current (a rectifier). His invention of the vacuum tube was the foundation of modern electronics which helped to enable television. Fleming's invention of the diode advanced wireless electronics technology.

Fourier, Jean Baptiste Joseph (1768-1830): Constructed the mathematics of Fourier Transformation and Fourier's Law for applications involving heat transfer (based on Sir Isaac Newton's law of cooling) and vibrations. Fourier calculated that some discontinuous functions are the sum of infinite series.

Franklin, Benjamin (1706-1790): Franklin built an electric battery using glass and thin lead plates. It was Franklin that was credited with naming "positive" and "negative" charge and "charging" and "discharging" to describe electricity – the Principle of Conservation of electricity. The kite experiment to demonstrate that the air and clouds carried electricity and lightning and electricity were synonymous. Franklin also invented the lightning rod, the Franklin stove for more efficient home heating, bifocal glasses.

Galvani, Luigi (1737-1798): Recognized for his work in bioelectricity which contributed to the later work on the voltaic pile. .

Gauss, Carl Friedrich (1777-1855): Primarily noted for his contributions to mathematics, Gauss also made significant contributions to electricity, magnetism, statistics, optics, astronomy, and surveying. Gauss and Wilhelm Weber discovered how voltage and current are distributed in the branches of electric circuits (voltage is governed by the law of conservation of energy and current by the law of conservation of charge). This became Gauss's law. and Gauss's law of magnetism states that magnetic monopoles do not exist. Gauss also carried out experiments whose results allowed him to define the earth's magnetic field using units of millimeters, grams, and seconds. In other words he showed the earth's magnetic field can be defined using purely mechanical dimensions – mass, length, and time.

Gilbert, William (1544-1603): Considered to be the father of electricity and magnetism. Using a spherical magnetic lodestone and a freely moving needle, he observed that magnetic forces often produced circular motions. He connected the phenomenon of magnetism to the rotation of the earth and the earth's magnetism. This served as the theoretical foundation for geomagnetism. He discovered it was possible to create magnets from ordinary metals by rubbing them with a magnet and to strengthen magnets. He also observed that magnets lost their power when exposed to extremely high temperatures.

Heavised, Oliver (1850-1925): Invented mathematical techniques for the solution of differential equations (equivalent to Laplace transforms), reformulated Maxwell's field equations in terms of electric and magnetic electric and magnetic forces and en ergy flux, and independently co-formulated vector analysis.

Henry, Joseph (1797-1878): Joseph Henry and Michael Faraday might be regarded as the founding fathers of the electric industry.

Contributing to the development of electric motors, generators, transformers, radio and the telegraph all function on electromagnetic principles discovered by these men. The world of physics and electronics now uses the scientific unit "Henry" (H) to measure inductance.

Hertz, Heinrich Rudolf (1857-1894): The concept of frequency attaches to his name. Hertz built on the mathematical work of James Clerk Maxwell. Hertz proved the existence of electromagnetic waves. His work in electrodynamics served as a foundation for modern uses of light - electromagnetic waves. Hertz also discovered radio waves. James Ambrose Fleming was able to amplify radio waves.

Insull, Samuel (1859-1938): Expanded the electric industry to vast regions of the United States. His electric utilities' monopolies in 32 states were the basis for the Monopoly game's mustachioed character. At the direction of Thomas Edison, Insull managed General Electric. In 1892, Insull located in Chicago and began his acquisition of generating units and buy-out of his competitors. He constructed the Harrison Street Station that was, at the time, the largest electric generating facility in the world. Insull, implicitly recognized economies of scale and declining marginal and average costs which enabled him to continually lower electric rates. At a time when electricity was considered a luxury that could only be afforded by the wealthiest, Insull encouraged off-peak (non-evening) usage by having much lower rates during the day. Those that used electricity primarily in the evening hours paid for lower rates during the day which enabled businesses and others to pay for electric service. Insull's companies also installed the wiring and even gave away some appliances to increase electric use. He purchased railways as a means of expanding his electric service territories.


To pay for expansion, Insull sold low-price bonds and stock. Over a million middle-class Americans bought in -- but their investments were made worthless by the Great Depression. Overnight, Insull went from a hero on the cover of *Time* magazine to the villain who had stolen the people's money. In 1932, he owed $16 million dollars more than his worth -- "too broke to be bankrupt," according to one banker. Charged with fraud, Insull was tried in 1934 and acquitted of the charges. The collapse of the Insull empire was a major factor in the enactment of the Public Utility Holding Company Act.

