



EISPC Energy Zones Final Report

October 2013 •



**The EISPC Energy Zones Workgroup
For EISPC and NARUC
Funded by the U.S. Department of Energy**

EISPC ENERGY ZONES STUDY

FINAL REPORT

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ACKNOWLEDGEMENT

This material is based upon work supported by the Department of Energy, National Energy Technology Laboratory under Award Number DE-OE0000316.

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OTHER ACKNOWLEDGEMENTS

We extend our sincere appreciation to the members of the Energy Zones Workgroup (EZWG). Their alacrity, diligence and engagement throughout the Study helped ensure its successful completion. We congratulate them individually and collectively on doing such an outstanding job!

The EZWG members were: Commissioner David Littell, Maine Public Utilities Commission; Jerry Lein, North Dakota Public Service Commission; Hans Mertens, Vermont Department of Public Service. Brian Rybarik, Wisconsin Public Service Commission; Michael Ryan, New Jersey Board of Public Utilities; Chairman Betty Ann Kane, District of Columbia Public Service Commission; C. Dukes Scott, South Carolina Office of Regulatory Staff; Allyn Powell, South Carolina Office of Regulatory Staff; Bob Leker, North Carolina Department of Commerce, State Energy Office; Michael Wegner, Kansas Corporation Commission, Brian Davison - Texas Public Utilities Commission, Delanie Breuer Wisconsin Public Service Commission; Ed McNamara, Vermont Department of Public Service; and observer Ginny Kreitler, National Audubon Society, and a representative of the stakeholder community that actively participated in the EZ Work Group.

We also want to acknowledge and express our appreciation to the hard working and dedicated representatives from the National Laboratories with whom we collaborated on this project. As the technical experts, they developed and are updating and maintaining the web-based mapping tool. It was a pleasure working with them and we thank them for sharing their expertise with us and, more importantly, their willingness to address our questions and include our suggestions in the mapping tool design. They were wonderful collaborators and we thank them for cooperation and the esprit de corps we developed over the course of the Study.

The representatives from the National Laboratories were: **Argonne National Laboratory:** Vladimir Koritarov, James Kuiper, Kevin Hlava, Andrew Orr, Katherine Rollins, Donna Brunner, Herman Green, Jr., Jeffrey Makar, Andrew Ayers, Michael Holm, Kathy Simunich, Jianhui Wang, Michael McLamore, Shabbir Shamsuddin, James Kavicky, Edgar Portante, Guenter Conzelmann, John Molburg, Corrie Clark, Seth Snyder, Seth Darling, Joseph Braun, Audun Botterud, John Gasper, Pamela Richmond, Brett Beardsley, and Scott Schlueter. **National Renewable Energy Laboratory:** Chad Augustine, Donna Heimiller, David J. Hurlbut, Anelia Milbrandt, and Thomas R. Schneider' **Oak Ridge National Laboratory:** Stanton W. Hadley, Jose R. Gracia, Gary T. Mays, Randy Belles, Olufemi A. Omitaomu, Steven Fernandez, Boualem Hadjerioua, Kevin M. Stewart, Jeffrey Kodysh, and Travis Smith.

EISPC offers a special thank you to those individuals who participated on the EZWG coordination calls, gave presentations at our Council meetings and/or conducted training for EISPC members on the mapping tool—Vladimir Koritarov, James Kuiper, Andrew Orr, Katherine Rollins and Donna Brunner, Argonne National Laboratory; and Stan Hadley, Oak Ridge National Laboratory.

Warren Leon, representing the Clean Energy States Alliance and his colleague Heather Rhoads-Weaver, consultant with eFormative Options were also great collaborative partners. They too participated on the EZWG coordination calls and made presentations at EISPC meetings. We thank them for their outstanding work on the development of the public policy inventory and for our collegial partnership.

EISPC also wishes to express its gratitude for the generous assistance of the experts such as Ginny Kreidler of the National Audubon Society and NatureServe for their significant contribution to the Energy Zones work.

Finally, EISPC would like to acknowledge the support of the National Association of Regulatory Utility Commissioners for their contract administration.

PREFACE

This Energy Zones Final Report is comprised of three discrete sections. The first section includes the Executive Summary of the activities undertaken by the Eastern Interconnection States' Planning Council (EISPC) in support of the Energy Zones Study, along with two appendices of the work approved by the EISPC membership that guided the activities of the Energy Zones Workgroup.

The second section is a report entitled the "Energy Zones Study: A Comprehensive Web-Based Mapping Tool to Identify and Analyze Clean Energy Zones in the Eastern Interconnection" prepared by Argonne National Laboratory in cooperation with the, Oakridge National Laboratory, National Renewable Energy Laboratory, U.S. Department of Energy, Eastern Interconnection States' Planning Council's Energy Zones Workgroup and the Clean Energy States Alliance.

The third section is the report prepared by the Clean Energy States Alliance, entitled "State-by-State Existing and Potential Clean Energy Zones: Survey of Relevant State Laws, Rules, Regulations and Orders in the Eastern Interconnection."

These reports will be submitted individually to the National Association of Regulatory Commissioners (NARUC) and the Department of Energy, but should be viewed as companion study reports.

FORWARD

The Eastern Interconnection States' Planning Council (EISPC) represents the 39 states, the District of Columbia, the City of New Orleans, and 8 Canadian Provinces located within the Eastern Interconnection (EI) electric transmission grid. This is the first time in the nation's history that these entities have worked together on transmission-related issues.

The United States depends on electricity and our electric infrastructure is aging and generally at capacity. Accordingly, there is a need for improved collaborative planning and leveraging of new tools and resource technologies to ensure our electric infrastructure maintains reliability, is economically viable and sensitive to environmental concerns.

Supported by funding from the U.S. Department of Energy (DOE), EISPC was asked to identify Energy Zones within the EI that can support low-or no-carbon electricity generation, including (1) renewable-rich areas with suitable topographic and other characteristics for variable or baseload generation; (2) non-terrestrial areas particularly suited to offshore wind and ocean power technologies; (3) areas with geology or other characteristics particularly suited to carbon capture and sequestration (CCS); and (4) areas particularly suited to other forms of low- or no-carbon electricity generation.¹ A total of nine (9) clean energy resource areas were identified and studied.

To meet the requirements under the DOE Cooperative Agreement, the EISPC created an Energy Zones Workgroup (EZWG) and the WG, in collaboration with three (3) of the DOE National Laboratories funded to participate in the Energy Zones Study: Argonne National Laboratory (ANL), Oak Ridge National Laboratory (ORNL) and the National Renewable Energy Laboratory (NREL), along with the Clean Energy States Alliance (CESA) and other stakeholders, undertook the preparation of the Energy Zones Study. Their work included the development of a web-based mapping tool that incorporated the public policy inventory prepared by CESA and its subcontractor, eFormative Options.

The Energy Zones Workgroup developed two foundational documents that directed their work and the nature of their collaborations with the National Laboratories and others²:

- Energy Resources and Resource Criteria: Attachment A
- Scope of Assistance by and Collaboration with the National Laboratories and Other Entities in Conducting EISPC's Energy Zone Study: Attachment B

¹ NETL/NARUC Statement of Project Objectives under US DOE Award DE/OE0000316, page one.

² Attachment A was approved by the EISPC membership at its September 6-7 2012 meeting and Attachment B was approved by the membership at its meeting on July 27, 2011. Both documents are attached as Appendices A and B to this Executive Summary Report.

EISPC EXECUTIVE SUMMARY OF THE ENERGY ZONES STUDY

Mandated under the Department of Energy (DOE) Funding Opportunity in 2010,³ the Eastern Interconnection States' Planning Council (EISPC) formally initiated its work on the development of a comprehensive energy zones database, mapping tool and public policy inventory in March 2011. From the outset, EISPC members believed that the development of clean energy zones would be an important tool in assisting state, provincial, and federal policymakers, utility executives, and other stakeholders in better understanding the potential associated with making decisions based upon the location of clean energy resources. This potential would be of special interest to those policymakers looking to achieve no- or low- carbon generation and transmission of electric power.⁴

In collaboration with three (3) of the DOE's National Laboratories (National Labs) and the Clean Energy States Alliance (CESA), the EISPC Energy Zones Mapping Tool (EZ Mapping Tool) was developed. The EZ Mapping Tool contains over 250 data layers and incorporates a public policy inventory and database feature that covers nine (9) different resources and twenty-nine (29) resource technologies.

EISPC established the Energy Zones Work Group (EZWG) Chaired by Commissioner Littell (Maine Public Utilities Commission) and Vice Chaired by Jerry Lien (Staff Engineer, North Dakota Public Service Commission) to coordinate with the National Labs in preparing the Energy Zones Study (EZ Study) and EZ Mapping Tool with a 2030 planning horizon that was comparable to the work EISPC was engaged in with the Eastern Interconnection Planning Collaborative (EIPC). The collaborative effort was led by Argonne National Laboratory (ANL) in collaboration with the National Renewable Energy Laboratory (NREL) and Oak Ridge National Laboratory (ORNL).

According to the original Goals and Objectives⁵ one of the primary purposes of the EZ work is to provide objective, accurate and comprehensive information to policymakers at the

³ Funding for the EZ Study was provided by the Department of Energy, National Energy Technology Laboratory under Award Number DE-OE0000316. The source of funding was the American Recovery and Reinvestment Act (ARRA).

⁴ Defining "Clean Energy Zones" is a prerogative of state authorities. For the EISPC Study, no or low carbon-emitting energy technologies or fuels such as renewable energy, Clean Coal Technologies, Natural Gas and Nuclear are included in the definition. Smaller distributed-sized energy technologies are excluded with the exception of roof-top solar technologies. Although no specific zones would be identified, the impacts of other technologies may be identified for the development of energy resources. For example, the impacts of technologies may include Smart Grid deployment, leading-edge energy efficiency and market-responsive Demand Response. Approved by EISPC on July 22, 2011 and attached hereto as an Appendix A.

⁵ Approved by the EISPC membership on July 22, 2011. *Energy Zone* – An area which is identified as containing resources conducive to generating certain types of energy. Moreover, such an area does not necessarily have to be a "zone" as strictly defined. Rather, it could be geographic areas meeting criteria specified by EISPC to identify areas where commercial interests, market structures or political jurisdictions are already indicating energy resources that could be developed. For example, criteria could include current commercial interest in developing resources demonstrated by filings with the jurisdictional RTO/ISO, or adoption of policies through

official acts of legislatures, Governors and/or Commissions encouraging the siting of specific resources within

state, provincial, and federal levels, utility executives and other stakeholders to facilitate collaboration in the development of a more optimal mix of energy facilities and to support public policy objectives. The EZWG, with the assistance of ANL and the other National Labs, continually sought ways of ensuring the tool would be useful to all interested parties. Critical to the success of this initiative was the capability of the interactive Geographic Information Systems (GIS) computer-based tool to assist in identifying areas that may be problematic for future resource development. The corollary is that the EZ Mapping Tool is also useful in identifying areas in each state that may be regarded as having relatively high concentrations of clean energy resources that may be suitable for development. ANL's software design, graphics, and attention to detail, exceeded the expectations of the EZWG and EISPC.

Throughout its work, the EISPC emphasized that the EZ Mapping Tool is only intended to support *indicative planning analysis* and was not designed to conduct a detailed siting study of individual projects. Therefore, nothing in the development of this Tool should imply state or federal approval for the siting or construction of any specific resource. However, EISPC hopes the EZ Mapping Tool provides valuable information that could, with more granularities of data, be used to assist in the selection and siting of resources.

After extensive discussions within the EZWG and in collaboration with the National Labs, EISPC identified nine (9) clean energy resource categories⁶ to be included in the EZ Mapping Tool. According to the Argonne Report (page 3), "[b]ecause an energy resource category may comprise multiple technologies for electricity generation that utilize different types of energy inputs, the database also includes a total of 29 clean energy technologies." Detailed empirical information, including information from Studies and Whitepapers conducted by EISPC, about these nine (9) resource categories and the twenty-nine (29) clean energy technologies are included in the Energy Zones Study prepared by the National Labs.

The EZWG, with invaluable assistance from environmental experts such as the Audubon Society and NatureServe, developed crucial information, such as identifying screening criteria for clean energy resource areas on maps, that was included in the data library. The technical experts at ANL were then able to incorporate one hundred (100) data layers of environmental information into the EZ Mapping Tool.

The EISPC recognized the definitional, legal, and regulatory policy differences among the states in the Eastern Interconnection made it difficult to conduct a consistent evaluation of resource data or policies that promoted, discouraged, or prohibited development of specific

specific areas such as nuclear facilities in some Southeastern States and Carbon Capture and Sequestration (in combination with pulverized or gasified coal generation) in States promoting such technologies.

⁶ The nine identified clean energy resource categories are: Biomass, Clean Coal technologies with carbon capture and sequestration (CCS), Geothermal, Natural Gas, Nuclear, Solar Photovoltaic (PV) and concentrated solar thermal, as well as rooftop PV, Storage (pumped storage hydro and compressed-air energy storage), Water (hydrokinetic and tidal power), and Wind (land-based and offshore).

resources. The EISPC wanted to build on the analysis that has already been done – particularly the analysis that is in the public domain.⁷ However, the current databases were less comprehensive than EISPC desired. For this reason, EISPC contracted with the CESA to obtain consistent and accurate characterizations of state policies from each EISPC member jurisdiction. This information was incorporated into the EZ Mapping Tool by ANL. At the time of this Report, the EZ Mapping Tool had in excess of 250 data layers⁸ that will facilitate the evaluation of a broad range of resource options or a narrowly focused assessment of a single resource.

CESA and its subcontractor, eFormative Options (EFO), prepared an inventory of state and regional policies, laws, regulations, and orders that promote, encourage, or inhibit the development of the nine (9) clean energy technologies identified by EISPC. CESA did superlative work, in conjunction with the National Labs, ANL in particular, incorporating the state-by-state policy results into the EZ Mapping Tool. The coordinated work provides users of the EZ Mapping Tool with up-to-date information that would facilitate a variety of planning analyses tailored to their unique needs.

In a concerted effort to ensure the usefulness of the EZ information and EZ Mapping Tool, ANL conducted fourteen (14) in-person training programs at EISPC, NARUC, and the Western Governors Association meetings, as well as several webinars, to afford the states, utilities, and stakeholders an opportunity to “test drive” the EZ Mapping Tool. This training also included the “Beta Testing” of the Tool. ANL incorporated feedback from participants and made enhancements to the EZ Mapping Tool. EISPC believes upgrades and improvements to the EZ Mapping Tool will be made over time and be incorporated into the planning processes and planning tools of policymakers, utility executives and other stakeholders.

EISPC is hopeful that we can collaborate with one or more Planning Coordinators and the affected states to conduct a case study(ies) that utilizes the EZ Mapping Tool and the extensive catalog of data. Among other things, EISPC is very interested in ascertaining the

⁷ The Database of State Incentives for Renewable Energy (DSIRE), which is separately funded by DOE and managed by the North Carolina Solar Center and the Interstate Renewable Energy Council was the foundational information because it is highly regarded for its accuracy. However, after assessing the DSIRE database, and receiving feedback on its accuracy from EISPC members, EISPC deemed it appropriate to expand the database. According to the Clean Energy States Alliance, “The final EISPC Energy Zones inventory is more than three times the size of the portion of the DSIRE database that is relevant to electricity generation in the EISPC region.” Clean Energy Zones Policy Project Draft Final Report,” August 9, 2013, page 2.

⁸ The EZ Study data layers include, but are not limited to: state-by-state (and county level) information on generation technologies that are capable of providing grid-scale power generation, transmission lines, pipelines, major roads, railroads, water bodies, and 100 environmental data layers such as protected lands, sensitive habitats, and imperiled species (page 5). The Energy Zones Study includes reference material to work prepared by Oak Ridge National Laboratory on Demand Response and Georgia Tech on Energy Efficiency. This work was coordinated with the Studies and Whitepaper commissioned by EISPC regarding Demand Response, Energy Efficiency, Energy Storage, Customer-Owned Generation (renewable), Customer-Owned Generation (fossil-fuel), and Smart Grid. Studies that examined the long-term potential for coal and nuclear are also included in the database.

value of the EZ Mapping Tool to Planning Coordinators and policymakers in knowing where to avoid building new infrastructure such as power lines or to mitigate problems in areas that are often controversial and difficult to address such as National Trails and rivers.

