Committee on Energy Resources and the Environment

Microgrids: Policy Pathway for Progress

NARUC Summer Policy Summit

Products, Services, and Regulations Moving Up and Down the “Energy Ladder”

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Microgrids: Policy Pathways for Progress

Committee on Energy Resources and the Environment
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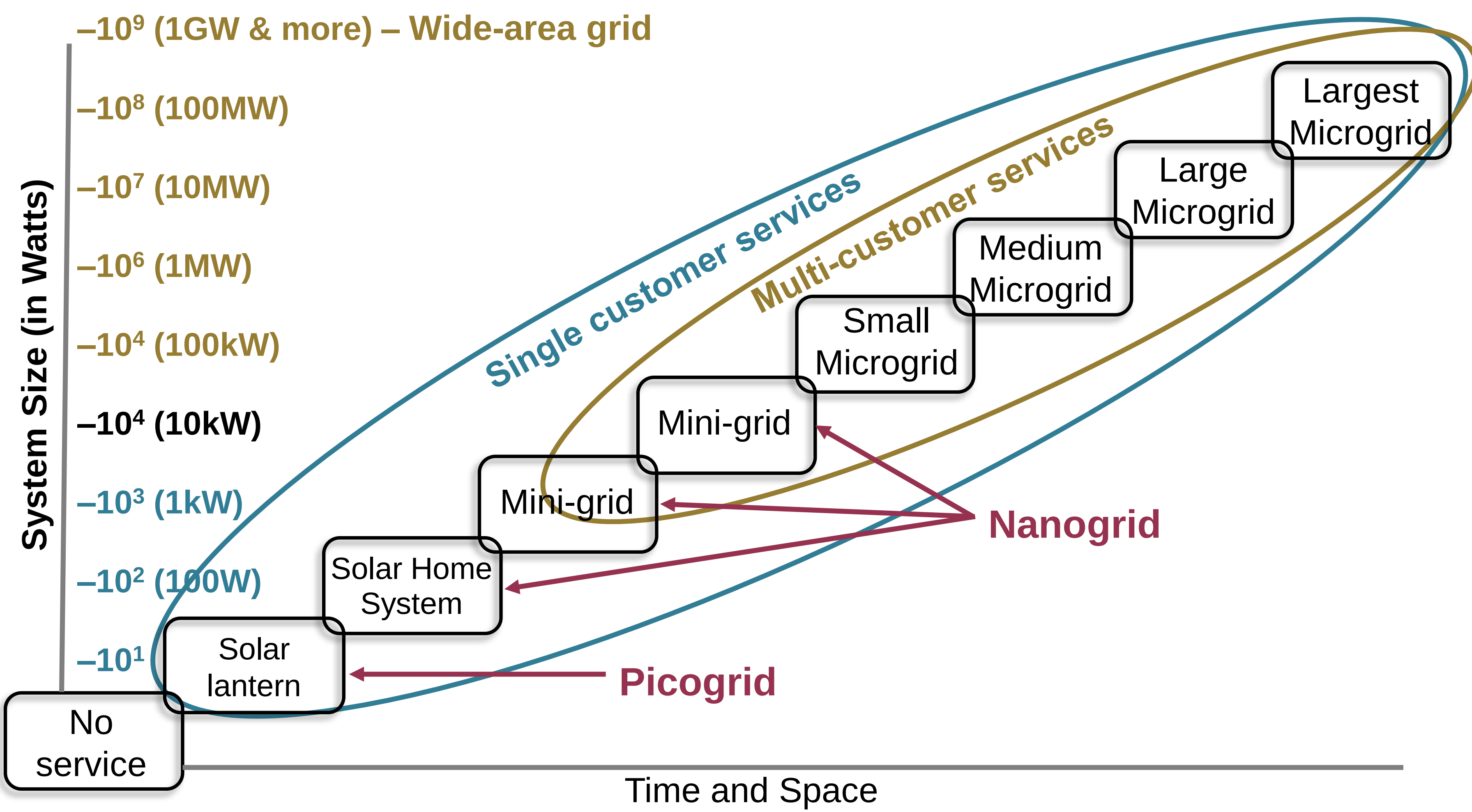
Regulating Energy Ladder Products and Services

- What is the ‘Energy Ladder’ and how does it apply, both to areas with and without any existing grid?
- Why now? What’s new and different today – for utilities, for customers, and for the technologies themselves – that makes this discussion relevant?
- Possible utility and regulatory roles for stand-alone (off-grid), on-grid, and dual use products and services
- Identifying regulatory and institutional barriers & breakthroughs, and if necessary opening up energy ladder development pathways

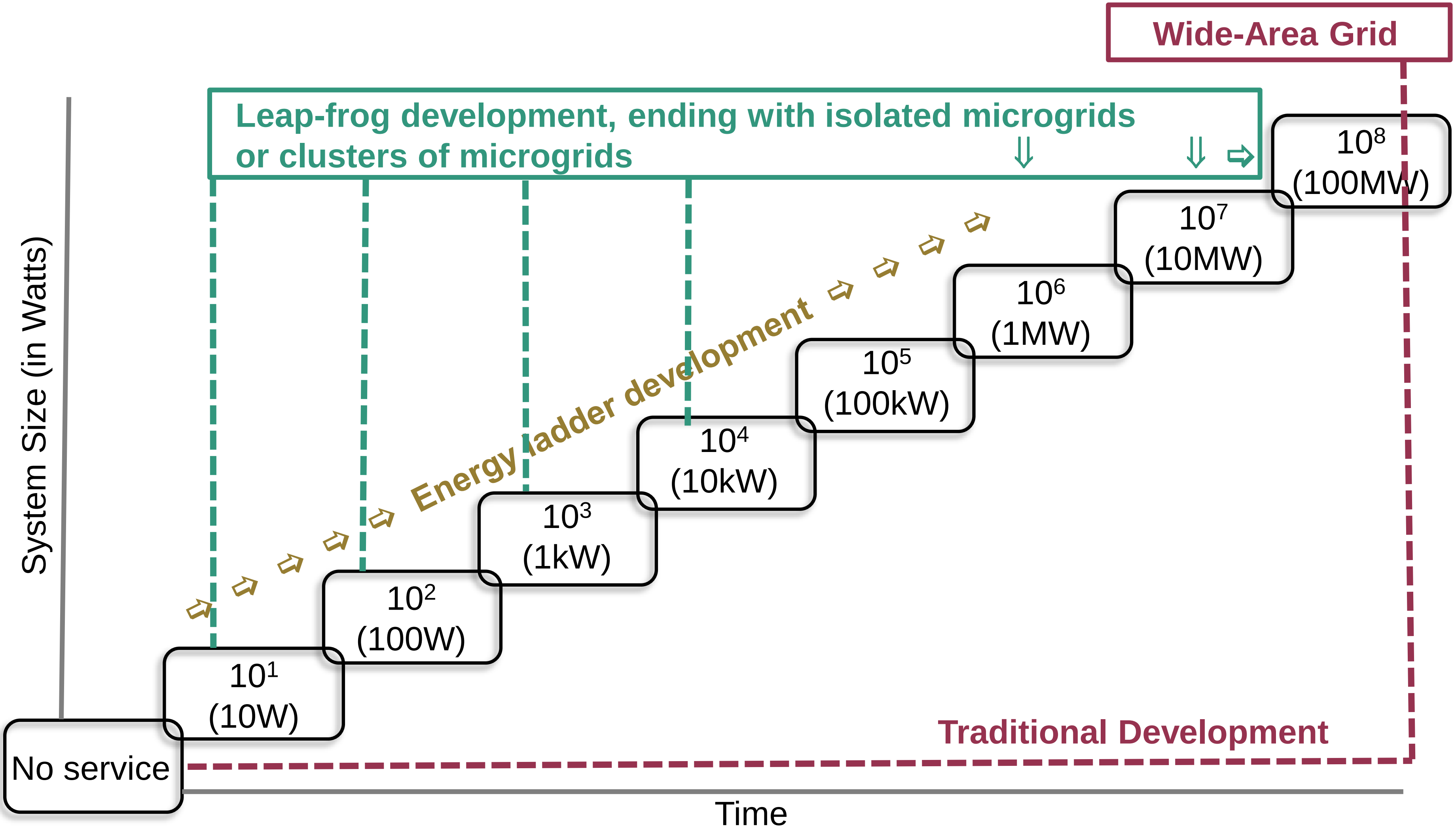
Heading up or down the energy ladder…
Possible steps to an energizing future