Joule, James Prescott (1818-1889): Joule made significant contributions to knowledge of electricity (Joule's Law) and thermodynamics. Joule's law described electric heating by saying the amount of heat produced each second in a conductor by a current of electricity is proportional to the resistance of a conductor and to the square of the current. The unit for this is joule, equal to one Watt-second.

Kahn, Alfred (1917-2010): Wrote extensively on utilities and the public interest where he advocated for marginal cost pricing of electricity and telecommunications. He was an architect of selective deregulation to dismantle anti-consumer cartels that were sustained by government regulation (e.g., The Airline Deregulation Act of 1978 which led to deregulation of interstate trucking and natural gas production and transport, railroads). Dr. Kahn wrote several books including *The Economics of Regulation: Principles and Institutions, Lessons from Deregulation.* Dr. Kahn said his one regret about airline deregulation was his failure to recognize the development of "fortress hubs" that prevented significant competition.

Kilby, Jack (1923-2005): Kilby's primary contribution to electric systems was the development of a practical solution to replace the vacuum tube as a switch or amplifier for controlling the flow of electrons. Bell Labs successfully used semiconductor materials to create the transistor in 1956. Kilby's Noble Prize in physics in 2000 was for the transistor. many transistors, resistors, and capacitors could be grouped on a single board of semiconductor material. The integrated circuit, or microchip, came to be a vital component in computers and other electronic equipment. The rapid development of electronic computer technology started at Texas instruments in the summer of 1958. Kilby's notebook has the first diagram of an integrated circuit where all components were made of the same material. The integrated circuit concept was accepted around 1960 and many applications followed, beginning with the pocket calculator in 1964. Since then, development has been rapid, following Moore's law, where the number of integrated circuits on a chip doubles every 18 months.

Kirchoff, Gustav Robert (1824-1887): In 1845 Kirchhoff first announced Kirchhoff's laws, which allow calculation of the currents, voltages, and resistances of electrical networks. Extending the theory of the German physicist Georg Simon Ohm, he generalized the equations describing current flow to the case of electrical conductors in three dimensions. In further studies he demonstrated that current flows through a conductor at the speed of light.

Lagrange, Joesph-Louis (1736-1813): Lagrange was one of the creators of the calculus of variations, deriving the Euler–Lagrange equations for extrema of functionals. He also extended the method to take into account possible constraints, arriving at the method of Lagrange multipliers. Lagrange invented the method of solving differential equations known as variation of parameters, applied differential calculus to the theory of probabilities. His treatise *Theorie des fonctions analytiques* laid some of the foundations of group theory. In calculus, Lagrange developed a novel approach to interpolation and Taylor series. In 1772, he found the special-case solutions to this problem that yield what are now known as Lagrangian points. He is best known for his work on mechanics, where he transformed Newtonian mechanics into a branch of analysis, Lagrangian mechanics as it is now called, and presented the so-called mechanical "principles" as simple results of the variational calculus.

Laplace, Pierre-Simon, Marquis de (1749-1827): His work in improving upon differential equations, building on the work of Lagrange, and advances in probability theory were significant.

Latimer, Lewis (1848-1928): Noted for his longer-lasting filament for the electric light. He also helped Alexander Graham Bell obtain the patent for the telephone.

Leclanché, Georges (1839-1882): Inventor of the Leclanché Cell for batteries which was the basis for the dry cell battery.

Lenz, Heinrich Friedrich Emil (1804-1865): Noted for his work in electromagnetism, Lenz's Law, based on the work of Michael Faraday, demonstrated that when electricity is generated by a changing magnetic field, the magnetic field generated by that electrical current opposes the magnetic field that generated the current. This is the Law of Conservation of Energy.

Maxwell, James Clerk (1831-1879): Clerk's research in electromagnetic radiation united the sciences of electricity, magnetism and optics. Electricity flows through many metals because of the movement of electrons amongst the atoms of the metal. Moving electrons also produce a magnetic field, the strength of which depends on the number of moving electrons. Maxwell also combined the electric and magnetic fields articulated by Gauss into a single, unified electromagnetic field in 1864.

Moivre, Abraham de (1667–1754): A pioneer in the development of analytic trigonometry and in the theory of probability. The 1756 edition of *The Doctrine of Chance* contained what is probably de Moivre's most significant contribution to this area, namely the approximation to the binomial distribution by the normal distribution in the case of a large number of trials.