There is recognition that, for this Tool to be broadly accepted, the states must take an active role in encouraging their jurisdictional entities to use the databases and the capabilities of this Tool. EISPC also recognizes that more outreach and training should be provided for new users so they become comfortable with the Tool. Ideally, experienced users will train novices.

The Energy Zones Study represents an unprecedented collaboration that is unparalleled in its scope (footprint and jurisdictional), application of state-of-the-art planning tools and long-term public policy ramifications. It is EISPC's expectation that the Energy Zones work will serve as a foundation for future work by states, provincial, and federal policymakers, utility officials, public interest groups, universities, and others. In this regard, EISPC views the work completed to date as a *living document* that will be enhanced over time to ensure it provides long-term benefits. EISPC also believes the Planning Coordinators and other energy utilities would incorporate the EZ Mapping Tool and database into their resource planning process.

Moreover, EISPC intends to continue to integrate its Studies and Whitepapers to enhance the usefulness of the Energy Zones work as part of an on-going effort to encourage the development of a suite of next generation resource planning tools and planning processes. To better ensure the future benefits of this important tool, EISPC suggests that the EZ Mapping Tool incorporate comparable information from the Western Interconnection and the Electric Reliability Council of Texas. To this end, ANL has demonstrated the Tool and offered to incorporate information that is useful to other regions in an effort to encourage their participation in this important endeavor.

In conclusion, EISPC wishes to gratefully acknowledge the funding by the United States Department of Energy for making this important work possible. EISPC recognizes the extraordinary work that was done by ANL in developing the Energy Zones Mapping Tool and the support by Oak Ridge National Laboratory and the National Renewable Energy Laboratory. EISPC has been continually impressed by the combined expertise and dedication of the Laboratory personnel engaged in this endeavor and we trust that this collaboration between the National Labs, states, provincial, and federal policymakers will continue to advance the public interest in a wide range of analysis. EISPC is also grateful to Commissioner David Littell, Mr. Jerry Lein, and the EZ Work Group for their extraordinary efforts.

One of the important lessons of EISPC was that states, even with differences in market and regulatory structures, were able to find common cause in the development of objective analysis and next generation planning tools that would enable state, provincial, and federal policymakers to better fulfill their various statutory obligations to ensure reliable and economic energy consistent with their respective environmental regulations. The EZ

Mapping Tool should also facilitate the planning and development of cost-effective energy infrastructure by providing essential information for energy utilities and developers to improve their planning processes. Finally, the EZ Mapping Tool should inform the broad public policy debates on environmental and resource issues without bias.

The “deliverables” envisioned in the “EISPC Energy Zones Work Group statement entitled: *Identified Goals and Objectives, Desired Deliverables And Definition of Terms* and approved by EISPC on July 27, 2011 have been much more than satisfied by the quality, depth, and breadth of the Study. The Eastern Interconnection States’ Planning Council is pleased to present the Energy Zones Study Reports prepared by Argonne National Laboratory and the Clean Energy States Alliance.

EISPC Energy Zones Workgroup

Attachment A: Energy Resources and Resource Criteria

Energy resources and resource criteria were prepared by the EISPC Energy Zone Workgroup during a series of weekly conference calls in June and July 2011. Adding the natural gas resource category was approved by the Council membership at its September 6-7, 2012 meeting.

Introduction

This attachment describes several categories of energy resources that are candidates for consideration for energy zones in the Eastern Interconnection. Broadly this attachment describes the following energy resources.

1. The traditional renewable energy resources that have been examined in earlier energy zone studies have been delineated and they are wind, solar, biomass and geothermal
2. Central station nuclear and fossil carbon capture and storage (CCS) have been defined along with their siting requirements.
3. The various water power resources have been defined and resource criteria have been provided.
4. Energy storage technologies which are not actually an energy resource per se but where there is GIS information about the potential sites have been described. The energy storage resources are pumped storage hydroelectric and compressed air energy storage.
5. Due to the overall potential, rooftop photovoltaic systems have been described. However, other local resources such as energy efficiency and various distributed resources will not be considered as they generally do not require transmission and are largely under control of the individual states.
6. Emerging renewable technologies (marine and hydro kinetic, enhanced geothermal systems) where the gross resource can be estimated have been described. However, practical estimates of the energy potential cannot be fully evaluated because the conversion technology is immature or is too site specific for ready generalization.
7. *On-shore and off-shore natural gas reserve and production areas, identified or in production, including potential for new technologies to extract natural gas from shale or "tight sands" formations and geological formations and areas appropriate for siting storage of natural gas sufficient to supply a power plant for one day of operations.*

General resource criteria are provided where practical in tables as illustrative of the restrictions on siting the various technologies. It is anticipated that as the EISPC Energy Zone Study moves forward, the resource criteria will evolve and be refined to suit the needs of the project.

1. Nuclear Generation

A nuclear power plant is a thermal power station in which the heat source is one or more nuclear reactors. In the reactor, the heat necessary to produce steam is generated by fission of atom nuclei. The steam drives a turbine generator, which generates electricity. The nuclear steam supply system is therefore the counterpart of coal-, gas- or oil-fired boilers of fossil-fueled plants. Nuclear fuel is a material that can be 'consumed' by fission or fusion to derive nuclear energy. Nuclear fuels are the densest sources of energy available.

As of 2008, nuclear power in the United States is provided by 104 commercial reactors (69 pressurized water reactors and 35 boiling water reactors) licensed to operate at 65 nuclear power plants, producing a total of 806.2 TWh of electricity, which was 19.6% of the nation's total electric energy generation in 2008.

Since about 2001, the term “nuclear renaissance” has been used to refer to a possible nuclear power industry revival, driven by rising fossil fuel prices and new concerns about meeting greenhouse gas emission limits. China has 27 new reactors under construction and there are also a considerable number of new reactors being built in South Korea, India, and Russia. As of June 2011, in the U.S., there are 28 combined license applications for new reactors filed with the Nuclear Regulatory Commission for nuclear units expected to be built over the next 10 years.

Several generations of reactors are commonly distinguished. Generation I reactors were developed in 1950-60s, and outside the United Kingdom, none are still running today. Generation II reactors are typified by the present U.S. and French fleets and most in operation elsewhere. Generation III are the Advanced Reactors and are the basis of the large reactor in energy zone study also referred to as the U.S. Evolutionary Power Reactor (U.S. EPR™). Generation IV reactor designs are at concept stage and will not be operational before 2020 at the earliest.

Generation III reactors have:

- a standardized design for each type to expedite licensing, reduce capital cost and reduce construction time,
- a simpler and more rugged design, making them easier to operate and less vulnerable to operational upsets,
- higher availability and longer operating life - typically 60 years,
- further reduced possibility of core melt accidents,
- 72-hour grace period, so that following shutdown the plant requires no active intervention for 72 hours,
- resistance to serious damage that would allow radiological release from an aircraft impact,
- higher burn-up to reduce fuel use and the amount of waste,
- greater use of burnable absorbers ("poisons") to extend fuel life.

Large Reactor

A large reactor is a light water reactor with a nominal output of 1600 MW(e), representative of a single U.S. EPR™. The U.S. EPR™ reactor is a pressure water reactor (PWR) class plant based on the design being built in Olkiluoto, Finland; Flamanville, France; and Taishan, China.

In a PWR class plant, the primary coolant (water) is pumped under high pressure to the reactor core where it is heated by the energy generated by the fission of atoms. The heated water then flows to a steam generator where it transfers its thermal energy to a secondary system where steam is generated and flows to turbines which, in turn, spins an electric generator. In contrast to a boiling water reactor (BWR), pressure in the primary coolant loop prevents the water from boiling within the reactor.

In general, this 1600 MW(e) plant size bounds all large Generation III plant designs under consideration by the NRC. The power output is used to determine the necessary stream flow to supply makeup water for cooling, which is subsequently reflected in the criteria for identifying resources. Plant cooling in all cases is provided by a closed-cycle mechanical-draft cooling tower with make-up water required for evaporation and blowdown. Based on knowledge of current reactor plant installations, available data on proposed new large reactor designs, and expert judgment, it is assumed that a single or dual plant U.S. EPR can be accommodated on a 500-acre footprint.

Small Reactor

Small modular reactors (SMRs) are part of a new generation of nuclear power plants being designed all over the world. The objective of these SMRs is to provide a flexible, cost-effective energy alternative. Small reactors are defined by the International Atomic Energy Agency as those with an electricity output of less than 300 MWe, although general opinion is that anything with an output of less than 500 MWe counts as a small reactor. Modular reactors are manufactured at a plant and brought to the site fully constructed. They allow for less on-site construction, increased containment efficiency, and heightened nuclear materials security.

A small reactor is a light water reactor with a nominal output of 350 MWe, representative of a single Innovative and Secure Reactor (IRIS) small modular reactor (SMR) design. As with the large reactor, the power output is used to determine the necessary stream flow to supply makeup water for cooling, which is subsequently reflected in the criteria for identifying resources. Plant cooling in all cases is provided by a closed-cycle mechanical-draft cooling tower with make-up water required for evaporation and blowdown. Based on preliminary design information and expert judgment, it is assumed that an SMR single or multi-module site can easily be accommodated on a 50-acre footprint.

Nuclear Generation	
Criteria for identifying resources areas	
Parameter	Criteria
Population	Land with a population density greater than 500 people per square mile (including a 20-mile buffer) is excluded.
Earthquake	Land with a safe shutdown earthquake peak ground acceleration greater than 0.3g is excluded.
Fault lines	Land too close to identified fault lines (length determines standoff distance) is excluded;
Wetlands	Wetlands and open water are excluded.
Protected Areas	Protected lands (national parks, historic areas, wildlife refuges, etc.) are excluded.
Slope	Land with a slope greater than 12% is excluded.
Landslide	Land with moderate or high landslide hazard susceptibility is excluded.
Floodplain	Land that lies within a 100-year floodplain is excluded.
Cooling Water	Land areas that are greater than 20 miles from cooling water makeup sources with at least 200,000 gpm for large reactor—exclusionary and 50,000 gpm for small reactor is excluded
Hazardous Facilities	Land located in proximity of hazardous facilities is avoided (buffer zones can vary). major airports—10 mile buffer zone and military bases, oil pipelines, refineries, oil/gas storage, etc.—5 mile buffer zone.
Infrastructure	Land near adequate roads and railroads for infrastructure delivery and spent fuel waste hauling.

2. Coal Generation and Coal Gasification with Carbon Capture and Storage/Sequestration

Carbon capture and storage (CCS), alternatively referred to as carbon capture and sequestration, is a means of mitigating the contribution of fossil fuel emissions to global warming. The process is based on capturing carbon dioxide from large point sources, such as fossil fuel power plants, and storing it in such a way that it does not enter the atmosphere.

The following criteria are for a nominal 750 MW advanced coal plant positioned on 300 acres of land.

Coal Generation and Coal Gasification with CCS	
Criteria for Identifying Resources Areas	
Parameter	Criteria
Population	Land with a population density greater than 500 people per square mile (with no) is excluded.
Earthquake	Land with safe shutdown earthquake peak ground acceleration greater than 0.3g is excluded.
Wetlands	Wetlands and open water are excluded.
Protected Areas	Protected lands (national parks, historic areas, wildlife refuges, etc.) are excluded.
Slope	Land with a slope greater than 12% ($\sim 7^\circ$) is excluded.
Landslide	Land with moderate or high landslide hazard susceptibility is excluded.
Floodplain	Land that lies within a 100-year floodplain is excluded.
Cooling Water	Land areas that are greater than 20 miles from cooling water makeup sources with at least 125,000 gpm are excluded
Infrastructure	Land that is greater than 20 miles from rail access or greater than 1 mile from barge access is avoided;
Carbon Transport and Storage	Carbon pipelines should avoid crossing fault lines, slopes greater than 12%, and crossing protected lands. Land that is greater than 150 miles from a saline aquifer geologic formation is avoided
Air Pollution Standards	Land that does not meet the EPA air pollution standards based on nonattainment data is avoided

3. Biomass and Biogenetic Fuels

This table reflects criteria used to develop maps showing the availability of biomass resources potentially applicable to energy zones. Biomass resource maps will be overlaid onto energy zone maps identified using wind, solar, and geothermal data to determine the level of biomass resource capacity within an energy zone.

The EISPC Energy Zone Study does not supersede or negate state renewable energy initiatives, but is intended to provide a foundation for interstate collaboration on commercial delivery of clean energy. Resources outside the proposed zones will be identified in this study, but they will not be considered in the supply curve analysis as they are developable as in-state resources and do not depend on regional collaboration.

Biomass	
Base Resource Maps	<ul style="list-style-type: none"> • Crop residues • Forest lands • Forest Residues • Primary Mill Residues • Secondary Mill Residues • Urban Wood Waste • Dedicated Energy Crops on Conservation Reserve Program Lands • Dedicated Energy Crops on Abandoned Mine Lands • Methane from Landfills • Methane from Manure Management • Methane from Domestic Wastewater
Criteria for Identifying Resources Areas	
Treatment of biomass in energy zone identification	Biomass feedstocks can be transported to a power plant site. As a result, project locations depend much less on the location of the feedstock resources than other energy zone technologies assessed.
Resource categories	<ul style="list-style-type: none"> • Agricultural residues • Wood, farmed or forested • Forest residues • Primary mill residues • Secondary mill residues <ul style="list-style-type: none"> ○ Urban wood residues (urban wood waste, tree service waste, C&D waste)

Additional Resource categories included	<ul style="list-style-type: none"> • Municipal solid waste • Dedicated energy • Vegetable or farmed crops • Liquid food processing wastes
Estimation of amount available for electricity generation	One third of technically available resource. Information should be differentiated by region, based on information by each States biomass resources used for electricity generation versus other existing and projected uses.
Unit of analysis	Biomass power availability will be determined on the county level
Exclusions	Do not affect resource availability because plants can be flexibly sited

Definition of Biomass Resources

Definitions for the major categories of biomass considered are used as the starting point for the specific areas that will be considered for energy zone. Additional resources identified by the stakeholders will supplement this analysis and are included below. Greater detail for each category will be included if available from the developers of the data sets. Agricultural residues are defined as the residues from production of the following crops.

- Corn
- Wheat
- Soybeans
- Cotton
- Sorghum
- Barley
- Oats
- Rice
- Rye
- Canola
- Beans
- Peas
- Peanuts
- Potatoes
- Safflower
- Sunflower
- Sugarcane
- Flaxseed

Forest residues are defined as logging residues and other removals. These include material already utilized as well as material that is disposed as waste. Logging residues are the unused portions of trees cut by logging (tops and branches) and left to be burned or decay in the woods. Other removals include trees removed as a part of thinning projects, land clearings, and forest health uses that are not directly associated with round wood product harvests.

Primary mill residues include wood materials and bark generated at manufacturing plants (primary wood-using mills) when round wood products are processed into primary wood products. Among the materials included in this category are the following

- Slabs
- Edgings
- Trimmings
- Sawdust
- Veneer clippings and cores
- Paper pulp screenings.

Secondary mill residues include wood scraps and sawdust generated by the following types of businesses

- Pallet companies
- Woodworking companies
- Truss manufacturers
- Wood container/pallet manufacturers
- Lumber, plywood, millwork and wood panel wholesale companies.

Urban wood waste includes the following three categories:

1. Wood disposed of in municipal solid waste (MSW) and handled by MSW haulers such as household yard waste, clean construction debris, household remodeling scrap, municipal and utility tree trimmings, and wooden shipping containers (other than pallets) disposed of by retail and grocery stores. This includes clean wood residues and green waste that is sorted out of a raw MSW stream. It does not include plastics and tires.
2. Wood waste from the tree service industry, which is generally in the form of mulch (75%) and firewood (25%) from tree trimming activities
3. Wood waste from the construction and demolition industries such as clean construction debris, wood cleared from land before construction, and wood mixed in with other types of debris generated during demolition.

Virgin recycled paper fibers are not included. Industrial wastes are included if the waste stream contains any clean wood that is separated from MSW.