The same 'energy ladder' steps, with or without a pre-existing grid

- Individual loads served by stand-alone (off-grid) or dual-use (on- or off-grid) equipment, for high reliability and portability
- Remote facilities – long-distance wires and small loads
- Mini-grids with redundant supplies and back-up service, for critical power needs
- Public-purpose microgrids for emergency response functions and services
- Campus-wide microgrids for high reliability and resilience

Possible energy ladder progress via leap-frog advancement



Big picture ideas for 'energy ladder' conditions and considerations

- World Bank (2017b, p. xii) states: "Both grid and off-grid approaches will be critical, but they will have to be supported by a conducive **enabling environment of the right institutions, policies, strategic planning, regulations, and incentives**." The two approaches [grid and off-grid] can and should be complementary, including long-term plans for transforming off-grid and mini-grid systems, when the time comes, by absorbing and consolidating them into larger distribution grid systems.
- Energy ladder products and services should be fully **compatible with one another, and scalable, so that they integrate seamlessly** with either single or multiple microgrids or with a wide-area grid (Stanton, in press)

The changing U.S. utility landscape

- Aging, brittle infrastructures (energy & water), prone to breakdown, expensive repairs, massive replacement costs
- More natural disasters resulting in long-term outages and billion-dollar damages
- Large grid-modernization expenditures
- Environmental pressures, both pushes from regulators and pulls from customers
- Flat or declining utility load & revenues
- Proliferating, cost-effective utility and customer DER options that can produce and deliver multiple benefits
- Growing importance of the food/energy/water nexus
- Changing consumer needs and choices for clean energy, power quality, reliability, and resiliency

What's new and different for customers?

- Major world-wide efforts to bring basic energy services to everyone – "Sustainable Energy for All"
- Changing consumer choices and customer needs for 21st Century power sources, quality, reliability, resilience
- Consumers evolving into prosumers
- Increasing numbers of wide-scale weather-related outages
- Increasing electrification and the use of electricity for mission-critical applications
- A granular view of reliability and resilience, all the way to individual facilities, circuits, and even devices
- Increasing choices for portable power

What's new and different for energy ladder technologies?

- Growth in practical, cost-effective technologies at any scale, including solar plus batteries, plus a dozen other DER options
- Emerging DC equipment standards at every scale, from USB-3 to 12Volts, 24V, 48V, and on up to 384V for commercial buildings
- Innovative financing, including pay-as-you-go
- Massive, growing experience with off-grid systems and services – large and growing markets in remote and rural areas

Pico- and Nano-Solar Market

Market estimates:

- $20 billion (USD) cumulative market 2017-2022
- 25% compound annual growth rate

Source: small excerpt from Global Off-Grid Lighting Association (GOGLA), *Off-grid Solar Market Trends Report 2018.* www.gogla.org

Top energy ladder opportunities where wide-area-grids already exist

- Customers want ultra-high reliability and resilience for some end uses or facilities, including public purpose microgrids for critical needs facilities (e.g., transportation, medical care)
- Sometimes and for some uses, customers value portability and remote, off-grid usage
- Non-wire alternatives can be fully cost-effective
- Electric vehicles will present multiple opportunities, including vehicle-to-grid and second-life batteries
- Increased self-reliance and resilience for different kinds of campuses, and commercial or industrial parks
- Bonuses from special government support policies for selected technologies

Top energy ladder barriers where wide-area-grids already exist

- Rules for monopolies versus third-party providers
- Rules and regulations for private wires and self-generation, including added utility charges for B.Y.O. distributed generation
- Incomplete understanding of the full benefits and costs of DER
- Poorly designed standby and backup rates
- Poorly designed compensation for energy outflow
- Few if any pathways for monetizing ancillary services
- Anti-islanding interconnection rules
- Outmoded centralized-power models for IRP and DSP
- Obstacles in financing, insurance, building and fire codes, tax rules
- Lack of consumer awareness of choices and opportunities

NRRI energy ladder research next steps

- Continue describing sound regulatory approaches and incentives for each step in the ladder, in multiple development scenarios, e.g.:
  - led by regulated utilities or provided by competitive suppliers and markets
  - in areas both with and without pre-existing wide-area grids
  - for multiple scales of technologies that operate in one or more of three modes, stand-alone (off-grid), grid-connected, or dual-use
- Case study reports of multiple development scenarios, documenting experiences with several steps up and down the energy ladder

Energy ladder regulatory challenges for areas with a pre-existing grid

- Roles for regulated utilities versus competitive service providers
- Interconnection technical standards, rules and procedures that enable any practical and safe operations, including intentional islanding
- Product and service quality assurance and quality control
- Full compatibility for products and services up and down the energy ladder
- Rates and tariffs for partial requirements service accounting for both benefits and costs
- Considering rules enabling mini- and micro-grids:
  - for single customer facilities and campuses;
  - for public-purposes; and,
  - for multi-customer facilities and campuses

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Values of DER & Microgrid in a Modernized Grid