Newton, Isaac (1643-1727): Sir Isaac Newton's theories on light, calculus and celestial mechanics significantly transformed math and physics but his most significant contribution may be the development of the "scientific method." Years of research culminated with the 1687 publication of "Principia" which established the three lows of motion and the law of universal gravity.

Nicholson, William and Anthony Carlisle (1753-1815): Used a voltaic pile to decompose water into hydrogen and oxygen that resulted in electrolysis.

Norris, George W, Senator (1861-1944): The Senator of Nebraska led the New Deal effort to establish the Tennessee Valley Authority promoting public power, rural development, and jobs during the depth of the depression.

Ohm, Gerog Simon (1789-1854): The physical unit of electrical resistance, the Ohm (symbol: Ω), was named after him. Ohm determined that the flow of current through a conductor is directly proportionate to the potential difference (voltage) and inversely proportional to the resistance.

Orsted, Hans Christian (1777-1851): Orsted discovered the link between electricity and magnetism. By experimentation with an electric current flowing through a wire, he could move a nearby magnet. This discovery of electromagnetism led to the eventual development of our electric systems.

Siemens, Ernst Werner (1816-1892): The pioneer of the electro industry and brought about a great technological advancement with many of his discoveries. He invented the pointer telegraph and he independently discovered the dynamo-electrical principle.

Steinmetz, Charles Proteus (1865-1923): Steinmetz was a mathematician and an electrical engineer recognized for his development of alternating current that made possible the expansion of the electric power industry in the United States, formulating mathematical theories for engineers. Steinmetz made ground-breaking discoveries in the understanding of hysteresis (for example magnetic induction lags behind the magnetizing force) that enabled engineers to design improved electromagnetic equipment including especially electric motors for use in industry. Steinmetz held over 200 patents and developer of the Steinmetz's equation, Steinmetz solids, Steinmetz curves, and Steinmetz equivalent circuit.

Thevenin, Leon Charles (1857-1926): In 1882, Thevenin became interested in measurement in electrical circuits. As a result of studying Kirchhoff's circuit laws and Ohm's law, he developed his famous theorem, Thévenin's theorem, which made it possible to calculate currents in more complex electrical circuits and allowing people to reduce complex circuits into simpler circuits called Thévenin's equivalent circuits.

Tesla, Nikola (1856-1943): Tesla discovered and patented the rotating magnetic field, the basis of most alternating-current machinery. He also developed the three-phase system of electric power transmission. Tesla sold the patent rights to his system of alternating-current dynamos, transformers, and motors to George Westinghouse. Westinghouse used Tesla's alternating current system to light the World's Columbian Exposition at Chicago in 1893. This success was a factor in their winning the contract to install the first power machinery at Niagara Falls, which bore Tesla's name and patent numbers. The project carried power to Buffalo by 1896. 1900, Tesla made what he regarded as his most important discovery—terrestrial stationary waves. By this discovery he proved that Earth could be used as a conductor and made to resonate at a certain electrical frequency. He also lit 200 lamps without wires from a distance of 40 km (25 miles) and created man-made lightning, producing flashes measuring 41 meters (135 feet). In 1898 Tesla announced his invention of a teleautomatic boat guided by remote control. In 1891 he invented the Tesla coil, an induction coil widely used in radio technology. Tesla's research was the foundation for Generation 5 (G-5). He theorized that electricity could be transmitted wirelessly through the air at long distances, perhaps via a series of strategically positioned towers.

Volta, Alessandro (1745-1827): Italian physicist whose invention of the electric battery and the electrochemical cell provided the first source of continuous current. The term "volt" was in honor of Volta.

Watt, James (1736-1819): Because of Watt's contributions to science and industry, the watt, the unit of power in the International System of Units (SI) equal to one joule of work performed per second (or $^1/_{746}$ horsepower), was named for him. Watt's improvement of the efficiency of the steam engine and played a considerable role in advancing the role of steam engines during the Industrial Revolution.

Weber, Wilhelm Eduard (1804-1891): Researching magnetism with the great mathematician and astronomer Karl Friedrich Gauss in the 1830s, German physicist Wilhelm Weber developed and enhanced a variety of devices for sensitively detecting and measuring magnetic fields and electrical currents.

Westinghouse, George (1846-1914): Primarily noted for his development and commercialization of alternating current. Westinghouse had more than 100 patents. His first patent was for the rotary steam engine. Famous for his building of the Niagara Falls hydroelectric facility and his rivalry with Thomas Edison.

Wheatstone, Charles (1802-1875): The Wheatstone bridge, a device that accurately measured electrical resistance and became widely used in laboratories.