Other sources will include:

- Municipal solid waste located adjacent to urban centers
- Dedicated energy crops
- Manure
- Vegetable crops
- Liquid food processing wastes

Availability of Biomass for Power Generation

Once the gross amount of biomass available is reduced to take into account material necessary for soil quality, animal consumption, terrain accessibility, and collection inefficiencies, an amount of material that is “technically” available is derived. A “technical” estimate has been made in recent work performed by NREL and a review will be performed for this Study by the National Labs. This needs to be further broken down into how this technically available biomass may be utilized. According to the DOE Energy Information Administration, the main categories for biomass utilization are the following:

- Industrial Usage (~60%, including co-gen)
- Power (~18%)
- Residential and Commercial Use (~19%)
- Transportation Fuels (~3%)

The main purpose of industrial, residential, and commercial use is for heat and not power. And 80 percent of the industrial usage is for heat. This is a simple, inexpensive way to use available residues. The growth of any of these sectors could expand demand for biomass. Allocating the power generation from biomass in the industrial sector to power only 30 percent of the biomass utilized today goes to the production of power. It has been estimated that one-third of the available biomass, consistent with the amounts used today, could be utilized for power. While some areas of utilization may increase such as transportation fuels, other areas may have limited growth such as residential use. This estimate is also supported by NREL due to the competing thermal and pelletizing demand. Maintaining a one-third estimate for biomass utilization to power takes into account potential utilization in other sectors due to policy mandates, GHG reduction strategies, and increases in the cost of alternate fuels.

4. Geothermal

This table reflects criteria used to develop maps showing the availability of geothermal resources potentially applicable to energy zones. The geothermal maps that result will show both general areas and specific locations of developable geothermal resources and/or commercial interest. These maps will be overlaid with similar maps showing wind, solar and biomass resources to select resource areas.

The EISPC Energy Zone Study does not supersede or negate state renewable energy initiatives, but is intended to provide a foundation for interstate collaboration on commercial delivery of renewable energy. Resources outside the proposed zones will be identified in this study, but they will not be considered in the supply curve analysis. It will be assumed that they are developable as in-state resources and do not depend on regional collaboration. Resource areas are precursors to identification of more defined energy zones.

Geothermal	
Resource Maps	
<ul style="list-style-type: none"> • USGS identified geothermal systems map • SMU well database (available for analysis, but display of raw data may be restricted) <ul style="list-style-type: none"> ○ EGS temperature map at various depths (viewable on Google Earth at http://www.google.org/egs/index.html) ○ Bottom-hole temperature map (oil and gas co-production sites) • MIT, "The Future of Geothermal Energy: Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century" (2004) (http://geothermal.inel.gov/) • Map of known direct use and geothermal heat pump sites (as small power potential and direct use) • Map of all existing geothermal leases on federal lands. • Assessment of Moderate- and High-Temperature Geothermal Resources of the United States http://pubs.usgs.gov/circ/2004/c1249/c1249.pdf 	
Criteria for Identifying Resource Zones	
Network or distributed resources	In some cases, geothermal resource areas are large enough and/or occur in high enough spatial density to justify the creation of a zone for transmission planning. In other cases, geothermal projects may be smaller scale and/or so dispersed that they are more appropriately modeled as distributed resources.

Geothermal resource types	<ul style="list-style-type: none"> • Conventional hydrothermal • Enhanced geothermal systems (EGS) • Co-production of electricity at existing oil/gas wells • Geopressured geothermal power • Direct use
Resource estimation	<ul style="list-style-type: none"> • Discovered conventional hydrothermal resources will be used to identify commercial interest and to estimate potential where exploration is already known to have occurred. • Potential for undiscovered conventional resources will be mapped and estimated with respect to the likely cost and productivity of a single well. Number and density of wells will be based on land use exclusions and other limitations approved by the Work Group. • Mapping and estimation techniques are evolving for EGS, co-production, geopressured geothermal and direct-use heating. State-of-the-art estimation approaches will be used to identify Eastern energy zones.
Land use exclusions	To be determined

Enhanced Geothermal Systems (EGS)

Enhanced Geothermal Systems (EGS) enable the utilization of geothermal resources for power that have traditionally been considered uneconomical to develop. EGS produces heat and electricity by harnessing the energy from hot rock deep below the earth's surface, expanding the potential of traditional geothermal energy by orders of magnitude. Several research projects are underway in the US, Europe and Australia to determine the most effective methods of water use and heat recovery. The project at Soultz-sous-Forêts in France is one of several small projects already producing power from EGS resources, and other projects in Europe, Australia and the United States are expected to begin generating power within the next several years. Another market development that signals a growing interest in this technology is Google.org's \$10 million investment in an EGS project in the Pacific Northwest, new drilling technology and more refined resource assessments as well as the recent agreement of GE to partner with Google in pursuing rapid expansion of this technology.

Significant utility-scale EGS development may be 10 years or more from widespread commercial deployment, but the recent infusion of interest and investment will lead to near term development and its pace cannot be accurately predicted at this point in time. It's eventual pace of development may be determined by how fast cost- reductions follow from added experience in the development and operational aspects of EGS projects.

Estimates by MIT⁹ of near-term development of EGS sites show economic potential within the range of other advanced technologies. Recent estimates¹⁰ of the supply of electricity generation potential from geothermal resources in the United States and the levelized cost of electricity, capital costs, and operating and maintenance costs associated with developing these geothermal resources provide a sound basis for evaluation. This would indicate that prime EGS opportunities should be defined as part of the energy zone process, since their cost and timing may well be within the idealized goals for new renewable development.

⁹ "The Future of Geothermal Energy: The Future of Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century," INL/EXT-06-11746, Nov. 2006.

<http://www.inl.gov/technicalpublications/Documents/3589644.pdf>

¹⁰ "Updated U.S. Geothermal Supply Curve," NREL/ CP-6A2-47458 February 2010.

<http://www.nrel.gov/docs/fy10osti/47458.pdf>

5. Water Power

This table reflects criteria used to develop maps showing the availability of hydroelectric resources potentially applicable to energy zones. Hydro resource maps will be overlaid onto energy zone maps identified using wind, solar, and geothermal data to determine the level of hydro resource capacity within an energy zone. The availability of hydropower itself will not be used to define an energy zone.

The EISPC Energy Zone Study does not supersede or negate state renewable energy initiatives, but is intended to provide a foundation for interstate collaboration on commercial delivery of energy. Resources outside the proposed zones will be identified in this study, but they will not be considered in the supply curve analysis as they are developable as in-state resources and do not depend on regional collaboration. In particular, the impact of Canadian Hydropower facilities may impact the identification of energy resource areas within the United States. Resource areas are precursors to identification of more defined energy zones.

Water Power	
Base Resource Maps	Maps and environmental data available from Idaho National Laboratory http://hydropower.inel.gov/resourceassessment/index.shtml and National Hydropower Association
Criteria for identifying resources areas	
Locations	Potential water projects are distributed throughout the Eastern US.
U.S. water power resources	<ol style="list-style-type: none"> 1. Incremental hydropower 2. New hydropower at existing non-powered dams 3. Irrigation power 4. New hydropower at existing diversions or other impoundments 5. Hydroelectric tidal power generation
Canadian water power resources	The impact of Canadian water power imports will be considered as it relates to the identification of U.S. energy resource areas and the designation of U.S. energy zones. Water power energy zones in Canada will not be defined or evaluated.

Definition of United States Water Resources

The definition for water power in the Energy Zone Study incorporates language in the existing IRS Code Section 45 for the Production Tax Credit (PTC). The purpose of this definition is not to define what is renewable, but what resource will be reviewed for purposes of inclusion in an energy zone. In the simplest form, hydro, for purposes of the

Energy Zone Study is retrofitting existing diversions and impoundments with no change in water deliveries. To clarify:

1. Incremental hydropower
2. New hydropower at existing non-powered dams
3. Irrigation power
4. New hydropower at existing diversions or other impoundments
5. Hydroelectric tidal power generation

The study will detail all exclusions and note that the resource is not defined as 'non-renewable'. Furthermore, hydro projects/resources that fall outside of the energy zones, the resource potential and benefits will be identified.

The definition below will be used for water power resources and is based on existing rules for the Renewable Energy Production Tax Credit.

- 1) Incremental hydropower
 - a) Incremental production from an existing hydropower production facility that is attributable to efficiency improvements or additions of capacity determined by using the same water flow information used to determine an historic average annual hydropower production baseline for such facility.
- 2) New hydropower developed at existing non-powered dams
 - a) The hydroelectric project is operated so that the water surface elevation at any given location and time that would have occurred in the absence of the hydroelectric project is maintained, subject to any license requirements imposed under applicable law that change the water surface elevation for the purpose of improving water quality of the affected waterway.
 - b) The hydroelectric project installed on a non-hydroelectric dam or other impoundment that is licensed or permitted by the Federal Energy Regulatory Commission, the Bureau of Reclamation, or other agency as specified by Federal legislation or applicable agency rule making, and meets all other applicable environmental, licensing and regulatory requirements.
 - c) The non-hydroelectric dam was placed in service for flood control, navigation or water supply purposes and did not produce hydroelectric power.
- 3) New irrigation hydropower
 - i) Free flowing water in an irrigation system, canal or other man-made channel, including projects that utilize non-mechanical structures to accelerate the flow of water for electric power production purposes.
- 4) New hydropower at other existing diversions and impoundments
 - i) New hydropower at existing diversions and impoundments, not identified above, that has little or no incremental environmental impact (e.g., municipal water systems, pressure reducing valves, or other energy dissipating features).
- 5) Hydroelectric tidal power generation

- a) Tidal power is the generation of electricity from the energy of the earth's oceanic tides. Tides are the periodic motion or currents in the earth's oceans as a result of variations in gravitational forces, primarily between the earth, moon and sun. These variations in gravitational forces result in local changes in ocean levels and currents where rivers and estuaries meet the sea. Different technologies and project designs have been used to generate electricity from tides. Tidal power can be generated through the use of a barrage or dam like civil structure and hydroelectric generators, or through a tidal stream flow generator. Worldwide, tidal power generation is only a few hundred megawatts as economic sites using conventional technologies have been limited. New hydrokinetic, or tidal stream flow energy conversion devices, are being developed. These are classified as marine and hydrokinetic energy and discussed in the next section.

Marine and Hydro Kinetic

A new generation of water power technologies is under development that offers the possibility of generating electricity from water without the need for dams and diversions. Broadly categorized as "marine and hydrokinetic" energy systems, the term "marine and hydrokinetic renewable energy" means electrical energy from (1) waves, (2) tidal currents in oceans, estuaries, and tidal areas; (3) free flowing water in rivers, lakes, and streams; or (4) free flowing water in man-made channels. There are numerous plans, both in the United States and internationally, to develop these energy conversion technologies. However, because the concepts are new, few devices have been deployed and tested in rivers and oceans.

The term "marine and hydrokinetic renewable energy" does not include energy from any source that uses a dam, diversionary structure, or impoundment for electric power purposes. Those are considered as hydroelectric. The amount of energy that can be extracted from marine and hydrokinetic resources is not fully known. The assessments and demonstrations are underway for wave, tidal, current, in-stream hydrokinetic and ocean thermal energy gradients in a number of locations across the United States. The technologies can be broadly classified as current energy and wave energy devices. Current energy technologies (also called in stream tidal or hydrokinetic technologies) convert the kinetic energy associated with moving water into electricity. Current energy technologies depend on the horizontal movements of river and ocean currents (tidal and stream) to drive a generator that converts mechanical power into electrical power.

Current energy devices are often rotating machines that can be compared to wind turbines – a rotor spins in response to the movements of water currents with the rotational speed being proportional to the velocity of the fluid. The rotor may have an open design like a wind turbine or may be enclosed in a duct that channels the flow. Further, the rotor may be characterized by conventional "propeller-type" blades or helical blades. There are no commercial developments of current energy converting technologies in the U.S., although several partial- or full-scale prototypes have been tested.

Wave energy technologies convert wave energy (the sum of potential energy [due to vertical displacement of the water surface] and kinetic energy [due to water in oscillatory motion]) into electricity. Thus, these devices operate by means of changes in the height of ocean waves (head or elevation changes). There is a wide variety of wave energy converter designs.

It will be some time before the economics, environmental impacts and resource potential of marine and hydrokinetic energy is understood sufficiently to develop general siting criteria.

6. Storage Technologies

Electricity storage facilities store electricity in a form that is easily converted back to electricity at a later time. The main method currently in use is pumped storage hydroelectric (PSH), with water raised to a higher elevation for later release. Compressed Air Energy Storage (CAES) is another promising bulk power storage technology, although there are only two plants operating in the world. Smaller scale storage technologies such as flywheels and batteries are also being explored.

Strictly speaking, these technologies are not necessarily clean and renewable energy sources; it depends on the initial generation technology used in the stored electricity. Storage can be used in various parts of the electricity grid. It may be useful to be placed in conjunction with variable generation technologies such as wind and solar. This would allow a more controllable electricity flow and improve the economics of the transmission system to the generation site through increased capacity factor. Storage can be placed on the backbone of the grid to provide system support, operating reserves, and other ancillary services. Storage may also be placed closer to the end-user to improve reliability and power quality.

Pumped Storage Hydroelectric

There are currently roughly 40 pumped storage hydroelectric facilities in the country, providing over 21 GW of peak summer capacity. Most were built in the 1960s-1980s, with the most recent being the 1,046 MW Rocky Mountain plant in Georgia in 1995. They range in size from 4 MW to 2700 MW, with an average size of 550 MW. There are additional small-scale sites as well not reflected in the EIA data source. The upper and/or lower reservoirs can be natural or man-made. These are generally on or near rivers or other bodies of water, but if both the upper and lower reservoirs are artificial and no natural waterways involved then the site is known a “closed-loop”. Reservoirs can be placed high on a hill or below ground using old mines or quarries. Some facilities use the height difference created by a dam on a river and simply use reversible pump/generators instead of the conventional one-way generators in a hydroelectric plant.

Pumped storage hydroelectric is the most widespread energy storage system in use on power networks. In addition to providing a significant amount of valuable peaking capacity through load shifting (or price arbitrage), PSH plants are also used to provide various ancillary services that increase overall efficiency and reliability of grid operation. Due to their flexibility and quick response characteristics, PSH plants are typically used to provide regulation and contingency reserves (e.g., fast spinning, non-spinning, and supplemental reserves), load following, load balancing, and to compensate the variability of wind and solar generation. A new class of advanced variable speed PSH plants will provide even more flexibility in their use for other valuable grid services.

Because PSH can be placed in a wide variety of locations including man-made sites, it is difficult to establish geographically based siting criteria. Either large amounts of land or a

great elevation difference are required to create a large energy storage capacity. There are over twenty PSH projects before FERC currently, but the major constraint on development has been financing because of their high capital cost and difficulty in establishing long-term contract mechanisms for their electricity production. Some of the main PSH siting criteria are outlined in the table below.

Pumped Storage Hydroelectric	
Base Resource Maps	USGS Topographic Maps – 7.5 minute Digital Elevation Models (DEM)
Criteria for developing resource areas	
Power Potential	PSH projects of larger size (several hundred to several thousand MW) are preferred. Small PSH projects are often uneconomic due to high capital investment costs.
Water Availability	Proximity to sufficient water sources for initial filling of the upper reservoir and for daily operations (e.g., to allow for high-rate pumping from the lower reservoir). PSH projects do not consume water except for small losses due to evaporation and seepage.
Topography	An elevation differential of at least several hundred feet between the upper and lower reservoirs is preferred. The horizontal distance between the upper and lower reservoirs typically should not exceed 15 times the elevation difference. Maximum horizontal distance between the reservoirs should be less than 3-4 miles to avoid excessive hydraulic losses in penstocks.
Reservoir Size	The upper reservoir should be big enough to provide at least 8-12 hours of daily generation at full plant capacity.
Geologic	Porous and unstable geologic formations which may not be able to support a large dam are excluded.
Population	Excluded is land with high population density. Also excluded is land that would require relocation of population.
Protected Lands	Protected lands (national parks, historic areas, wildlife refuges, etc.) are excluded.
Environmental	Similar criteria as for the conventional hydro power plants.

Compressed Air Energy Storage

Current CAES plants are not just a storage technology. The storage side of CAES involves using off-peak electricity (grid, solar, wind, etc.) to charge an underground reservoir with compressed air. Subsequently, during peak demand periods, energy is generated when the stored compressed air is mixed with natural gas and combusted before expanding it

through a turbine to generate power. This is similar to a conventional gas turbine power plant, except that a conventional gas turbine requires a substantial amount of the energy generated to operate air compressors. Therefore, the CAES plant is more efficient than a similarly rated conventional gas turbine. However, the operating cycle time is limited to the available compressed air storage capacity.