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Executive Vice President
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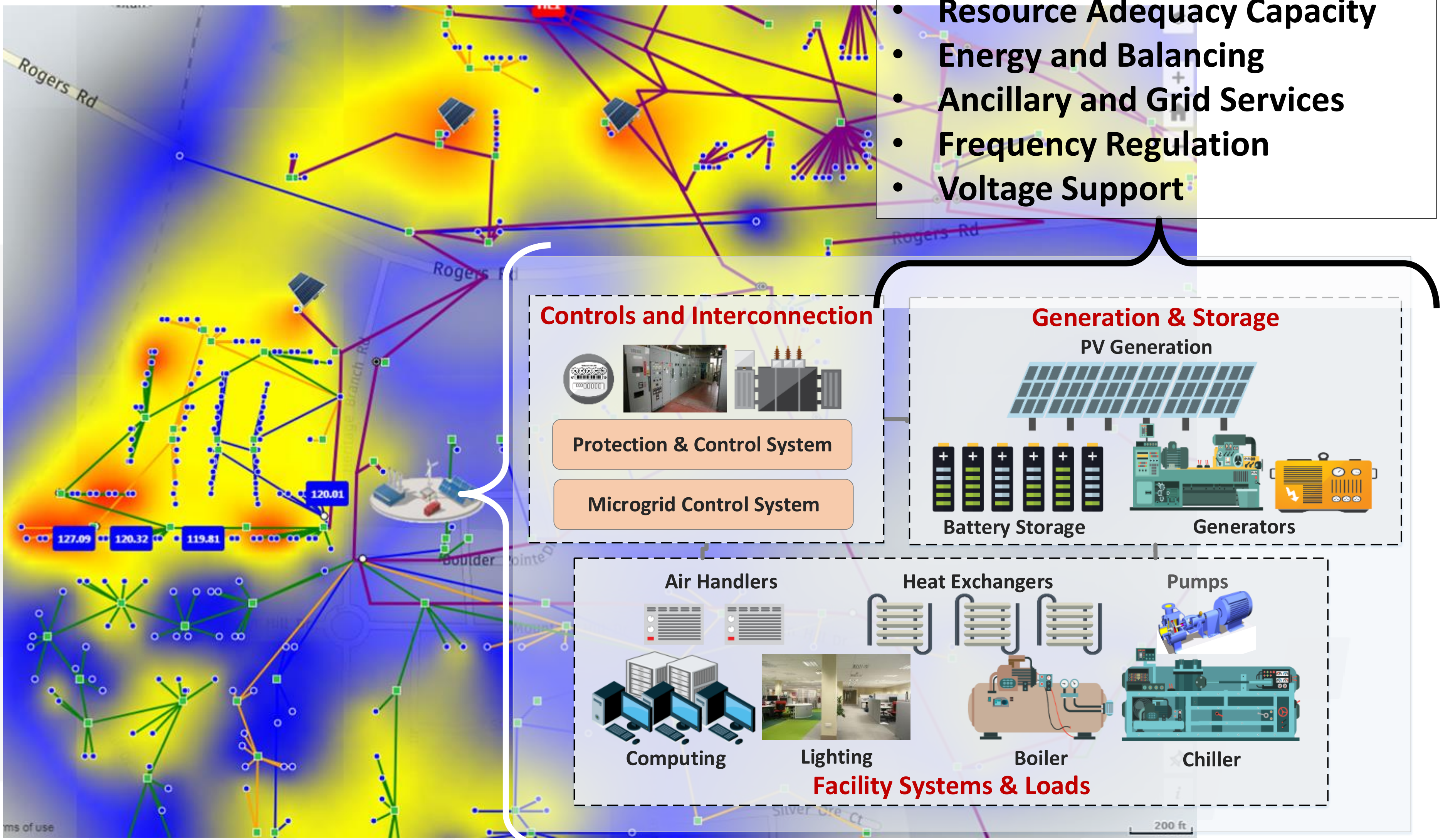
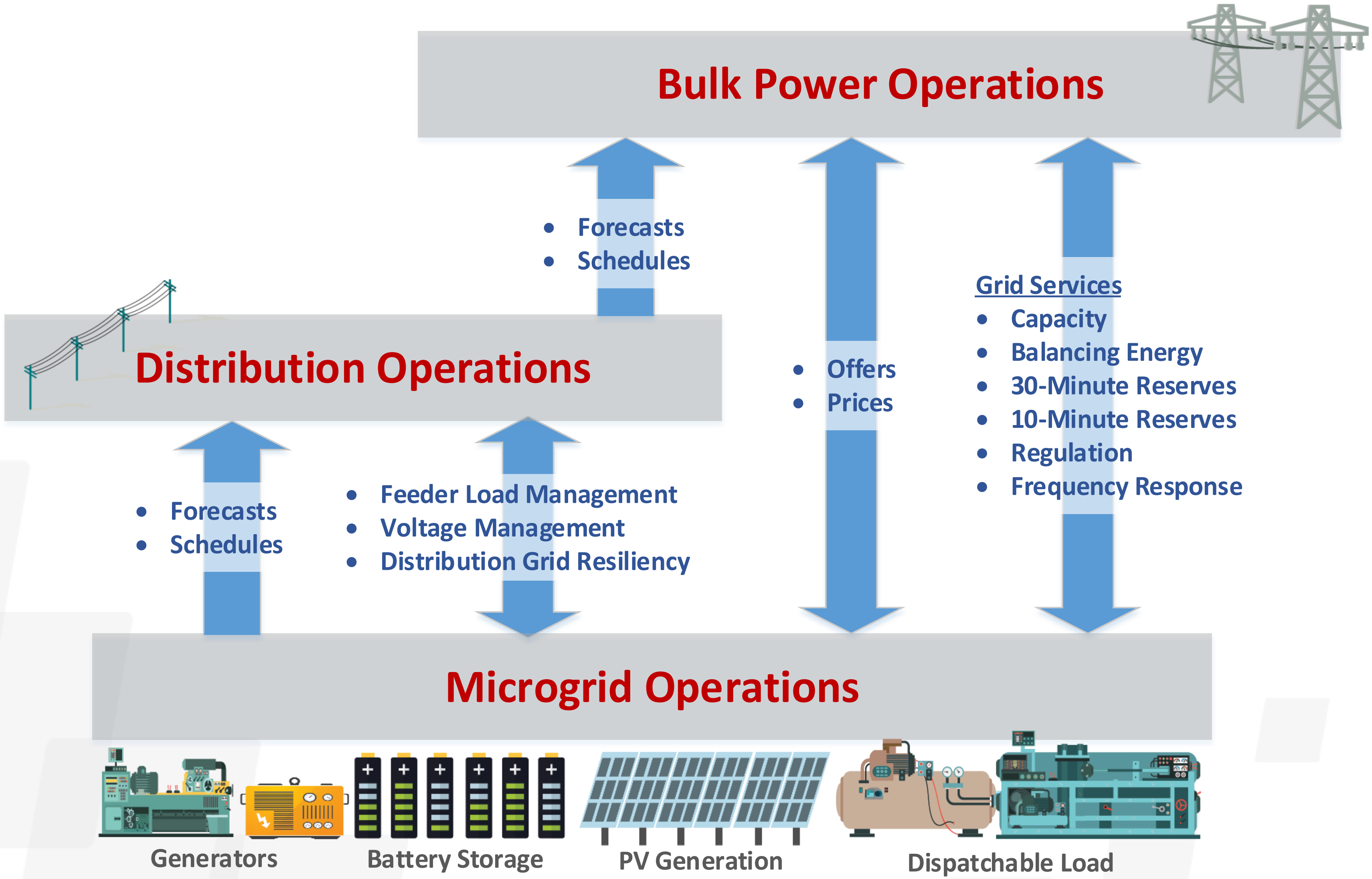
NARUC Summer Meeting
July 17, 2018

A Typical Microgrid Capabilities

- Resource Adequacy Capacity
- Energy and Balancing
- Ancillary and Grid Services
- Frequency Regulation
- Voltage Support



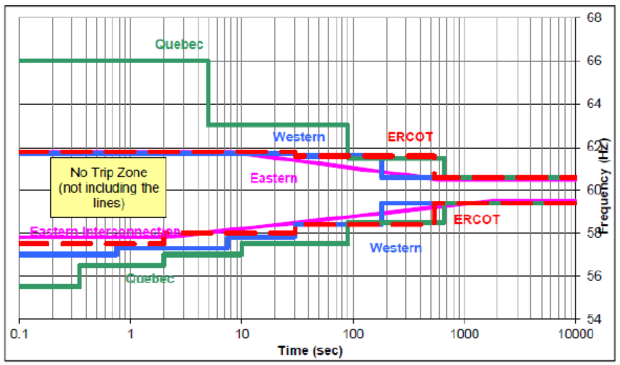
Microgrid Interactions with Grid Operations



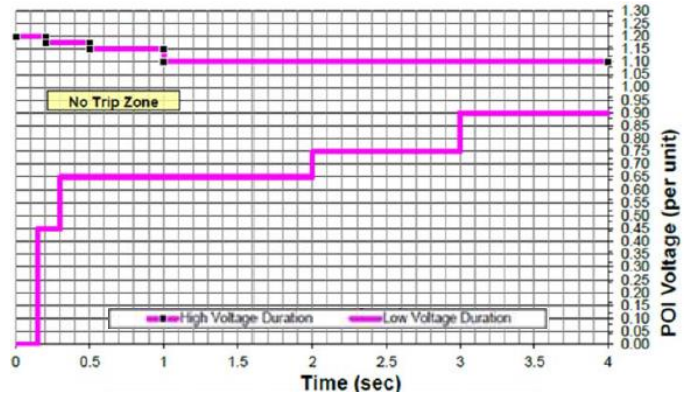
Smart Inverter Based Resources Provide Similar Capabilities as Conventional Generation Resources