Since air heats up during compression, this heat must be removed to avoid dangerous temperatures. In the process described above the heat is removed through heat exchangers and released to the atmosphere. An alternative CAES design uses an adiabatic process to remove the heat of compression and storing it in stone, concrete or a hot fluid. The heat would then be reintroduced during expansion so that natural gas is not needed for operation.

Geology plays a large part in the siting of a CAES plant. Possible geological storage types include salt domes, bedded salt, or deep aquifers. Hard rock geology may also be used, but has not been extensively studied since the 1980's. CAES also generate a reasonable amount of noise with the expansion of gas so would not be suitable in populated areas. Other siting parameters are listed below.

Compressed Air Energy Storage	
Base Resource Maps	LandScan Global 2007 Population Dataset; Digital Terrain Elevation Dataset, National Geospatial Intelligence Agency; USGS National Seismic Hazard Mapping data (2008); National Land Cover Dataset; FEMA National Flood Hazard Layer (2009); USGS Landslide Hazards Program (2002); others
Criteria for developing resource areas	
Storage Geology	Land areas that are greater than 1 mile from salt dome formations, bedded salt formations, and aquifers is avoided.
Slope	Land with a slope greater than 12% ($\sim 7^\circ$) is excluded
Floodplain	Land that lies within a 100-year floodplain is excluded
Population	Land with population density greater than 500 people per square mile (with no stand-off buffer) is excluded
Wetlands	Wetlands and open water are excluded
Protected Lands	Protected lands (national parks, historic areas, wildlife refuges, etc.) are excluded
Landslide	Land with a moderate or high landslide hazard susceptibility is excluded

Distributed Storage

Distributed storage such as batteries and flywheels may be placed anywhere within the grid, most likely at end-user locations or substations. They will be helpful for improving power quality at the local level, providing short-term back-up supplies, and adding some complementary resources for distributed, variable generation. These will not be considered for development of energy zones and no siting criteria are required.

7. Solar

This table reflects criteria used to develop maps showing the availability of solar resources potentially applicable to energy zones. These maps will be overlaid with similar maps showing wind, biomass, geothermal, and small hydroelectric resources to select energy resource areas.

The EISPC Energy Zone Study does not supersede or negate state renewable energy initiatives, but is intended to provide a foundation for interstate collaboration on commercial delivery of energy. Resources outside the proposed zones will be identified in this study, but they will not be considered in the supply curve analysis as they are developable as in-state resources and do not depend on regional collaboration. Energy resource areas are precursors to identification of more defined energy zones.

Concentrated Solar Plants

Water-cooled or thermal concentrated solar plants (CSPs) typically employ arrays of ground-based mirrors that focus energy on a heat transfer medium in a pipe. The heat transfer medium may be oil, a salt slurry, or water. The heat transfer medium is pumped to a heat exchanger where steam is generated to run a turbine. The steam is condensed in a condenser, where heat is rejected to an ultimate heat sink. The ultimate heat sink (typically a cooling tower) requires makeup water to replace water lost to evaporation. A representative plant size for consideration is 100 MW situated on 500 acres.

Concentrated Solar Plants	
Base Resource Maps	NREL Climatological Solar Radiation Model (40 km by 40 km grid using historical data from)
Criteria for developing resource areas	
Solar Irradiation	Greater than 5 to 6kWh /m ² /day
Slope	Land with a slope greater than 5% (~3°) is excluded
Floodplain	Land that lies within a 100-year floodplain is excluded
Population	Land with population density greater than 500 people per square mile (with no stand-off buffer) is excluded
Wetlands	Wetlands and open water are excluded
Protected Lands	Protected lands (national parks, historic areas, wildlife refuges, etc.) are excluded as well as active mines and airports
Cooling Water	Land areas that are greater than 20 miles from cooling water makeup sources with at least 15,000 gpm are excluded for thermoelectric plant applications

Concentrated Solar Plants (Continued)	
Criteria for developing resource areas (Continued)	
Landslide	Land with a moderate or high landslide hazard susceptibility is excluded

Utility-Scale Solar PV

In grid-connected application, the DC power from solar photovoltaic cells runs through an inverter and supplies the power system with electricity. Large-scale grid-connected photovoltaic power plants to be considered are in the size range of 10- to 100-MW.

Utility-Scale Solar PV	
Base Resource Maps	NREL Climatological Solar Radiation Model (40 km by 40 km grid using historical data from)
Criteria for developing resource areas	
Solar Irradiation	Greater than 5 to 6kWh /m ² /day
Slope	Flat terrain or south facing sloped areas
Landcover	Areas without vegetation or short vegetation Avoid forested areas
Protected Areas	Protected lands (national parks and historic areas) are excluded as well as active mines and airports.
Infrastructure	Land near adequate roads for construction delivery. Land near electric utility infrastructure.
Floodplain	Land that lies within a 100-year floodplain is excluded
Landslide	Land with a moderate or high landslide hazard susceptibility is excluded

Roof-Top Solar PV

Roof-top solar photovoltaic systems are a robust, flexible, scalable technology which can provide electricity for houses, commercial and industrial buildings. The cost of photovoltaics has dropped as the industry has scaled-up manufacturing and incrementally improved the technology with new materials. Installation costs have reduced with more experienced and trained installers.

The urban environment offers a tremendous amount of “empty” rooftop and can inherently avoid the potential land use and environmental concerns. Estimating rooftop solar insolation is a multi-faceted process, as insolation values are impacted by:

- Time of the year
- Weather conditions

- Shading from adjacent buildings
- Shading from overhanging vegetation
- Roof slope
- Roof aspect

In particular, shading from adjacent buildings and trees can dramatically change a given rooftop insolation potential.

A GIS tool (Visual-SOLAR) is being developed that uses high-resolution LiDAR-derived DSMs to accurately recreate the earth's surface, including building rooftops. Light detection and ranging (LiDAR) is an optical remote sensing technology that can measure the distance to, or other properties of a target by illuminating the target with light, often using pulses from a laser. Downward-looking LiDAR instruments fitted to aircraft and satellites are used for surveying and mapping. Digital surface models (DSM) depict the elevation of the top surfaces of buildings, trees, towers, and other features located above the bare earth. The tool processes upward-looking hemispherical view shed algorithms to calculate insolation for each location on the digital elevation models. The calculation evaluates the above the canopy against other algorithms for insolation under canopy locations. The framework considers only the insolation that falls on building rooftops, not on the ground. The method accounts for adjacent structures/trees, slope, aspect, elevation, latitude, temporal and atmospheric factors. Currently, the tool simply reports the total amount of insolation falling on a given rooftop and could be enhanced to provide an energy estimate. The high-resolution LiDAR-derived DSM data is available for about 100 large metropolitan areas in the country.

8. Wind

These tables reflect the criteria to be used to develop maps showing the availability of wind resources potentially applicable to energy zones. These maps will be overlaid with similar maps showing solar, biomass, geothermal, and small hydroelectric resources to energy resource areas.

The EISPC Energy Zone Study does not supersede or negate state renewable energy initiatives, but is intended to provide a foundation for interstate collaboration on commercial delivery of renewable energy. Resources outside the proposed zones will be identified in this study, but they will not be considered in the supply curve analysis as they are developable as in-state resources and do not depend on regional collaboration. Resource areas are precursors to identification of more defined energy zones.

Wind	
Data Source	NREL Wind Speed Maps at 50 meters, 80 meters or above and 1 km², (resolution or better, if available) annual data. Criteria listed below refines the base resource data to show the greatest potential wind resource available for development.
Criteria for creating resource areas	
Wind Class	Class 4 or equivalent nomenclature. Class 3 wind will be used to supplement class 4 in certain areas
Slope and Tower Height	20% (industry standard). Hub heights at current commercial usage.
Land cover	Avoid open water, wetlands, forest, urban areas.
Land management	Avoid protected land designations such as national parks, wilderness, etc. Avoid USFWS critical habitat. Avoid DOD lands and training areas.
Radar and airfields	Avoid proximity to radar systems and airfields.

Wind – Offshore

Data Sources	NREL Wind Speed Maps at 50 meters, 80 meters or above and 1 km ² , (resolution or better, if available) annual data annual data. Criteria listed below refines the base resource data to show the greatest potential wind resource available for development. State Wind Energy Areas as well as Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) Wind Energy Areas already defined for federal waters will be used to inform the data layers.
Wind – Offshore (Continued)	
Criteria for developing resource areas	
Wind class	Class 3 and higher.
Water depth	Practical water depth is a current subject of research and consideration is being given to floating facilities. Bathymetry data can be used to categorize the offshore resource potential according to the applicable foundation technology (sea bed monopole, sea bed truss, or moored floating foundation). ¹¹
Distance from shore/visual impacts	Avoid near shore locations near populated or scenic areas due to visual impacts
Bottom characteristics	Weight suitability of bottom substrates for turbine foundations and impacts
Shipping lanes	Avoid obstruction of shipping lanes, navigable waterways and harbors.
Commercial and sport fisheries	Avoid high-use fishery areas
Protected areas and habitat	Avoid marine sanctuaries and other protected areas. Avoid high quality habitat areas, including birds and aquatic species. Avoid reefs, shoals, artificial reefs, shipwrecks, mining and sand/gravel extraction sites, dredge and other disposal sites, and military exercise zones.

¹¹ “The depth of the water affects the type of technology used to develop a given offshore wind resource project. Current offshore wind turbine technology uses monopoles and gravity foundations in shallow water (0 m to 30 m). In transitional depths (30 m to 60 m), tripods, jackets and truss-type towers will be used. Deep water (> 60 m depth) may require floating structures instead of fixed bottom foundations, but this technology is currently in an early stage of development.” **Assessment of Offshore Wind Energy Resources for the United States** Marc Schwartz, Donna Heimiller, Steve Haymes, and Walt Musial, *Technical Report NREL/TP-500-45889* June 2010

9. Natural Gas

Of the natural gas (NG) consumed in the U.S. in 2011, about 94% was produced domestically. Louisiana, New Mexico, Oklahoma, Texas, and Wyoming, currently account for 79 percent of domestic production, with the majority recovered from conventional reservoirs (i.e. coexisting with crude oil). However, the lower 48 states also contain substantial amounts of gas in unconventional reservoirs such as shale formations, coalbeds, and tight gas formations¹².

Description of NG-based Power Generation

Natural gas can be used to generate electricity in a variety of ways. Gas turbine power plants serve various functions in the production of electric power and may require one or more types of fuel. There are two main types of gas turbine plants: combined-cycle gas turbine (CCGT) and open-cycle or simple-cycle gas turbine (SCGT) plants. CCGT is the dominant gas-based technology for intermediate and base load power. CCGT is more significant regarding future transmission system planning than the smaller-sized and infrequently operated SCGT technology.

A CCGT plant consists of one or more gas turbine electricity generators equipped with heat recovery steam generators (HRSGs) to capture heat from the gas turbine exhaust. These HRSGs may be equipped with a bypass damper that allows the gas turbine to operate independently from the steam cycle. Steam produced in the HRSG powers a steam turbine generator to produce additional electric power.

The following resource criteria are for a nominal 500 MW CCGT plant.

¹² A tight gas reservoir is defined as gas contained in a geologic formation with relatively low permeability such that some extent of fracturing of the rock by artificial means (typically hydraulic fracturing) is required before an extraction well can recover gas at economically viable rates and volumes.

CCGT Power Generation	
Criteria for developing resource areas ¹³	
NG Supply and Pipeline	Proximity to NG Supply onshore production and Transmission Pipeline and Distribution Systems is desirable. However, a few critical natural gas supply issues that can impact site selection need to be addressed such as gas pressure, gas quality, gas supply, and gas delivery.
NG Storage	Siting of NG fired power generation plant in the proximity of NG Storage on Transmission Pipeline and or Distribution System is critical. Development of new storage and siting requirements will depend on the type of storage is constructed (such as salt cavern,
Cooling Water	Proximity to sufficient cooling water sources for combined cycle natural gas power generation unit is a must. Exact requirements
Slope	Land areas with high geographical slope are excluded. Exact requirements TBD.
Earthquake	Land with safe shutdown earthquake peak ground acceleration greater than (value TBD) is excluded.
Population	Exact requirements TBD.
Protected Lands	Protected lands (national parks, historic areas, wildlife refuges, etc.) are excluded.

Natural Gas Storage Technologies

Underground Natural Gas Storage: Natural gas is commonly held in inventory in three types of underground facilities across the lower 48 States; including: (1) depleted reservoirs in oil and/or natural gas fields, (2) aquifers, and (3) salt cavern formations. Individual sites vary with respect to key physical and economic characteristics, such as porosity, permeability, retention capability, site preparation and maintenance costs, deliverability/injection rates, cycling capability, and proximity to market. Underground storage facilities are generally developed near market centers. On a cold winter day, approximately 30-50% of the gas consumed in the colder region of U.S. is withdrawn from storage facilities.

Above Ground Natural Gas Storage: Liquefied Natural Gas (LNG) is natural gas that has been cooled to -259 °F at atmospheric pressure at which point it is condensed into a liquid. This refrigeration process occurs in a liquefaction plant. Liquefying natural gas reduces its

¹³ The table currently contains a preliminary list of criteria. At this point they are more qualitative in nature. During the project the Resource Focus Team will refine the list of criteria and develop specific quantifications.

volume to 1/600 of its volume in gas form, and allows it to be transported long distances or where pipeline transport is not feasible. LNG terminals store LNG above ground. The terminals are owned by various types of companies (large integrated gas companies, local distribution companies (LDCs), and independent and large oil companies). These companies purchase LNG overseas, offload it, gasify it and inject it into the transmission or distribution system for sale.

Underground Natural Gas Storage	
Criteria for developing resource areas ¹⁴	
Depleted oil and gas reservoirs	The most commonly used underground storage sites because of their wide availability. In the U.S., most existing gas is stored in depleted NG or oil fields that are close to consumption market centers. Conversion of a field from production to storage duty takes advantage of existing wells, gathering systems, and pipeline connections.
Aquifer	More expensive to develop than depleted reservoirs, they are usually developed close to market areas in regions such as the Midwest, where there are no nearby depleted oil and gas reservoirs. An aquifer is suitable for gas storage if the water bearing sedimentary rock formation is overlain with an impermeable cap rock. While the geology of aquifers is similar to that of depleted production fields, the use of aquifers in gas storage usually requires more base (cushion) gas and more monitoring of withdrawal and injection performance. In some areas, (particularly the U.S. Midwest), natural aquifers have been converted to gas storage reservoirs.
Salt Caverns	The majority have been developed in salt dome formations in the Gulf Coast states. Salt caverns have also been leached from bedded salt formations in Northeastern, Midwestern, and Southwestern states.
Other	There have been a few attempts to use abandoned mines for storage, and at least one such facility is operational. There have also been one or two attempts to use naturally occurring caverns in hard rock formations, but this type of storage facility has not moved beyond the testing phase.

¹⁴ The table currently contains a preliminary list of criteria. At this point they are more qualitative in nature. During the project the Resource Focus Team will refine the list of criteria and develop specific quantifications.

Above Ground Natural Gas Storage	
Criteria for developing resource areas ¹⁵	
Regulatory	The Federal Energy Regulatory Commission (FERC) grants federal approval for the siting of new onshore LNG facilities under the Natural Gas Pipeline Safety Act of 1968 and the Energy Policy Act of 2005 (P.L. 109-58). This approval process incorporates minimum safety standards for LNG established by the Department of Transportation (DOT). DOT is charged with issuing minimum safety standards for the siting, design, construction, and operation of LNG facilities. It does not approve or deny specific siting proposals, because that authority is vested with FERC. While the federal government is primarily responsible for LNG terminal safety and siting regulation, state and local laws, such as environmental, health and safety codes, can affect LNG facilities as well. Under the Natural Gas Pipeline Safety Act, a state also may regulate intrastate pipeline facilities if the state submits a certification under section 60105(a) or makes an agreement with the DOT under section 60106.
Safety Exclusion Zones	Federal safety regulations require LNG terminals to be surrounded by “exclusion zones” to protect neighboring communities in the event of a pool fire or flammable vapor cloud (49 C.F.R. §§ 193.2057, 2059). For FERC site approval, a prospective LNG terminal owner or a government agency must exercise “legal control” of activities within such zones.

¹⁵ The table currently contains a preliminary list of criteria. At this point they are more qualitative in nature. During the project the Resource Focus Team will refine the list of criteria and develop specific quantifications.

EISPC Energy Zones Workgroup

Attachment B: Identified Goals and Objectives, Desired Deliverables And Definition of Terms

FINAL – EISPC APPROVED JULY 27, 2011

Scope of Assistance by and Collaboration with the National Laboratories and Other Entities in Conducting EISPC's Energy Zone Study

At the completion of the study, EISPC should receive:

- Clear, consistent and practical methods and processes to identify energy resource areas in all states.
 - The study will identify the categories of energy resources relevant to the Eastern Interconnection and its states, as determined by the Workgroup and EISPC. The study will specify functional criteria to distinguish between those resources that are conducive to zonal analysis, and those that are readily developed without pre-defined zones. The National Labs will provide technical assistance in characterizing relevant resource types as zonal or non-zonal using criteria established by the Workgroup.
 - The National Labs will assist the Workgroup in conducting a preliminary assessment to guide subsequent and more detailed studies. Screening will be based on threshold economic viability as well as land use restrictions, and will apply state, regional and interconnection criteria as established and directed by the Workgroup.

- The National Labs will provide technical support in defining and characterizing the load zones for the Eastern Interconnection using criteria established by and under the direction of the Workgroup.
- An inventory of potential energy resource areas in all states. As part of this goal, a layered map should be developed showing potential resource areas for each targeted technology that could be overlaid to show the effect of combinations of certain resources or all of the resources that may vary according to regional policies, energy infrastructure, or other factors. The map may be presented with gradations for the quality of each potential resource area in addition to possible layers for later deployment of currently unavailable technologies.
 - The National Labs will assist the Workgroup and collaborate with other entities, such as the Association of State Fish and Wildlife Agencies, the National Association of State Energy Officials and other Agencies and Stakeholders, in compiling resource data, taking into account the screens developed in the preliminary assessment, technical constraints and other content.
 - The Workgroup and the National Labs will work with the Association of State Fish and Wildlife Agencies, the National Association of State Energy Officials (NASEO), other State Agencies and potentially other stakeholders to identify laws, regulations or policies or other factors that may inhibit the development of Clean Energy in certain areas.
 - The National Labs will host and maintain a geographical information systems (GIS) portal where the baseline data, considerations and constraints are represented as individual layers on an interactive map. These layers are processed to enable testing of various scenarios for potential energy resource areas.
 - As requested and directed by the Workgroup, the National Labs will assist in developing other data visualizations, user interface tools, and deliverables necessary to communicate the results of the analysis to stakeholders such as policy makers, regulators, transmission planners, and load-serving entities.
- An inventory of state and regional laws, policies and regulations to encourage and/or discourage certain types of targeted energy technologies in those jurisdictions will be considered. States will be the primary resource for identifying laws or policies that will discourage certain types of technologies or restrict development in certain geographic areas. A version of the layered map identified

above will be provided to the States for review to ensure consistency with laws or policies in each jurisdiction before the map is finalized.

- The National Labs will assist the Workgroup in collecting from the States the laws, policies and regulations pertaining to the development of energy resources. The review should include renewable portfolio standards, energy tariffs and generation production incentives as well as laws limiting development or moratoriums on certain types of generation.
- Clear, consistent and practical information regarding circumstances that may impact the potential development of energy resource areas into energy zones
 - As requested and directed by the Workgroup, the National Labs will assist the Workgroup in specifying the types of information to be obtained or developed for each resource area, such as capital costs, busbar costs, delivered cost, integration costs, capacity value, energy value, and other metrics deemed necessary and useful.
- Clear, consistent and practical methods and processes offered to federal, state and regional lawmakers and policymakers to use to evaluate energy resource areas for potential development into energy zones in all states
 - As requested and directed by the Workgroup, the National Labs will assist the Workgroup in defining, characterizing and analyzing representative development scenarios, including case assumptions and sensitivities.

As requested and directed by the Workgroup, the National Labs will assist the Workgroup's efforts ensure that each baseline data layer that is compiled for this study is available to policy makers and their staff in a transparent, well-documented, and user-friendly fashion.



ENERGY ZONES STUDY

A Comprehensive Web-Based Mapping Tool to Identify and Analyze Clean Energy Zones in the Eastern Interconnection



EISPC



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Energy Zones Study

A Comprehensive Web-Based Mapping Tool to Identify and Analyze Clean Energy Zones in the Eastern Interconnection

prepared by

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September 2013

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Preface

This report describes the work conducted in support of the Eastern Interconnection States' Planning Council (EISPC) Energy Zones Study and the development of the Energy Zones Mapping Tool performed by a team of experts from three National Laboratories. The multi-laboratory effort was led by Argonne National Laboratory (Argonne), in collaboration with the National Renewable Energy Laboratory (NREL) and Oak Ridge National Laboratory (ORNL).

In June 2009, the U.S. Department of Energy (DOE) and the National Energy Technology Laboratory published Funding Opportunity Announcement FOA-0000068, which invited applications for interconnection-level analysis and planning. In December 2009, the Eastern Interconnection Planning Collaborative (EIPC) and the EISPC were selected as two award recipients for the Eastern Interconnection. Subsequently, in 2010, DOE issued Research Call RC-BM-2010 to DOE's Federal Laboratories to provide research support and assistance to FOA-0000068 awardees on a variety of key subjects. Argonne was selected as the lead laboratory to provide support to EISPC in developing a methodology and a mapping tool for identifying potential clean energy zones in the Eastern Interconnection. In developing the EISPC Energy Zones Mapping Tool (EZ Mapping Tool), Argonne, NREL, and ORNL closely collaborated with the EISPC Energy Zones Work Group which coordinated the work on the Energy Zones Study.

The main product of the Energy Zones Study is the EZ Mapping Tool, which is a web-based decision support system that allows users to locate areas with high suitability for clean power generation in the U.S. portion of the Eastern Interconnection. The mapping tool includes 9 clean (low- or no-carbon) energy resource categories and 29 types of clean energy technologies. The EZ Mapping Tool contains an extensive geographic information system database and allows the user to apply a flexible modeling approach for the identification and analysis of potential energy zones and is publicly available at <http://eispctools.anl.gov>. In addition to enabling EISPC members and other stakeholders to identify areas with a high concentration of clean energy resources that could provide significant power generation in the future, another objective of the study was to promote open and transparent collaboration among state-level energy planning and regulatory agencies and to foster consistent and coordinated direction for regional and interconnection-level electricity analyses and planning.

Funding for the project was provided by DOE's Office of Electricity Delivery and Energy Reliability (DOE/OE) under the American Recovery and Reinvestment Act.

Acknowledgments

The three national laboratories—Argonne National Laboratory (Argonne), the National Renewable Energy Laboratory (NREL), and Oak Ridge National Laboratory (ORNL)—would like to acknowledge the excellent collaboration with the Eastern Interconnection States’ Planning Council (EISPC) and its Energy Zones Work Group. The Work Group members, led by Commissioner David Littell (Maine Public Utilities Commission), collaborated very closely with the three-laboratory project team and provided outstanding guidance and coordination for the Energy Zones Study. Special thanks are due to all EISPC staff, and, in particular, to former and current EISPC directors, Marya White and Valerie Lemmie, for the extraordinary support and direction they provided to the Energy Zones Study, as well as Bob Pauley, the EISPC Studies and White Papers Work Group lead. The laboratories would also like to acknowledge the following Energy Zones Work Group members, past and present: Hans Mertens (Vermont Department of Public Service), Jerry Lein (North Dakota Public Service Commission), Brian Rybarik (Wisconsin Public Service Commission), Michael Ryan (New Jersey Board of Public Utilities), Chairman Betty Ann Kane (District of Columbia Public Service Commission), C. Dukes Scott (South Carolina Office of Regulatory Staff), Allyn Powell (South Carolina Office of Regulatory Staff), Bob Leker (North Carolina Department of Commerce, State Energy Office), Michael Wegner (Kansas Corporation Commission), Brian Davison (Texas Public Utilities Commission), Delanie Breuer (Wisconsin Public Service Commission), Ed McNamara (Vermont Department of Public Service), and Ginny Kreidler (National Audubon Society).

The authors would also like to acknowledge the beneficial collaboration with the National Association of Regulatory Utility Commissioners (NARUC), National Energy Technology Laboratory (NETL), Eastern Interconnection Planning Collaborative (EIPC), and numerous other organizations with whom the three-laboratory team has interacted during this project. The project team would also like to acknowledge the Clean Energy States Alliance (CESA) for very close collaboration in implementing its energy policy and regulations database into the Energy Zones Mapping Tool, as well as Navigant Consulting for its contributions related to demand-side resources.

In addition, the project team is very grateful to numerous environmental and non-governmental organizations, including The Conservation Fund, NatureServe, National Audubon Society, The Wilderness Society, and many others, for their collaboration and active role in the Energy Zones Study. Many of these organizations provided valuable environmental information for the Study. In addition, many environmental experts volunteered their time and effort to serve on the Environmental Focus Group and provided valuable input and guidance to the project team regarding the use of environmental information and criteria in assessing the suitability of different geographical areas for clean energy resource development.

Finally, the project team would like to thank the U.S. Department of Energy’s Office of Electricity Delivery and Energy Reliability (DOE/OE) for supporting this work. Special thanks are due to David Meyer for outstanding management and coordination of the entire project and to Lawrence Mansueti for providing valuable input and direction to the project team.

Notation

Acronyms

AC	alternating current
AMI	Automated Metering Infrastructure
ANS	American Nuclear Society
Argonne	Argonne National Laboratory
AWST	AWS Truepower, LLC
BAU	business as usual
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement (formerly Minerals Management Service)
BWR	boiling-water reactor
C&I	commercial and industrial
CAES	compressed-air energy storage
CBECS	Commercial Building Energy Consumption Survey
CCGT	combined-cycle gas turbine
CCS	carbon capture and sequestration
CESA	Clean Energy States Alliance
CFB	coal fluidized bed
CO	carbon monoxide
COL	combined operating license
CO ₂	carbon dioxide
CSC	Costal Services Center
CSP	concentrating solar power
CVR	Conservation Voltage Reduction
DC	direct current
DLC	direct load control
DNI	direct normal irradiance
DOC	Department of Commerce
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DR	demand response
DSIRE	Database of State Incentives for Renewable Energy
EFG	Environmental Focus Group
EGS	enhanced geothermal system
EIA	Energy Information Administration
EIPC	Eastern Interconnection Planning Collaborative
EISPC	Eastern Interconnection States' Planning Council
EPA	U.S. Environmental Protection Agency
EPAct	Energy Policy Act of 2005
EPRI	Electric Power Research Institute

EZ	Energy Zone
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FRA	Federal Railroad Administration
GHI	global horizontal irradiance
GIS	geographical information system
HAP	Hydropower Advancement Program
HRSG	heat recovery steam generator
HTGR	high-temperature gas-cooled reactor
HVAC	heating, ventilation, and air-conditioning
IGCC	integrated gasification combined cycle
iPWR	integrated pressurized-water reactor
IRP	Integrated Resource Plan
LIPA	Long Island Power Authority
LNG	liquefied natural gas
LWR	light-water reactor
MCDSS	Multi-Criteria Decision Support System
MIT	Massachusetts Institute of Technology
MMS	Minerals Management Service
MSW	municipal solid waste
NADR	National Assessment of Demand Response
NARUC	National Association of Regulatory Utility Commissioners
NCSU	North Carolina State University
NEI	Nuclear Energy Institute
NETL	National Energy Technology Laboratory
NGA	National Geospatial-Intelligence Agency
NGNP	Next Generation Nuclear Plant
NGO	non-governmental organization
NHD	National Hydrography Dataset
NHDPlus	National Hydrography Dataset Plus
NOAA	National Ocean and Atmospheric Administration
NOS	National Ocean Service
NO _x	nitric oxides
NPD	non-powered dam
NRC	U.S. Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory

OpenEI	Open Energy Information
ORNL	Oak Ridge National Laboratory
OR-SAGE	Oak Ridge Siting Analysis for Power Generation Expansion
PC	pulverized coal
PHMSA	Pipeline and Hazardous Materials Safety Administration
PLMA	Peak Load Management Alliance
PM	particulate matter
PM _{2.5}	particulate matter with an aerodynamic diameter of 2.5 µm or less
PM ₁₀	particulate matter with an aerodynamic diameter of 10 µm or less
PSH	pumped storage hydroelectric
PV	photovoltaic
PWR	pressurized-water reactor
Reclamation	U.S. Bureau of Reclamation
RECS	Residential Energy Consumption Survey
RPS	Renewable Portfolio Standard
SMESE	superconductive magnetic energy storage
SMR	small modular reactor
SO ₂	sulfur dioxide
SO _x	sulfur oxides
SUNY	State University of New York
TBR	Time-Based Rate
TVA	Tennessee Valley Authority
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WSU	Washington State University

Units of Measure

bbl	barrel(s)
Bcf	billion cubic feet
Btu	British thermal unit(s)
°C	degree(s) Celsius
cfs	cubic feet per second
cm	centimeter(s)
°F	degree(s) Fahrenheit
ft	foot (feet)
ft ²	square foot (feet)

GJ	gigajoule(s)
gpm	gallons per minute
GW	gigawatt(s)
J	joule(s)
kg	kilogram(s)
km	kilometer(s)
kV	kilovolt(s)
kWh	kilowatt hour(s)
m	meter(s)
m ²	square meter(s)
MMBtu	1 million British thermal units
MW	megawatt(s)
MW(e)	megawatt(s) electric
MWh	megawatt hour(s)
ppm	part(s) per million
Qcf	quadrillion cubic feet
s	second(s)
Tcf	trillion cubic feet
TWh	terawatt hour(s) (10^{12} watt hour[s])
Wh	watt-hour(s)
yr	year(s)

Executive Summary

Background and Objectives

The Energy Zones Study was carried out by the Eastern Interconnection States' Planning Council (EISPC) in collaboration with three U.S. Department of Energy (DOE) National Laboratories. The multi-laboratory effort was led by Argonne National Laboratory (Argonne) in collaboration with the National Renewable Energy Laboratory (NREL) and Oak Ridge National Laboratory (ORNL).

The main purpose of the EISPC Energy Zones (EZ) Study was to develop a comprehensive mapping tool that would enable EISPC members and other stakeholders to identify areas within the U.S. portion of the Eastern Interconnection that are suitable for the development of clean (low- or no-carbon) electricity generation. This report details the methodologies used in developing the tool's many features and databases.

The EZ Study itself does not identify specific energy zones. Rather, its objective was to provide EISPC members and stakeholders with an interactive, web-based decision support system to assist them in identifying areas with a high density of clean energy resources that may potentially be designated as Clean Energy Zones. Defining and designating Clean Energy Zones is left to jurisdictional authorities in each state. In addition to enabling states and regions to identify areas with a high concentration of energy resources conducive to developing clean power generation, the second objective was to promote collaboration among state-level energy planning and regulatory agencies for regional and interconnection-level electricity analyses and planning.

The main tasks of the EISPC EZ Study can be summarized as follows:

- Compile clean energy resource data for nine clean energy resource categories;
- Develop a web-based geographical information system (GIS) mapping tool that utilizes clean energy resource availability information and flexible screening factors for identifying areas suitable for clean power generation;
- Provide policy and law information that encourages or inhibits potential clean energy resource development; and
- Conduct outreach and training so that states (and stakeholders) can use the tool to collaborate effectively on long-term regional transmission planning.

The work on the study was coordinated by the EISPC's Energy Zones Work Group. Funding for the EZ Study was provided by DOE's Office of Electricity Delivery and Energy Reliability (DOE/OE) under the American Recovery and Reinvestment Act.

Clean Energy Resources and Technologies

The EZ Study included an investigation of nine types of clean energy resources that could be considered for the development of clean (low- or no-carbon) electricity generation facilities in the U.S. portion of the Eastern Interconnection (Figure ES-1). These energy resources are:

1. Biomass,
2. Clean coal technologies with carbon capture and sequestration (CCS),
3. Geothermal,
4. Natural gas,
5. Nuclear,
6. Solar photovoltaic (PV) and concentrated solar thermal, as well as rooftop PV,
7. Storage (pumped storage hydroelectric and compressed-air energy storage),
8. Water (hydrokinetic and tidal power), and
9. Wind (land-based and offshore).