- IEEE 1547-2018, IEEE 2030.5
- CA Rule 21, Hawaii H14

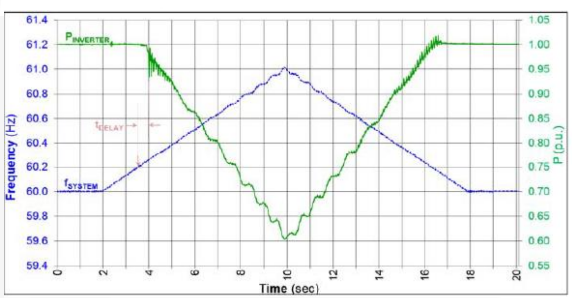
Frequency Ride-Through



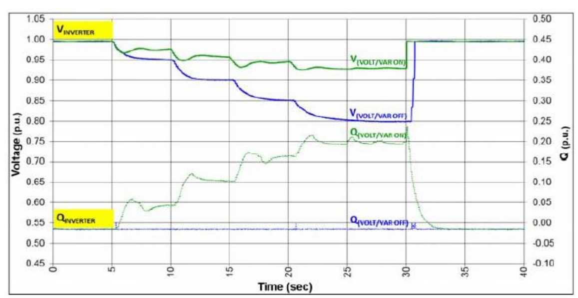
Voltage Ride-Through



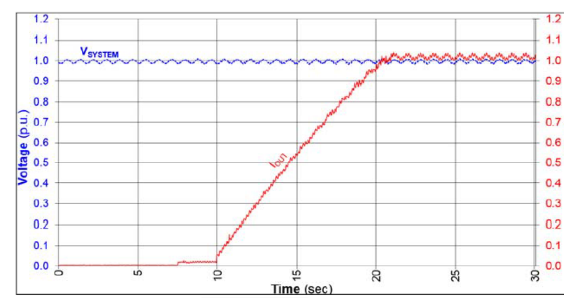
Frequency Droop Capability



Voltage Support Capability

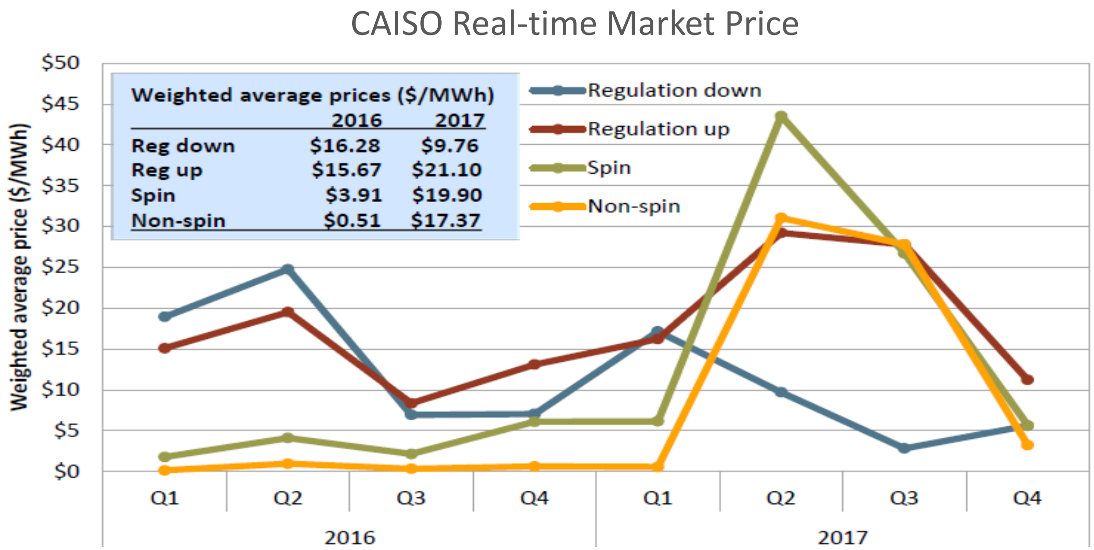


Ramping Capability

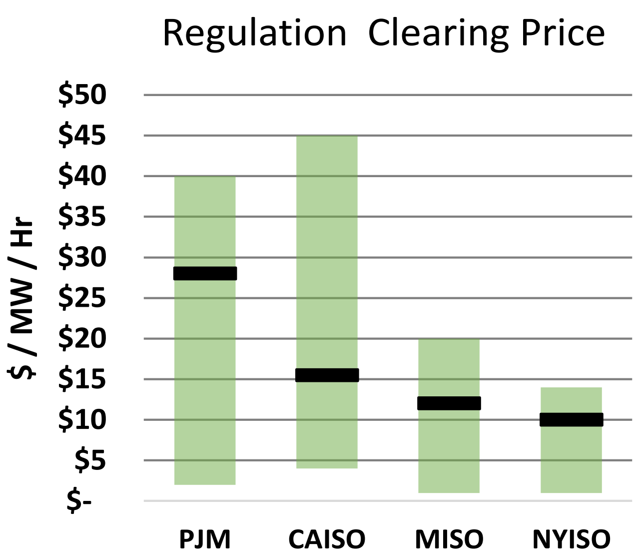


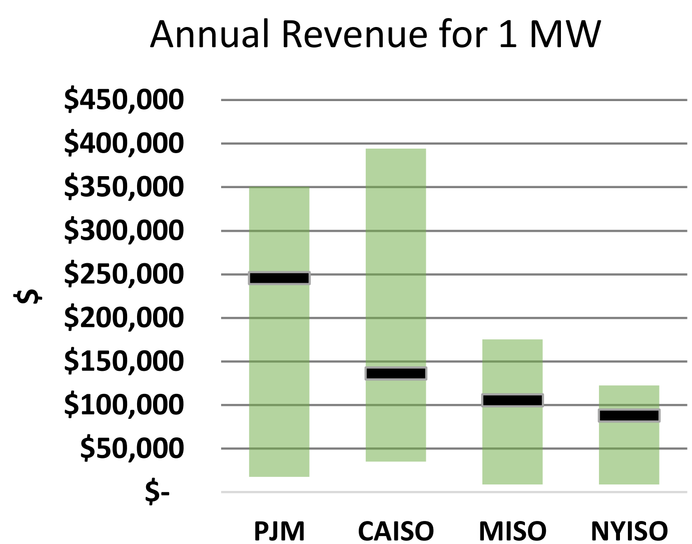
Source: Impact of IEEE 1547 Standards on Smart Inverters - PES-TR67, May 2018

Value of Frequency Regulation Services



80.7% Higher Prices in 2017 compared to 2016

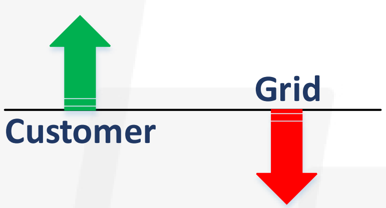




Interconnections, Power Export and DER Tariff

Customer Managed

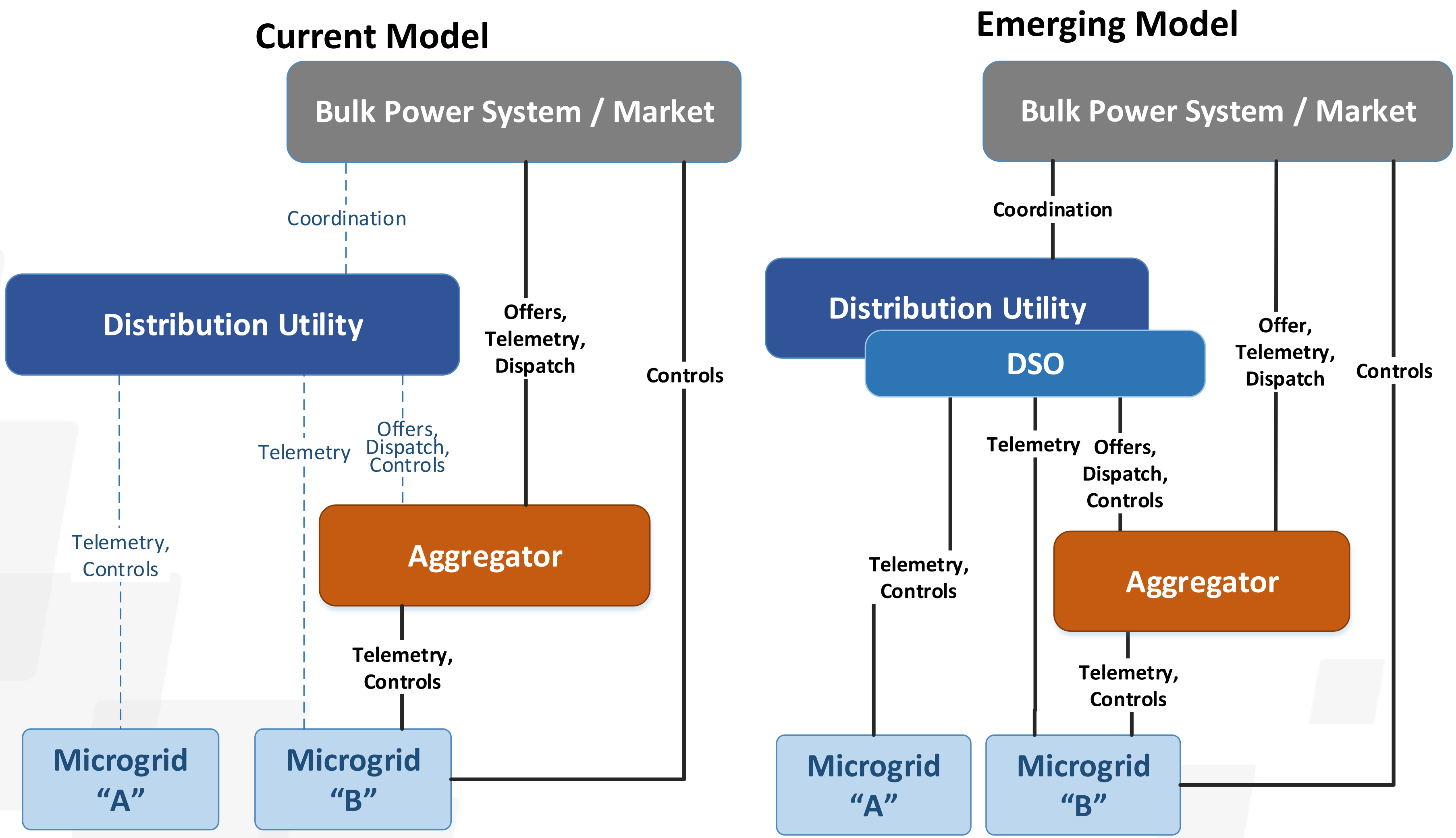
- Limited telemetry, no utility/grid controls
- NEM Challenges / Export Limitation
- Potential Negative Grid Impact
  - *Load and Demand Forecasting*
  - *Loss of Sales*
  - *Feeder and Transformer Loading*
  - *Voltage Issues*
  - *Customer Dissatisfaction*