For each of these major categories, the resource data and information have been compiled, reviewed, and assembled into a web-based GIS database. Because an energy resource category may comprise multiple technologies for electricity generation that utilize different types of energy inputs, the database also includes a total of 29 clean energy technologies (Table ES -1).

The information in the database is accessible in the web-based EISPC Energy Zones Mapping Tool (EZ Mapping Tool) that allows stakeholders to identify potentially suitable areas for developing clean energy

resources or to analyze and determine potential clean energy zones. This tool contains an extensive library of GIS data layers, including energy resources, electrical transmission, oil and gas pipelines, protected lands, habitat, and other related information. It also includes interactive suitability models, a variety of reports that can be run and customized for user-specified regions, and a searchable energy policy and regulations database. The EZ Mapping Tool is publicly available on the web at <http://eispctools.anl.gov> (Figure ES-2).

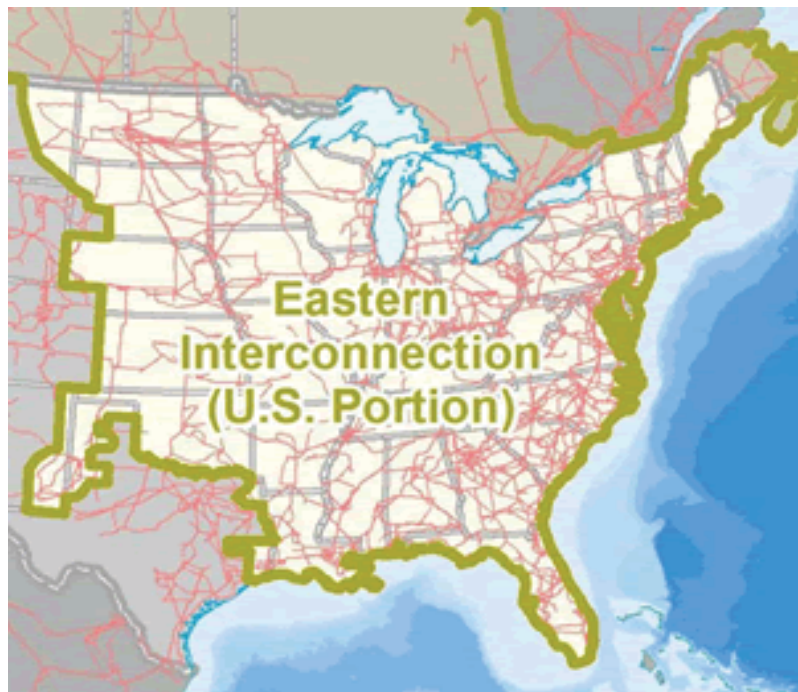


Figure ES-1 U.S. Portion of the Eastern Interconnection
(Source: Argonne National Laboratory)

Table ES-1 Clean Energy Resources and Technologies

Resource	Technology
Biomass	New biomass-fired plant with traditional combustion Biomass co-fired with existing coal plant Landfill gas extraction and plant inventory Methane extraction from wastewater treatment Methane extraction from animal manure processing
Clean Coal (with CCS)	New clean pulverized coal (PC) technology (subcritical and supercritical technologies) New integrated gasification combined cycle (IGCC) New coal fluidized bed (CFB) Retrofitting of existing pulverized coal (PC) with clean coal technology
Geothermal	Enhanced geothermal systems (EGS) Geopressured geothermal
Natural Gas	Combined cycle Underground natural gas storage Aboveground natural gas storage
Nuclear	Large light-water reactor Small modular reactor, integral pressurized-water reactor High-temperature gas-cooled reactor (HTGR)/very high temperature gas-cooled reactor (VHTR)
Solar	Concentrating solar power (CSP) Utility-scale photovoltaic (PV) Rooftop PV
Storage	Pumped storage hydroelectric (PSH) Compressed-air energy storage (CAES)
Water	Added output from existing hydropower dams New output from existing non-powered dams River and tidal hydrokinetic energy Marine tidal hydrokinetic energy Wave energy
Wind	Land-based wind turbines Offshore wind turbines

As one of the objectives of the study is to assist with the long-term regional and interconnection-level transmission planning process, the scope of the EZ Study includes the analysis of generation and storage technologies identified by the EISPC that are capable of providing grid-scale power generation. The EZ Mapping Tool may assist transmission planners by providing information on the areas within the Eastern Interconnection where a significant potential for new power generation exists, thus potentially requiring new transmission lines (or upgrades of existing ones) for transferring that power to electricity demand centers. For this purpose, the EZ Mapping Tool also includes a screening capability of potential future energy corridors. Just as the EZ Mapping Tool is designed for identifying potential geographical areas suitable for clean energy resource development and power generation and not for the siting of individual power plants, the corridor screening capability is designed for analyzing potential energy corridors and not for the siting of specific transmission lines or gas and oil pipelines. The corridor screening tool provides the capability to generate custom reports for potential energy corridors defined by the user. The report provides mileposted information along the corridor, including the states, counties, populated places it overlaps; major road, railroad, transmission line, pipeline, stream, and water body crossings; and other factors meaningful for corridor analysis. Reports can also be



Figure ES-2 Home Page for the EISPC EZ Mapping Tool

generated to examine environmental information for corridors, such as protected lands, sensitive habitats, and imperiled species.

With the exception of the rooftop PV solar resource, which is included because of its potential impact on the reduction of peak electricity demand and reduced need for new transmission lines, the EZ Study does not include analysis of distributed generation resources. Distributed energy resources and non-zonal technologies, such as demand response, energy efficiency, and smart grid, have been covered by separate studies and white papers commissioned by the EISPC. The main results and findings of these separate studies are included in the EZ Study and are available within the EZ Mapping Tool through the Rooftop PV and Demand Side Resources reports.

The geographical scope of the EZ Study for which the mapping of energy resources is provided includes the U.S. portion of the Eastern Interconnection. However, the policy and regulations database that is provided within the EZ Mapping Tool also covers the Canadian provinces that are part of the Eastern Interconnection.

Methodological Approach

Figure ES-3 illustrates the general modeling approach for identifying clean energy resource areas. The analysis can be performed either for a single clean energy resource or for a combination of resources or technologies (synergy analysis). The EZ Mapping Tool has more than 250 GIS data layers to which users can apply customized screening factors and other criteria. Users can analyze energy resource availability data under various scenarios, and the tool will provide customized maps depicting the suitability of different areas within the Eastern Interconnection for clean power generation based on criteria selected by the user. The EZ Mapping Tool database contains more than 100 environmental data layers to help ensure that protected lands, imperiled species, and other environmental factors are taken into account when determining the suitability of certain areas for clean energy resource development.

Suitability Models

Suitability models built into the tool allow users to identify areas suitable for the development of a specific clean energy technology. Starting with the energy resource information, the user can define which thresholds of the resource are suitable for the technology of interest. Other screening criteria are then applied to filter out areas unsuitable for resource development because of land use, ecological, and other constraints. For example, these types of criteria might exclude areas with high topographic slope, high population density, protected lands such as national and state parks, and sensitive habitat areas.

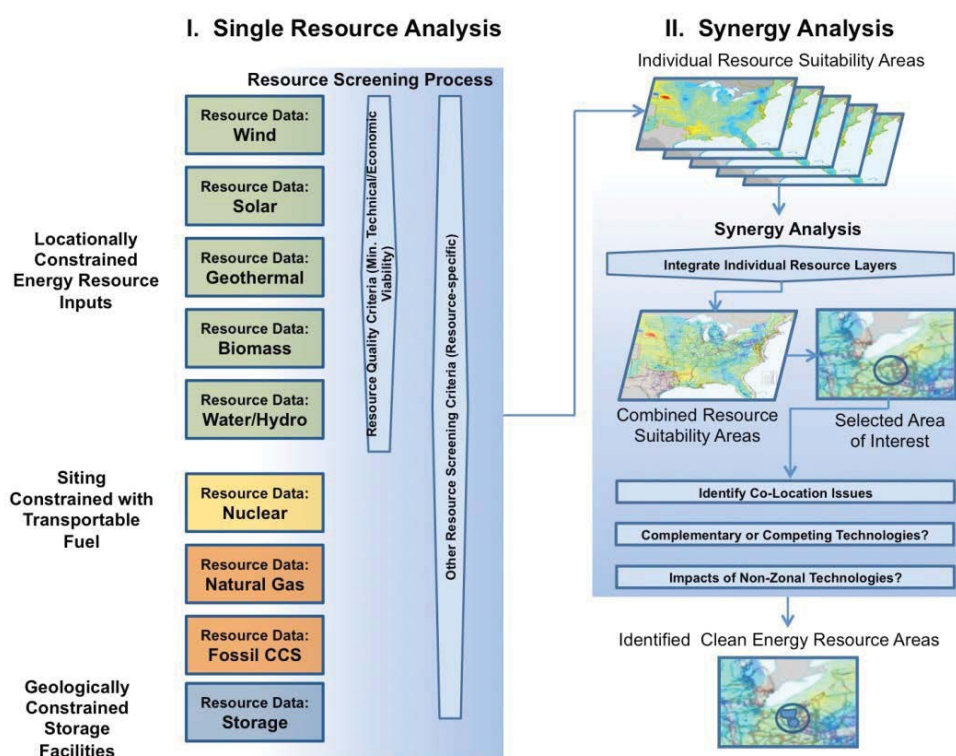


Figure ES-3 Methodology and Process for Identifying Clean Energy Resource Areas Using Single-Resource Analysis (I) and a Synergy Analysis (II)

Many of the screening factors represent terrain, land use, or other location-based characteristics that could affect whether areas can be developed, regardless of whether the energy resource itself is productive enough to be economical. For each location in the U.S. portion of the Eastern Interconnection, the “suitability” metric from these models combines the quality of the energy resource itself with factors that could limit development. Having selected an area based on its overall suitability, the user may then look more closely at the separate factors that affect whether development would be economical. Suitability scores generated by the models in the EZ Mapping Tool range from 0 (unsuitable) to 100 (best suitability). Results are dependent on the quality and accuracy of the input data, the user's choices about how to weight the importance of different parameters, and input suitability scores within each layer. They are intended to provide a regional screening-level analysis to compare locations with respect to the same technology. The models have not been calibrated to the level that suitability scores can be quantitatively compared across different technologies.

Figure ES-4 shows sample input mapping layers and criteria for the utility-scale PV model. Suitability model results include customized maps that show areas that fit user-specified screening factors and criteria with different suitability levels (Figure ES-5). These suitability levels for clean energy resource development are illustrated in the maps using a gradation of colors. For example, the areas with highest suitability for solar PV development are shown in red, while those with the lowest suitability are shown in black.

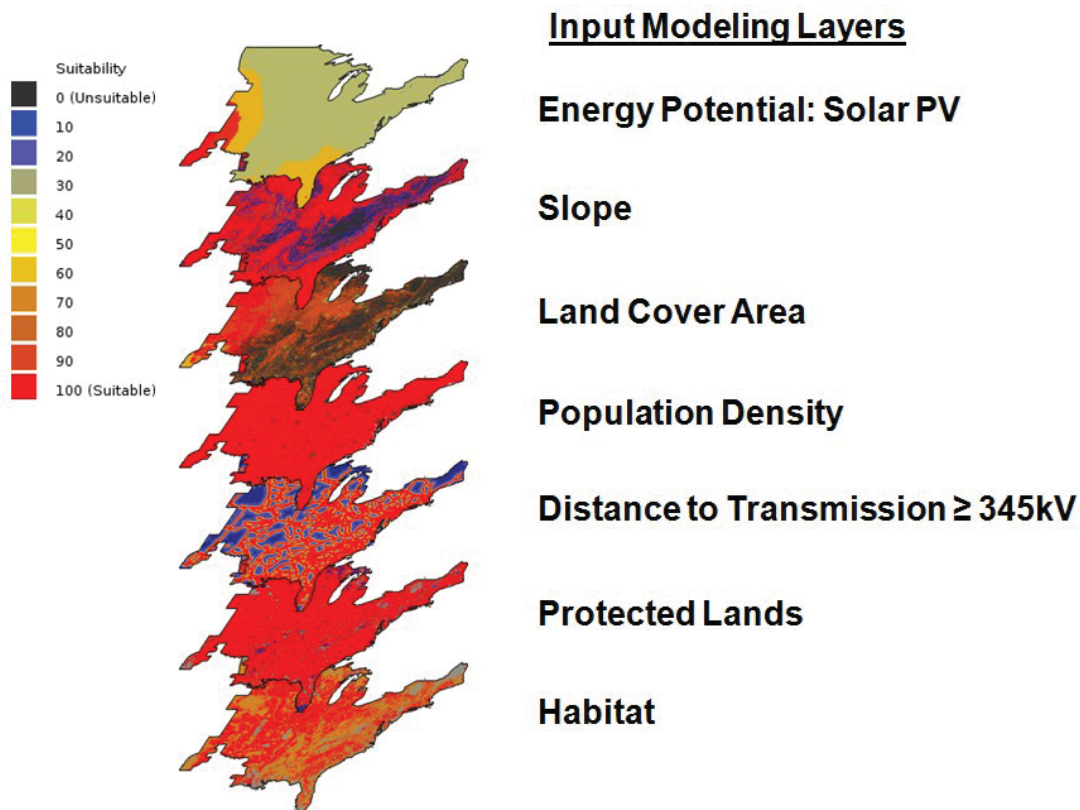


Figure ES-4 Sample Input Layers and Screening Criteria for Utility-Scale Solar PV Modeling

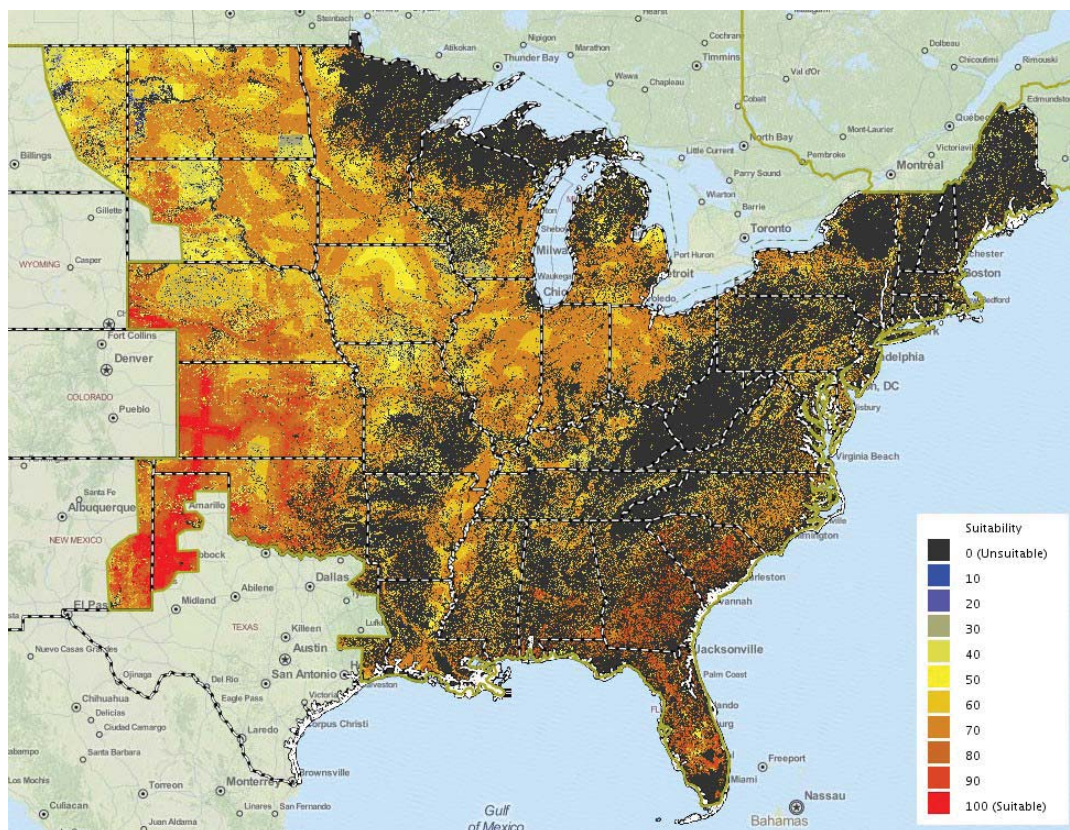


Figure ES-5 Draft Suitability Map for Solar PV Technology

Reports

In addition to customized suitability maps, the EZ Mapping Tool includes custom reporting capabilities for technologies that do not have suitability models. Several of the technologies included in the EZ Study are associated with either specific existing facilities, or are new technologies in early stages of development and/or deployment and lacked sufficient data for meaningful suitability models to be developed. The analysis approach for these technologies was therefore based on existing studies and plant or resource inventories rather than suitability modeling.

Reports can be run for an analysis area drawn on the map by the user or for a state or county of interest. The reports provide useful information pertaining to the technology that can help guide EZ planning. Figure ES-6 provides an example report for wave energy potential in the state of Maine.

Reports can also be run to obtain other information of interest in the process of identifying potential clean energy zones. Figure ES-7 provides an example of a report on protected lands for Livingston County in Illinois and surrounding areas.

Wave Energy Report

Location Analyzed: Maine

The area of interest is located at 45° 23' 21.874, 69° 14' 3.409.

It covers some or all of Androscoggin, Aroostook, Cumberland, Franklin, Hancock, Kennebec, Knox, Lincoln, Oxford, Penobscot, Piscataquis, Sagadahoc, Somerset, Waldo, Washington, and York in Maine and Carroll, Coos, and Strafford in New Hampshire.

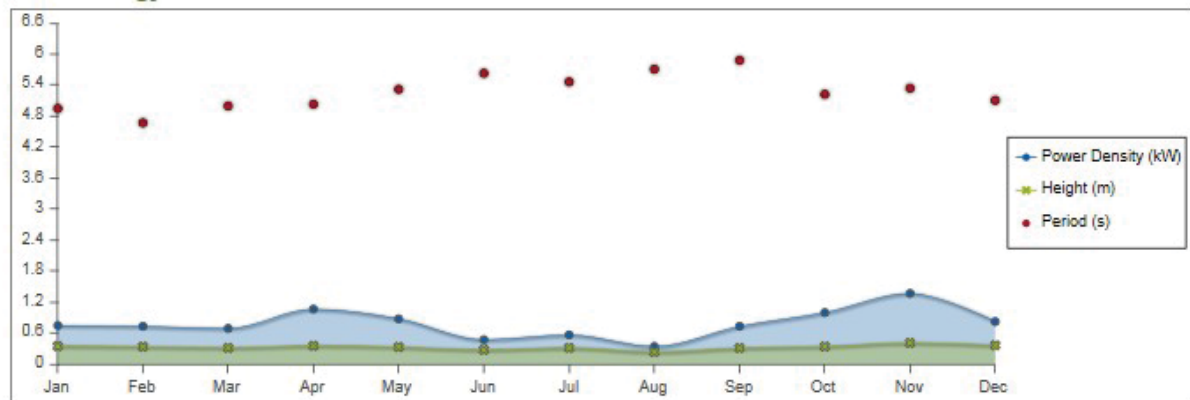
It has an area of 32161.176 square miles with surrounding buffers of areas 55954.438 and 82077.749 square miles.

Water Depth (m)

Minimum	Maximum	Mean
1.0	60.8	11.2

Source: [National Renewable Energy Laboratory; et al \(Wave Energy - Power Density\)](#).

Wave Energy



	Period ¹ (sec)	Power Density ² (kW)	Height ³ (m)	Hindcast Direction ⁴ (deg)
Annual	5.193	0.781	0.326	175.00
January	4.950	0.748	0.351	206.80
February	4.673	0.733	0.340	223.40
March	4.997	0.693	0.317	206.40
April	5.031	1.067	0.357	165.20
May	5.320	0.879	0.333	155.80
June	5.630	0.474	0.279	143.80
July	5.464	0.567	0.318	142.60
August	5.710	0.343	0.236	131.40
September	5.882	0.733	0.314	150.60
October	5.223	1.000	0.343	177.40
November	5.340	1.371	0.414	182.00
December	5.107	0.826	0.366	212.40

Figure ES-6 Sample Wave Energy Report

EISPC EZ Mapping Tool

Protected Lands Report

Location Analyzed: livingston, Illinois

Area of Interest is located at 40° 53'44.101" S 89° 13'

43.543.

It covers some or all of Ford, Grundy, Kankakee, La Salle, Livingston, McLean, and Woodford in Illinois.

It is an area of 1055.694 square miles with surrounding buffers of areas 6390.799 and 15567.503 square miles.

Mapping Color*	Recommendation
Red	Exclude from development
Orange	Develop with extreme caution
Yellow	Develop with caution

*Locations having three or more data sources with yellow classifications are reclassified as orange for modeling, but are listed individually as yellow in this report.

Protected Areas Database

Primary Designation Name	Owner Name	IUCN Category	GAP Status	Exists inside Analysis Area	Exists within 25 Miles of Analysis Area	Exists within 50 Miles of Analysis Area
Kankakee River	Other State	V - Protected landscape/seascape	3 - Permanent Protection: Subject to extractive (e.g. mining or logging) or OHV use			
Barnhart Prairie Restoration	Private Conservation	IV - Habitat or species management area	1 - Permanent Protection: Ecological disturbance events allowed to proceed			✓
Monticello's Sangamon River Land And Water Reserve	Private Conservation	V - Protected landscape/seascape	1 - Permanent Protection: Ecological disturbance events allowed to proceed			✓
Robert Allerton Park	Private Conservation	V - Protected landscape/seascape	1 - Permanent Protection: Ecological disturbance events allowed to proceed			✓
Robert Allerton Park	Private Conservation	V - Protected landscape/seascape	1 - Permanent Protection: Ecological disturbance events allowed to proceed			✓
Robert Allerton Park	Private Conservation	V - Protected landscape/seascape	1 - Permanent Protection: Ecological disturbance events allowed to proceed			✓
Weldon Springs	Other State	Unassigned	3 - Permanent Protection: Subject to extractive (e.g. mining or logging) or OHV use			✓
Lodge Park	Private Conservation	V - Protected landscape/seascape	1 - Permanent Protection: Ecological disturbance events allowed to proceed			✓
Lodge Park	Private Conservation	V - Protected landscape/seascape	1 - Permanent Protection: Ecological disturbance events allowed to proceed			✓
Robert Allerton Park	Private Conservation	V - Protected landscape/seascape	1 - Permanent Protection: Ecological disturbance events allowed to proceed			✓
Robert Allerton Park	Private Conservation	V - Protected landscape/seascape	1 - Permanent Protection: Ecological disturbance events allowed to proceed			✓
Monticello's Sangamon	Private	V - Protected	1 - Permanent Protection:			

Figure ES-7 Sample Protected Lands Report

Synergy Analysis

The main objective of synergy analysis is to integrate the results of multiple “single-resource” analyses and to produce a map showing the resulting concentrations, or clustering, of selected clean energy resources. In this process, the suitability maps developed during the single-resource analysis are used to develop a composite image showing the resulting areas suitable for the joint development of multiple energy technologies. The resulting map provides visual information of highly suitable areas which could be considered for further analysis. Figure ES-8 illustrates a composite map for land-based wind and solar PV resources.

On the basis of model results, data visualization, and the user’s own knowledge of energy planning, the user may examine an area of specific interest for possible development of a clean energy zone. First, the analysis will include examining potential co-location compatibility of different energy technologies within the selected area, mainly with regard to the land use (e.g., wind and biomass could be co-located using the same land area). Next, other potential compatibility or competing issues need to be identified, especially if two or more technologies are competing for the same resource (e.g., cooling water needs). Lastly, the potential impacts of non-zonal technologies should be considered, such as the smart grid, energy efficiency, and

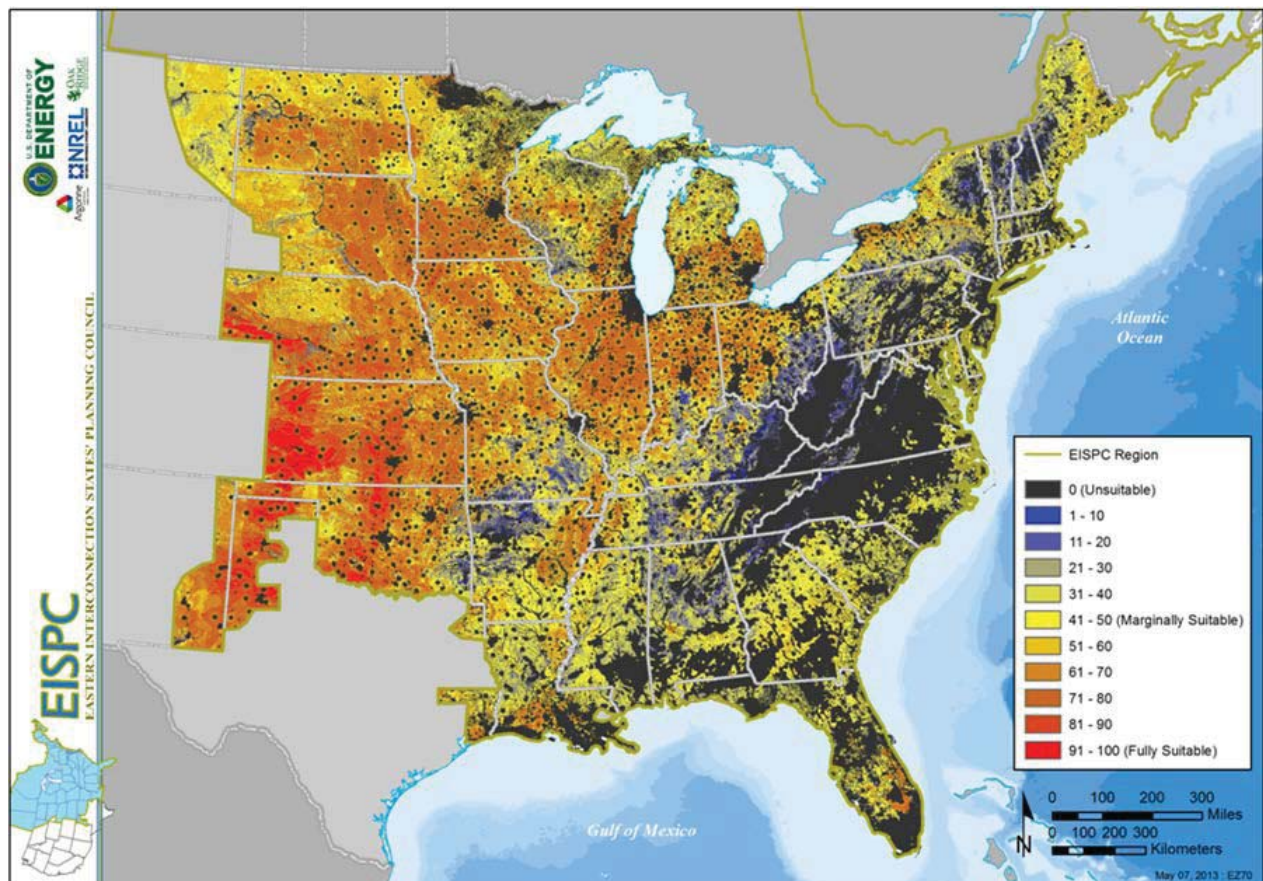


Figure ES-8 Synergy Results of Equally Weighted Solar PV and 80-m Land-Based Wind Models

demand response. In some cases, these non-zonal technologies may provide some positive synergies and enable wider penetration of certain clean energy resources (e.g., smart grid technology may support and accelerate the growth of rooftop solar generation).

Reviewing model results and analytical reports for the analysis area will provide information for which parts of the selected area of interest are most favorable for the development of multiple clean energy resources. This information may serve to identify potential clean energy zones that can support multiple co-existing technologies.

Energy Policy and Regulations Database

Finally, the user can check relevant energy policies and regulations pertaining to the area of interest for clean energy resource development. These energy policies may either promote or inhibit the development of certain energy technologies and resources.

The EZ Mapping Tool contains a database with a large inventory of laws, regulations, incentives, and other policies in the EISPC states related to clean energy electricity generation (Figure ES-9). The policies and regulations database was developed by the Clean Energy States Alliance (CESA). It connects to and incorporates other online databases through NREL's Open Energy Information (Open EI). The EZ Mapping Tool incorporates the database with a tab in the main navigation bar that allows the user to search for the policies and regulations by any combination of four main query boxes: political entity, policy type, implementation sector, and affected technologies. The search results are provided and include state-level summaries of the applicable policies.

The screenshot displays the EISPC EZ Mapping Tool interface. At the top right, there are links for 'Help' and 'My Account'. The main header reads 'EISPC EZ Mapping Tool'. Below this is a navigation bar with links: 'About the Study', 'Energy Resources', 'Data', 'Policies & Regs' (highlighted), 'Maps', 'Documents', 'Links', and a 'Launch Tool' button. The main section is titled 'Search for Policies & Regulations' with a note: 'Provide policy updates or edits to eispcctools@anl.gov'. Below this, a default search instruction states: 'By default, a search will return every available policy and regulation, up to a maximum of 200. To narrow your result set, select up to 10 filter items total from the four fields below.' The search interface consists of four columns of filter boxes: 'Country/State/Province' (listing US-National, Canada-National, Alabama, Arkansas, Connecticut, Delaware, District of Columbia, Florida, Georgia), 'Policy Type' (listing Bond Program, Climate Policies, Corporate Tax Incentive, Enterprise Zone, Environmental Regulations, Equipment Certification, Equity Investment, Fees, Generation Facility Rate-Making), 'Implementation Sector' (listing Federal, Local, Non-Profit, State/Province, Utility), and 'Affected Technologies' (listing Biomass/Biogas, Coal with CCS, Concentrating Solar Power, Energy Storage, Fuel Cells, Geothermal Electric, Hydroelectric, Natural Gas, Nuclear). A 'Search' button is located below the filter boxes. At the bottom right, there are links for 'Privacy/Security', 'News', 'About Us', 'User Community', and 'Contact Us'.

Figure ES-9 Policy and Regulations Database

Environmental Considerations

Environmental data layers and information have been fully incorporated into the EZ Mapping Tool's methodology and process for identifying potential clean energy zones, and environmental screening factors are included in each suitability model.

Environmental screening factors were grouped into three model input layers: Protected Lands, Habitat, and Imperiled Species, and categorized with sensitivity levels related to energy development. The protected lands and habitat environmental screening layers are composites made from many individual datasets. Selection of the included layers and determination of sensitivity levels were guided by an Environmental Focus Group (EFG). The EFG included subject matter experts from federal and state agencies, environmental non-governmental organizations (NGOs), and industry stakeholders.

Conclusions

The EZ Mapping Tool provides an extensive library of energy resource data and other relevant information useful for identifying potential areas suitable for clean energy resource development. It also includes interactive suitability models, a variety of reports that can be run and customized for user-specified regions, and a searchable energy policy and regulations database. The EZ Mapping Tool provides the user with a very flexible and well-documented web-based decision support system developed with open-source programming libraries, highly scalable cloud architecture for the server, a form-based administrative interface for maintaining the content, and flexible user interfaces for the GIS map layer library, models, and reports. The EZ Mapping Tool was publicly launched at the end of March 2013 and is already being accessed by a large number (more than 600 as of August 2013) of federal and state energy planners, NGOs, grid operators, energy industry professionals, and researchers.

1 Introduction

This section provides the background, goals and objectives, scope, and approach of the Energy Zones (EZ) Study and describes the organization of the report.

1.1 Background

The Eastern Interconnection States' Planning Council (EISPC) EZ Study included an investigation of nine types of energy resources to be considered for development of clean energy generation facilities in the U.S. portion of the Eastern Interconnection (Figure 1-1). These energy resource types are (1) biomass, (2) clean coal technologies with carbon capture and sequestration (CCS), (3) geothermal, (4) natural gas, (5) nuclear, (6) solar (photovoltaic [PV] and concentrated solar thermal, as well as rooftop PV), (7) storage (pumped storage hydro and compressed-air energy storage [CAES]), (8) water (hydrokinetic and tidal 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 accessible in a web-based EISPC Energy Zones Mapping Tool (EZ Mapping Tool) that is available at <http://eispctools.anl.gov>. The EISPC EZ Mapping Tool will allow stakeholders to identify potentially suitable areas for developing clean energy resources or to determine potential clean energy zones. Because an energy resource category may comprise multiple technologies for electricity generation that utilize different types of energy inputs, the database also includes a total of 29 clean energy technologies (Table 1-1).