Grid Coordinated Management

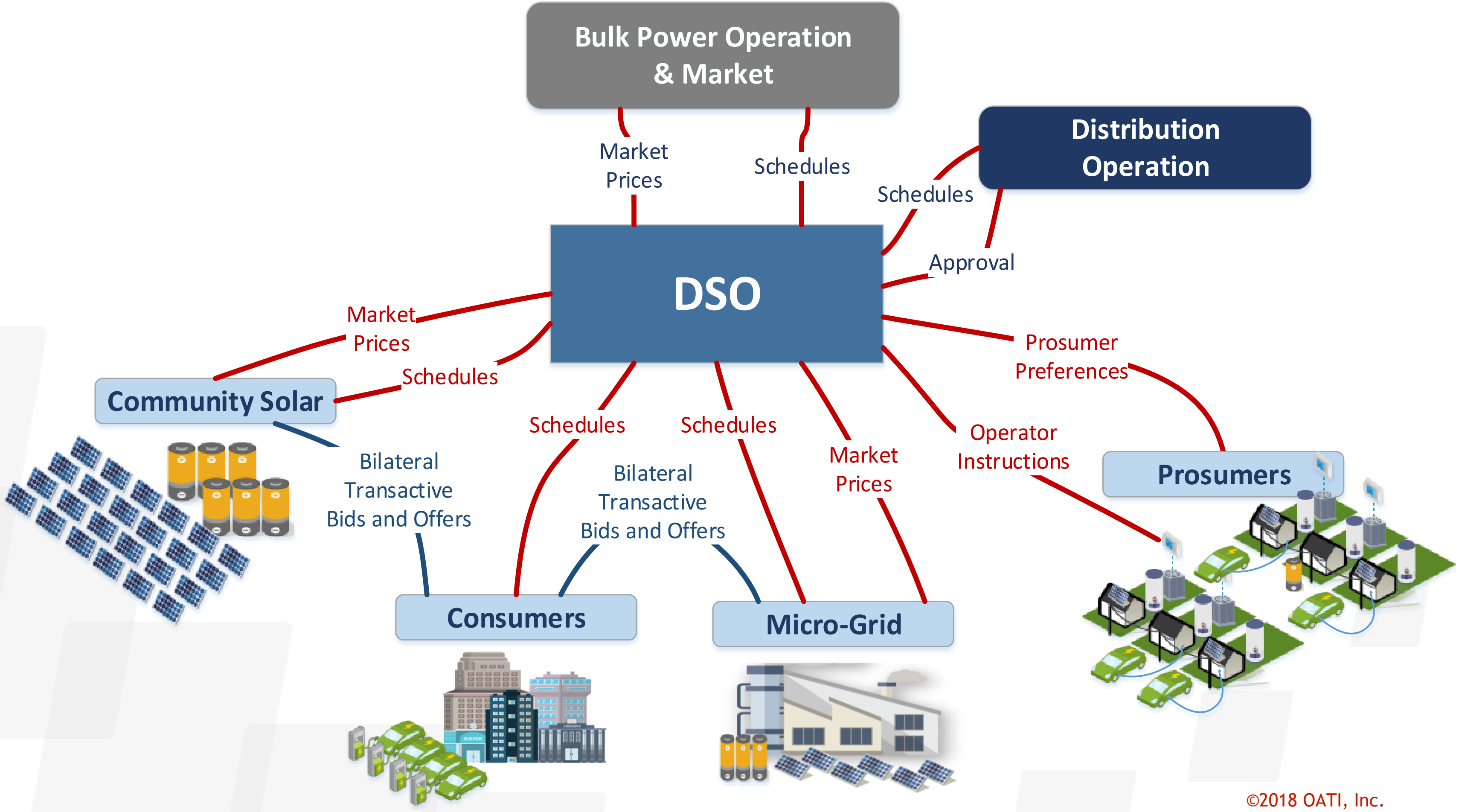
- Telemetry and control capability
- Co-optimization of Customer and Utility Benefits
- Positive Grid Impact
  - *Improved Load/Demand Forecasting*
  - *New Revenue Streams*
  - *Feeder and Transformer Load Mgmt*
  - *Voltage Management*
  - *Supply of Grid Services*
  - *Customer Satisfaction*

Operational Requirements – Data Interfaces



Transactive Distribution System Operation

- Bilateral and Centralized Transactions
- Retail Market – Regulatory & Operational Considerations



Modernized Grid of the Future

Need Favorable Tariffs for DER and Microgrid Participation in Power System Operations (Distribution & Transmission)

- Integral part of Resource Planning, and Resource Adequacy Assessment Process
- Cost-Effective and Secure Telemetry, Scheduling, Dispatch and Controls
- Forward Locational Price signals for 3rd Party DER Investments
- Formalized DER-based Grid Services definitions and associated operational and settlement rules – including Capacity, Energy, Ramping, Reserves, Frequency Regulation, Resiliency, and Voltage Management

Emergence of DSO-based Operation:

- Integration of DER Forecasting, Scheduling and Dispatch with Distribution Grid and System Operations
- A framework for competitive but voluntary supply of Grid Services resulting in improved power supply economics and system reliability – A DER/Grid Services Market Place - transparent DSO market rules.
- Approved Grid Access rights as part of DER interconnection, subject to grid constraint(congestion)-based transaction curtailment.

Creation of New Services and Associated Tariff for Bilateral Distribution-level Transactions

- Financial and Physical Transactions between Aggregators, Microgrids, Prosumers, and Consumers
- Distribution Grid Access and Grid Management Tariff - Similar to ISO/RTO Grid Management Tariff

Conclusions

- Technology advancements, declining cost of PVs and BESS, and climate related policies are changing the electric power systems landscape;
- Savvy customers and business are demanding the change;
- Significant economic and reliability benefits can be achieved;
- Technological means are available to enable end-to-end connecting consumers, smart buildings, microgrids, aggregators, distribution operators, and bulk power system operators;
- Distribution grid of the future should accommodate proliferation of utility-owned, and customer-owned, microgrids for enhanced resiliency and supply economics;
- A market place for supply of Grid Services from DERs and Microgrids will further improve supply economics;
- Regulatory provisions and new tariffs are needed to:
  - *Promote environmental friendly consumer-centric landscape*
  - *Support new-service oriented utility business and operational models*
  - *Allow distribution utilities to remain viable in providing reliable infrastructure and operational services*
  - *Ensure cyber-physical security and consumer privacy*

Thank You

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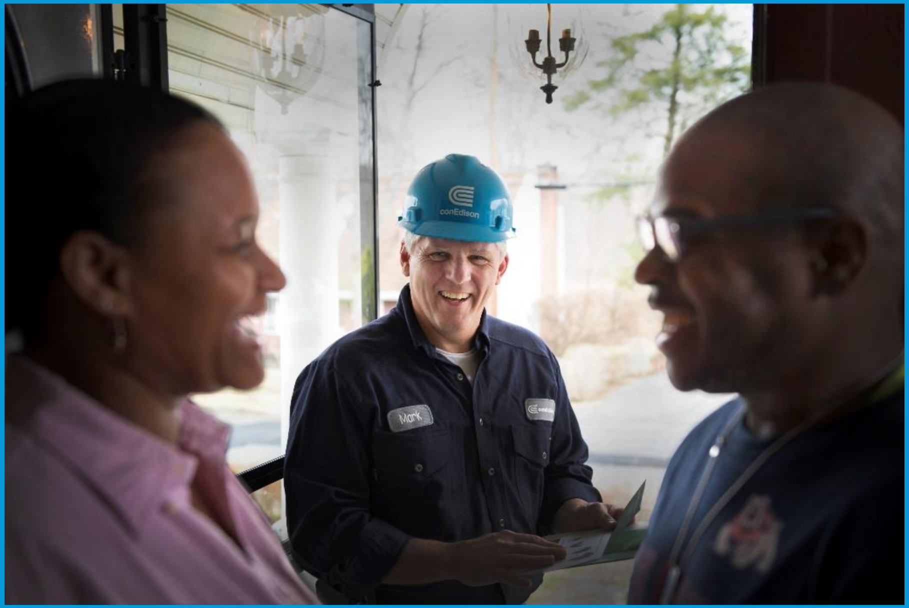


Marcus Garvey Houses Project

A Low Income Residential DER Customer

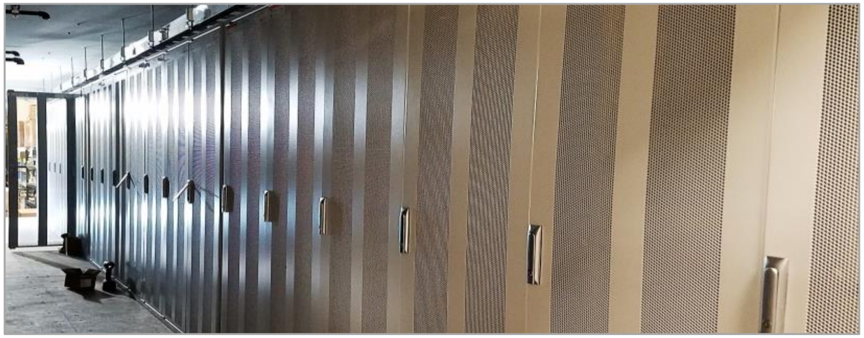
Stuart Nachmias
VP Energy Policy and Regulatory Affairs
Con Edison
NARUC July, 17th 2018

conEdison

Marcus Garvey Development

- 625-unit, low-income complex covering 8 blocks in Brownsville, Brooklyn
- Located within the footprint of a recent non-wires solicitation – the Brooklyn-Queens Demand Management program
- BQDM sought to offset 52 MW of usage during peak times through a combination of non-traditional customer-sited and utility-sited resources

Resilience: Solar + Fuel Cell + Battery



- BQDM incentives made it possible for the housing project to invest in a:
  - 400 kW Solar Array
  - 400 kW Fuel Cell
  - 300 kW Battery
- Together, these resources provide a resilience benefit, allowing the community center to remain powered during an outage
- Solar resource used to charge battery. Helps to reduce energy during the long 11-hour network need

Marcus Garvey Project Benefits

Marcus Garvey Residents

- Continuous power for community center during outages
- Monthly savings on campus-wide demand charges
- Ongoing visible engagement in local solar and clean energy

All Customers

- Deferral of new Brownsville substation results in net positive benefits to all customers
- Clean energy resources support state goals

Marcus Garvey Project Challenges

- Battery location, permits and fire requirements
- Building complex wiring
    - Within buildings
    - Between buildings

Discussion/Questions?

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Developing a Regulatory Eco-System for Advanced Microgrids

Microgrids: Policy Pathways for Progress
NARUC – July 17, 2018

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REGULATORY "ECO-SYSTEM" TOPICS

- **Capabilities Need to be Legally Recognized:** Advanced Microgrid Features
- **Source of "Value Creation":** Intelligent Energy Management Systems
- **Maximizing Benefits, Minimizing Costs:** Co-optimizing Benefits for Customers, Grid, Markets and Communities
- **Changing the Paradigm:** "System of Systems" Achieving Higher Value Cost-Effectively
- **Overcoming Legacy Regulatory Structural Biases and Disincentives**
- **Changing Utility Incentives for an Integrated Grid**: Shaping New Parameters, Players and Structures
  - Economic Regulation
  - Market Reform
  - Grid Architecture
- **Shaping Integrated Local Energy Networks in Communities**
- **New Tools, Methods and Demonstrations:** USDOE/National Labs

Smart Microgrids: Transforming Power System and Community Energy Infrastructure

- **Intelligent Electricity Delivery Network** that interconnects, interoperates, optimizes, orchestrates loads, DER and storage, using a hierarchical control scheme, within defined electrical boundaries that acts as a single controllable entity with respect to the macrogrid at the point of common coupling; Can island, connect, disconnect from grid to enable it to operate in both grid-connected or island modes; Balances demand with supply in RT; Schedules dispatch of resources; Preserves grid reliability; **Intelligently managed, energy/resource efficient Systems;**
- **Intelligent Energy Management System** uses software and hardware for balancing supply and demand to maintain stable service and reliable operation in real time;
- **"Smart System"** contains ICT, sensing, advanced control, Smart Controllers, and automation technologies to generate, manage, distribute and use electricity intelligently and effectively; also, enable interaction with Grid and other Microgrids;
- **Distributed Resources** treated as integrated and autonomous System; Microgrid configuration localized to customer, community or region;
- **Electricity** supplied by diverse range of DER (natural gas, solar PV, wind turbines, etc,);
- **Intelligent Load and Energy Management;** Balancing loads with renewables' variable generation; Efficiency, Demand Response and Storage capabilities;
- **Integrates** Storage, Load Shifting and Prioritization; Base plus variable generation with Grid;
- **Self-Healing –** Detect, analyze, respond and restore itself in case of disruptions, self-configuring, plug and play.

INTELLIGENT DISTRIBUTED ENERGY MANAGEMENT SYSTEMS

- **Intelligent Energy Management:** Maximize use of Demand and Supply Assets; Minimize Costs through Efficiencies; Resource and Load Profiling, Controlling, Forecasting; Master Controller for Resource and Load Management Optimization;
- **"System of Systems":** Agent-based, Hierarchical Communications/Control Scheme (Device Level; Site-Level; Grid Level Agents) to provide seamless integration, interoperability and optimization of disparate systems and manage competitive transactions from buildings to communities to utility service territories/regions ;
- **Advanced Microgrids** cluster compatible loads and DER units within an integrated, autonomous system operated by microgrid controllers, providing **intelligent energy management and smart delivery** through fast control, avoiding problems of standalone and randomly dispersed DER;
- **Networked Microgrids:** Microgrid cells connected or "Nested" within distributed networked electricity systems, using smart technologies; then connected to the bulk power system; Allows sharing of generation, controllable load and storage capabilities over wider areas for optimal energy and risk management;
- **C/E Distributed Control:** "System of Systems" approach yields higher levels of electricity performance; C/E power quality, availability, reliability/resiliency, efficiency and "heterogeneous" benefits, managing and optimizing dynamic sets of distributed and intermittent resources.

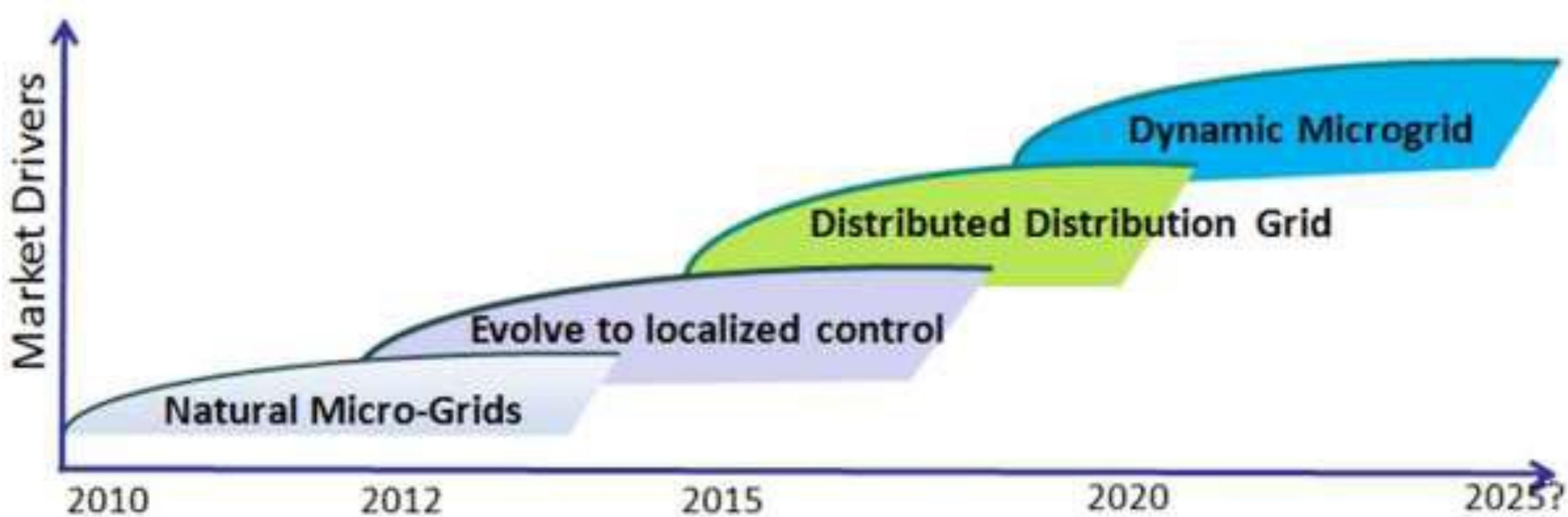
BENEFITS TO CUSTOMERS, GRID, MARKETS AND COMMUNITIES

- **Accelerate Policy Objectives:** Reliability/Resiliency; Sustainability, Renewable Energy/DER Integration; Zero Energy Buildings, Vehicles, Communities;
- **Deliver Integrated Energy Solutions –** Optimize energy availability across broad range of diversified resources, improving economics; delivery infrastructure for optimum management of overall energy requirements (heating, cooling, power); Local management and control of reliability/resiliency/power quality;
- **Shape Interactive, Flexible and Innovative Grid --** Highly flexible, configurable and interactive networks of utility, customer and third-party applications; market data, price signals and transactions; "**System of Systems"** operations for DER integration and load-side management;
- **Shape an Integrated Grid** designed to increase independence, flexibility and intelligence for energy use and management optimization within local energy networks (building, community and distribution system levels) and to integrate local energy resources (supply and demand assets) into Smart Grid and Smart Communities;
- **Build Transactive Energy Markets; Customer Energy Management Services**
- **Shape Local Integrated Energy Networks:** Expand Energy Sharing Parameters, Remove Silos and Advance Convergence between electricity and other energy infrastructure; Optimize Local Energy across Community End-Uses

PATHWAY: Technical, Business and Regulatory

- Iterative and Staged Pathway for **Advanced Microgrid System (AMS)** development; From **Interconnection** to **Integration** to **Intelligent Interconnectivity** within **Integrated Smart Grid** (from physical interconnection to Energy Internet/IoT for Energy sharing): Moving back and forth along technology development and commercialization continuum to change the dominant utility business model to spur value creation, measurement and compensation, evolving “interoperability” (technical, informational, organizational) within entire power value chain.

BNL: Roadmap to evolving dynamic microgrid, Sandia Advanced Microgrid Report



CHANGING THE PARADIGM

- **Regulatory and Market Reforms** needed to leverage AMS capabilities; capture the full range of benefits of **Energy and Resource Efficient Systems;**
- **Standardize Hierachical Control and Communications Infrastructure;** Standardization and Interoperability of Core AMS functions; Move out of "Niche" applications to "Market Mainstream" (Standardize Architecture, Customized Design;
- **Move from Asset-Based to "Value-Based;"** from Homogeneous Commodity to Heterogeneous Services;
- **Value-Based Reform** that credits and monetizes the cost-effectiveness of higher value applications (performance and efficiencies); Moving from technology-specific to integrated energy solutions/"systems" to maximize value delivery at all time/locational scales;
- **Address AMS Value Creation as part of Grid Modernization**; critical AMS functionalities and services for evolving an **Integrated Grid**;
- **Address the Value of AMS Role in Shaping an Integrated Grid to Evolve Integrated Local Energy Networks in Communities;** Capture synergies at Grid and Community Levels; Enable Energy to be managed seamlessly and interchangeably with intelligent interconnectivity (digitalization, IoT, energy internet).

“Regulatory Eco-System” to Capture Value: New Grid Design, Resource Valuation and Rules

- **“Interoperability” and Integration/Standardize Microgrid/DER Use throughout Electricity Value Chain:** Technical “Smart Grid” Design; Information Access and Valuation Methods; and New Rules, Institutional and Business Structures;
- **DESIGN: Smart Architectural Design to** advance interoperability and integration “end to end”; 4.0 Grid Operating System to meet digital age, integration of RE/DER demands (automated, widely distributed energy delivery networks);
- **RESOURCE VALUATION AND PLANNING:** Develop uniform, consistent and verifiable methods for valuing AMS; Integrate Microgrids into Utility Planning, Procurement and Investment decision-making processes; Optimize mix of centralized and distributed resources;
- **NEW REGULATORY COMPACT:** Change incentives of traditional regulatory and market decision-making to be indifferent to ownership; focused on achieving most cost-effective solutions; shape new Utility Business and Service Delivery Models.

OVERCOMING LEGACY STRUCTURAL BARRIERS

Legacy

- Centralized Model with Linear Constraints;
- Asset-Based, Homogeneous Commodity Delivery; Fossil Fuel Inflexible/Baseload Design; Historical Least-Cost Revenue Model;
- Cost of Service Regulation induces overinvestment in capital spending, spending tied to unmanaged peak loads; rate of return based on capital expenditures;
- One-way power flow; Inelastic demand/Predictable Aggregate Demand;
- Utility controlled, Centralized Generation Planning, Investment, Procurement; Volumetric Performance Metrics/Megawatts sold and meeting Peak Capacity;
- Uniform, Non-Cost-Reflective Rates at Distribution System/Retail Level
- RTO/ISO/TSO Capacity, Energy, A/S; Limited Competition to Support Legacy System Functions

Reform

- Digitalized, Decentralized, Distributed, "System of Systems," End to End Interoperability;
- Value Delivery/Services; Seamless Interaction at all Scales; Diverse, Intermittent, Low Zero Marginal Cost Resources; Forward-looking Revenue Model to Absorb Innovation;
- Align Utility Financial Interests with LT Customer Value; Equitable allocation between capital and operating expenses; Incent Innovation;
- Multi-Directional Energy, Information & Transaction Flows; Elastic Demand, Load Management, Peak Shaving; Prosumers;
- DER and Load Management Integration into Planning, Investment, Procurement; Deployment of non-regulated Third-party capital, price-responsive customer behavior; Tying Earnings to Performance Metrics/Results-Based to achieve Policy Objectives;
- Accurate Value Signals to reflect Value of Grid Services and Value of Customer Services;
- DSO & Reliability Services (Volt/Var; Peak Shaving/Shifting, etc.); Platforms; Expanded Competition and Market Players.

MOVING FROM ADMINISTRATIVE TO MARKET MECHANISMS

- **PRICING**: Increase the role and accuracy of pricing to signal, in short and long terms, energy usage and investment decision-making; expose the value of resources under system constraints and market conditions (location and timing granularity); provide a mechanism for efficiently coordinating and managing multi-objective, actor, function investment decision-making;
- **MARKET DESIGN:** Remove barriers to market participation by new resources in capacity, energy and ancillary service markets; Develop Participation Models based on the physical and operational characteristics of new resources, keyed to capabilities needed; Qualify new Market Participants;
- **PRODUCTS & SERVICES COMPETITION:** Facilitate market animation and competitive offerings, while safeguarding against market abuses; Improve Customer knowledge and tools; Enhance system-wide efficiency, reliability and resiliency; Support fuel and resource diversity;
- **ROLES & RESPONSIBILITIES:** Comprehensive but differentiated approach to wholesale/ISO and retail/DSO functions; Develop DSOs to perform Transmission-like functions that reduce need for transmission and generation investments in bulk system flexibility, ramping and reliability;
- **TRANSPARENCY & INFORMATION DISSEMINATION:** Reduce information asymmetries, increase data access while protecting privacy and security needs.

Reforms to Address Technical & Operating Characteristics of Advanced Microgrids

- **Consistent Definition of Salient Technical & Operating Characteristics of AMS;**
- **Address AMS as part of Grid Modernization/Integrated Grid –** Third Element of Smart Grid (along with macrogrid planning/operations and grid-load interaction;
- **Build upon "DER" Reforms, but Differentiate AMS Capabilities to achieve higher performance outcomes through "Integrated Energy Systems" for host customers, utilities and communities;** develop "value-based" reforms to incent locally-based smart distributed architecture that can link and optimize energy-using functions of diverse infrastructure systems and the built environment of communities;
- **Develop consistent, uniform and verifiable Methods for Valuing Benefits of AMS within Communities;**
- **Shift from technology-specific reforms to incenting integrated energy solutions to maximize value delivery at all time/locational scales and manage energy seamlessly and interchangeably** with intelligent interconnectivity;
- **Incent Development of Microgrid/Networked Microgrid Platforms** to enable transition, innovation, retail market integration and transactive interaction between Utilities and Communities;
- **Capture Synergies between Grid and Community Transformation;** Use AMS to advance resource integration, efficiencies, resilience and optimal energy use, investment in communities to reduce burden on and rationalize asset use of Grid.

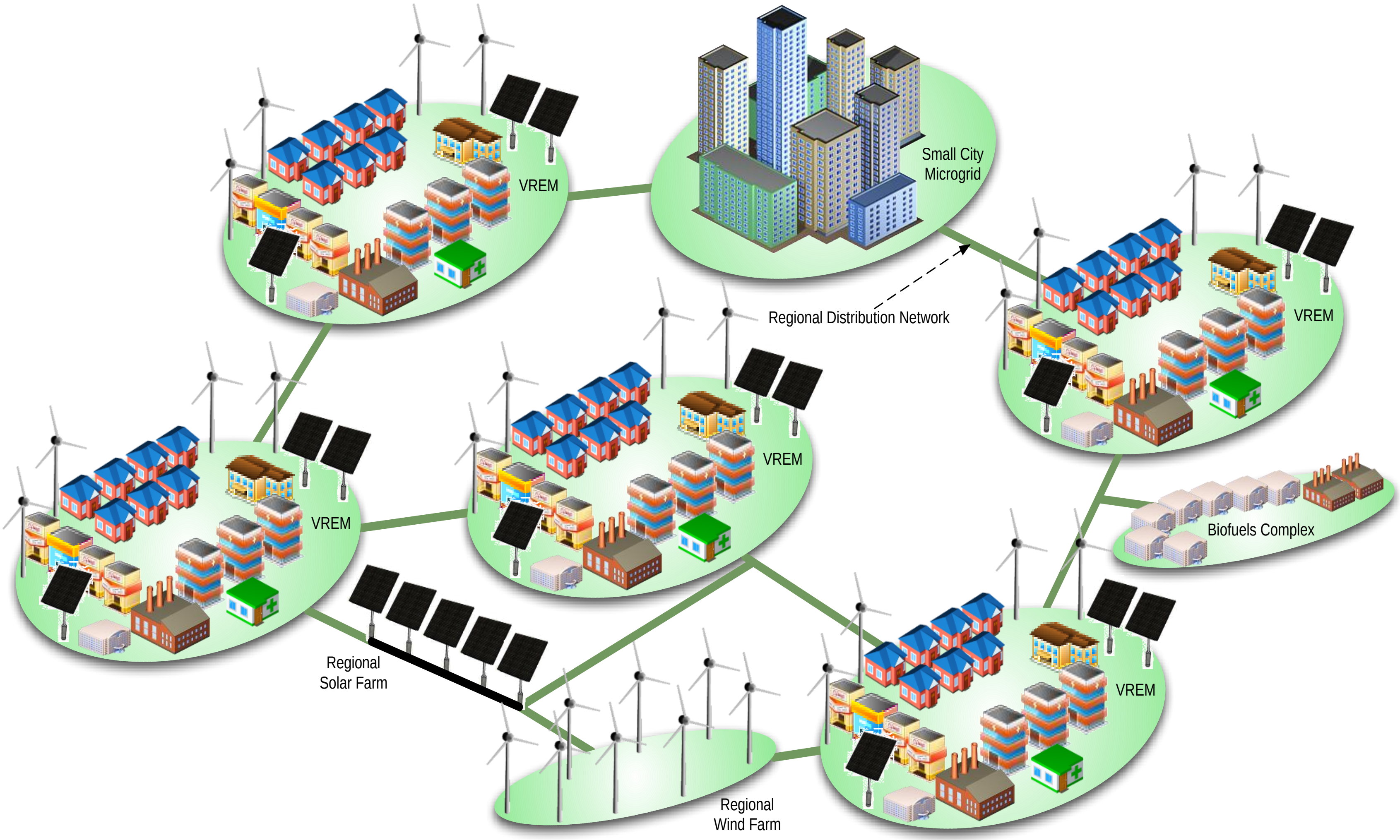
Smart Microgrid Development Within an "Integrated Smart Grid": Transforming our Power System and Communities

- **Iterative and Staged Pathway for Market Development: Interconnection, Integration and Intelligent Interconnectivity**
- **Combining Smart Grid, Microgrid-Managed Distributed Resources, and Sustainable Community Energy Systems for Intelligent Energy Management**
- **Smart Grid:** Manage and optimize energy, information, transaction flows and utility operations across supply and demand, transmission and distribution, and consumer end use programs and activities; Two-way communications and power flow, distributed sensors, automation and supervisory control systems
- **Smart Microgrid:** Coordinate, manage and optimize dynamic sets of distributed resources using smart technologies; balance demand against supply in real time to maintain stable service within defined boundary with islanding capability; evolve scalable systems and distributed networked electricity systems
- **Smart Cities and Communities:** Integrated community energy systems for efficient and sustainable energy and resource development and use.

NEW TOOLS, METHODS AND DEMONSTRATIONS

- **USDOE/National Lab Modelling & Simulation Tools, Analytical Methods, Testing Facilities and Testbeds** can support institutional changes by validating the functionalities of AMS to relate to value streams (economic, reliability/resiliency; power quality; environmental; security and safety;
- **USDOE Grid Modernization Initative** supports development of open source architecture, standards, protocols and configurations to achieve interoperability, integration, flexibility and spur competitive market opportunities – all essential to AMS market development;
- **USDOE Tools & Methods** shape Demonstration Design and Implementation; Perform Scenario Analyses of Alternative Microgrid Configurations and Compare Cost-effectiveness of Microgrid Energy Management and Delivery with DER Scenarios (Individual, Portfolio Combinations, DER Aggregation, VPP);
- **USDOE Assistance on AMS Valuation Methods and Cost/Benefit Analytical Frameworks** to quantify and modify value created by IEMS as distinctive from technology-specific applications;
- **Interrelate USDOE/Utility Decision Support Tools & Methods with C/E Local Decision-making processes and tools for Integrated Community Energy Systems Planning and Development.**

Interconnected Smart Districts



Committee on Energy Resources and the Environment

NARUC Summer Policy Summit