The EZ Mapping Tool incorporates numerous models for which the user can specify custom screening factors. Many of these screening factors represent terrain, land use, or other location-based characteristics that could affect whether areas can be developed, regardless of whether the energy resource itself is productive enough to be economical. When the screening factors are combined with energy resource data (map layers showing the locational productivity of wind, solar energy, or other resources) in the models, maps of suitable areas are provided.

The “suitability” metric from these models combines the locational quality of the energy resource itself with locational factors that could limit development. Having selected an area based on its overall suitability, the user may then look more closely at the separate factors that affect whether development would be economical. Suitability scores generated by the models in the EZ Mapping Tool range from 0 (unsuitable) to 100 (best suitability) and are dependent on the quality and accuracy of the input data, the user's choices about how to weight the importance of different parameters, and input suitability scores within each layer. They are intended to provide a regional screening-level analysis to compare locations with respect to the same technology. The models have not been calibrated to the level that suitability scores can be quantitatively compared across different technologies.

This EISPC EZ Study was a collaboration of three National Laboratories. Study team members from Argonne National Laboratory (Argonne), the National Renewable Energy Laboratory (NREL), and Oak Ridge National Laboratory (ORNL) provided analytical and model development support to the EISPC.

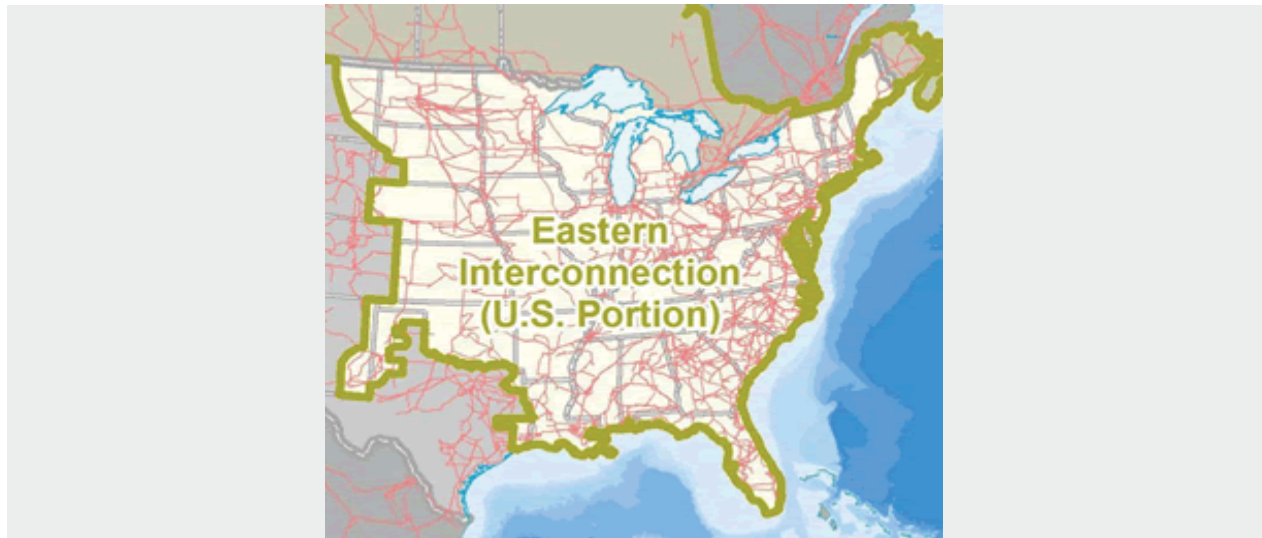


Figure 1-1 U.S. Portion of the Eastern Interconnection (Source: Argonne National Laboratory)

Table 1-1 Clean Energy Resources and Technologies

Resource	Technology
Biomass	New biomass-fired plant with traditional combustion
	Biomass co-fired with existing coal plant
	Landfill gas extraction and plant inventory
	Methane extraction from wastewater treatment
	Methane extraction from animal manure processing
Clean Coal (with CCS)	New clean pulverized coal (PC) technology (subcritical and supercritical technologies)
	New integrated gasification combined cycle (IGCC)
	New coal fluidized bed (CFB)
	Retrofitting of existing pulverized coal (PC) with clean coal technology
Geothermal	Enhanced geothermal systems (EGS)
	Geopressured geothermal
Natural Gas	Combined cycle
	Underground natural gas storage
	Aboveground natural gas storage
Nuclear	Large light-water reactor
	Small modular reactor, integral pressurized-water reactor
	High-temperature gas-cooled reactor (HTGR)/very high temperature gas-cooled reactor (VHTR)
Solar	Concentrating solar power (CSP)
	Utility-scale photovoltaic (PV)
	Rooftop PV
Storage	Pumped storage hydroelectric (PSH)
	Compressed-air energy storage (CAES)
Water	Added output from existing hydropower dams
	New output from existing non-powered dams
	River and tidal hydrokinetic energy
	Marine tidal hydrokinetic energy
	Wave energy
Wind	Land-based wind turbines
	Offshore wind turbines

1.2 Goals and Objectives

The Laboratories supported EISPC in addressing the following EZ Study goals and objectives:

- To provide information to identify (in map form) and to inventory opportunities for developing resources in all states and regions in the Eastern Interconnection that could potentially be used to support the development of energy facilities defined by the EISPC Energy Zones Work Group. Also, to develop a suite of methodologies that lays out the process for identifying EZs that support public policy objectives;
- To provide information to regions and states regarding circumstances (e.g., environmental factors, population densities) that could inhibit or prevent the potential development of energy infrastructure within areas containing identified energy resources and offer potential solutions;
- To enable the states to inform and collaborate in stakeholder generation and transmission planning within the time frames of the other EISPC modeling efforts, which is generally to 2030. Also, to include technologies and resources developed on both a long- and short-term basis; and
- To focus analysis on identifying resource areas in the Eastern Interconnection that have sufficient energy resources in concentrated areas. Depending on their locations in relation to load centers, such concentrated energy resource areas could potentially be developed to either avoid the need for transmission construction or to optimize transmission planning.

The Laboratories provided EISPC with a decision support tool that facilitates regional collaboration among states for planning future generation and transmission expansion, so that these states can achieve their energy policy objectives in the most efficient manner.

1.3 Scope

The scope of this study includes the U.S. portion of the Eastern Interconnection as described in Section 1.1. It also includes analysis of generation and storage technologies identified by EISPC and capable of grid-level power production. The study does not include analysis of distributed resources that generate electricity from many small energy sources, with the exception of rooftop photovoltaic.

1.4 Approach

The analysis approach and the EISPC EZ Mapping Tool enable stakeholders to identify, on a map, clean energy resource areas in the U.S. portion of the Eastern Interconnection that could potentially be developed as EZs. The EZs are not predefined in the study or the EZ Mapping Tool.

The EZ Mapping Tool will enable EISPC stakeholders to perform analyses and identify clean energy resource areas for potential generation development within the entire Eastern Interconnection or their state or region of interest. To perform this analysis, the web-based tool will allow EISPC stakeholders to use energy resource availability, flexible screening parameters, and other user-defined criteria to develop customized maps depicting the suitability of different areas within the Eastern Interconnection for clean energy resource development. The stakeholders will be able to perform custom-analysis for a single clean energy resource or for two or more energy resources by taking possible synergies among the resources into account. The synergy analysis will highlight areas suitable for more than one technology of interest and consider both positive synergies, where energy projects would complement each other, and negative synergies, where energy projects would compete with each other.

The EZ Mapping Tool may assist transmission planners by providing information on the areas within the Eastern Interconnection where a significant potential for new power generation exists, thus potentially requiring new transmission lines (or upgrades of existing ones) for transferring that power to electricity demand centers. For this purpose, the EZ Mapping Tool also includes a screening capability of potential future energy corridors. Just as the EZ Mapping Tool is designed for identifying potential geographical areas suitable for clean energy resource development and power generation and not for the siting of individual power plants, the corridor screening capability is designed for analyzing potential energy corridors and not for the siting of specific transmission lines or gas and oil pipelines. The corridor screening tool provides the capability to generate custom reports for potential energy corridors defined by the user. The report provides mileposted information along the corridor, including the states, counties, populated places it overlaps; major road, railroad, transmission line, pipeline, stream, and water body crossings; and other factors meaningful for corridor analysis. Reports can also be generated to examine environmental information for corridors, such as protected lands, sensitive habitats, and imperiled species.

1.5 Report Organization

The remainder of the report includes the following sections: Section 2, Methodology and Process for Identifying Clean Energy Resource Areas, which describes the general suitability modeling approach for identifying clean energy resource areas; Section 3, Clean Resource/Technology Options, which discusses the resources and technologies included in the study and possible synergistic effects of the technologies; Section 4, Environmental Considerations, which discusses the environmental screening layers included in the study; Section 5, Policy, Demand Response, and Smart Grid Considerations, which discusses their role in determining areas for potential EZs; Section 6, EISPC EZ Mapping Tool Overview and Tutorial, which describes the EZ Mapping Tool functions; Section 7, Case Studies and Interpreting Results, which describes the EZ Mapping Tool capabilities and how the tool can be utilized; Section 8, Recommendations for Future Work, which describes possible follow-up activities to this project; and Section 9, Bibliography. Appendices A, B, C, D, and E follow Section 9.

2 Methodology and Process for Identifying Clean Energy Resource Areas

2.1 Modeling Approach

Figure 2-1 illustrates the general modeling approach for identifying clean energy resource areas. The energy resources are grouped into several categories related to the main type of their constraints. The first group includes resources with energy potential primarily dependent on geographical location. These resource types include wind, solar, geothermal, biomass, and water (hydroelectric potential). The second group represents resources with energy potential primarily dependent on siting-related constraints—an example being nuclear technologies which have transportable fuel but are heavily dominated by other siting constraints, and natural gas technologies which are dominated by the proximity of existing large-diameter natural gas lines. The siting of energy storage facilities, such as CAES, is dominated by siting factors which require the existence of favorable geological formations for the economical construction of these facilities. Specifically, CAES plants typically need large air-tight underground caverns to store air under high pressure. Finally, clean coal technologies are positioned between nuclear and storage technologies because, similar to the nuclear technologies, they have transportable fuel, but are geologically constrained like CAES energy storage because they require underground caverns to store the carbon dioxide (CO₂) captured during plant operation. Suitability maps for individual energy resources can then be combined to identify locations suitable for multiple resources, and then analyzed in terms of the ways technologies exploiting the resources might compete with or complement each other.

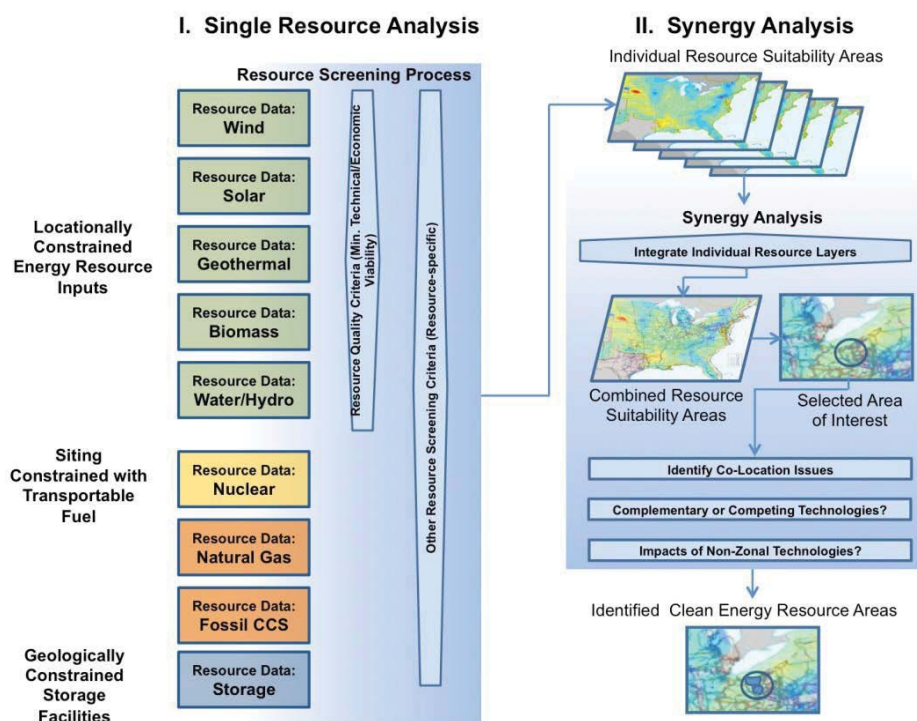


Figure 2-1 Methodology and Process for Identifying Clean Energy Resource Areas Using Single-Resource Analysis (I) and a Synergy Analysis (II)

For each major technology category shown in Figure 2-1, the resource data and information were compiled, reviewed, and assembled into a GIS database. The information in the database is accessed by a web-based tool that allows the stakeholders to identify areas suitable for developing clean energy resources. The analysis can be performed either for a specific clean energy resource (single-resource analysis) or for a combination of two or more energy resources or technologies (synergy analysis). The methodology for identifying single-resource areas involves the following major steps:

I. Single-Resource Analysis

- a. Select a clean energy resource of interest by choosing a model from the model catalog.
- b. Review the default layers in the model and add additional layers from the modeling layers catalog if required. Layers may also be removed if desired.
- c. Modify the importance of each layer present in the model by adjusting its weight.
- d. Modify the individual suitability of each feature within a layer.
- e. Run model and add model results to the map.
- f. If desired, add additional overlay layers such as energy infrastructure layers to provide visual information on how well the resulting energy resource areas are supported by the existing (and projected future) energy infrastructure facilities (e.g., transmission system, railroad network).
- g. Input area(s) of interest for a potential clean EZ development and further analysis. The area considered is expected to be a smaller geographical area, typically a state or part of a state. In addition, a geographical area with sufficient energy generation potential to justify a new transmission line could be of interest as an analysis area.
- h. Choose reporting options to run on the analysis area.
- i. Check relevant energy policies and laws for statutory and regulatory issues (e.g., land use exclusions or other policies and laws providing incentives or disincentives for the development of certain clean energy resources).
- j. Print or save the results of the analysis.

II. Synergy Analysis

- a. Perform single-resource analyses for selected clean energy resources.
- b. Develop a customized map by combining the suitability area maps for selected clean energy resources. This user-developed customized map will provide visual information regarding the concentration (or clustering) of different clean energy resources and indicate potential high-energy density areas which could be developed into clean EZs.
- c. Input area(s) of interest for a potential clean EZ development and further analysis. The area considered is expected to be a smaller geographical area, typically a state or part of a state.
- d. Identify potential co-location compatibility of different technologies within the selected area.
- e. Identify possible impacts of complementary or competing technologies.
- f. Identify potential impacts of non-zonal resources and technologies (e.g., demand response, energy efficiency, and smart grid).

- g. Print or save the results of the analysis.

More details on each of the process steps are provided in Sections 2.3 and 2.4.

2.1.1 Methodology for Analysis of Rooftop PV

The methodology for mapping the resource potential of rooftop PV is different from that for the other resources included in this analysis. First, the location of rooftop solar resource areas is not the main concern because location is primarily a function of known factors such as urban space and building density. Second, the ability of rooftop solar to offset demand within a high-load area is unique among the resources analyzed. Transmission is unnecessary to deliver the rooftop PV generated electricity to a load center, but more significantly, a high penetration of rooftop solar can change the peak load within a control area (or within a transmission-congested part of the control area). This in turn could affect planning for transmission to deliver power to the area. The questions most pertinent to this project, therefore, have to do with the characteristics of rooftop PV at known population centers. Figure 2-2 illustrates the approach for the analysis of rooftop solar PV and its load offset potential.

Mapping rooftop PV potential combines two analytical threads: population and buildings stock (residential, commercial, and industrial), and the amount of sunshine the area has during a typical year. This analysis relies on recent estimates of the building stock rooftop area that is potentially available for solar PV, aggregated by county. The data used for this are from NREL.

Not all of the rooftop surface can be utilized for solar PV, however. Out of what can be used, owners often choose to install less PV than the roof can actually accommodate. Most rooftop PV is sized commensurate with the amount of electricity consumed within the building where it is installed. Surplus power may flow to the grid during clear midday hours, but over a typical day or year, the net surplus fed back into the electric system is usually small. In addition, the level of rooftop solar market penetration may be affected by policies such as the availability of net metering, rebates, feed-in tariffs, and potential smart grid technologies in the future.

The results generated by the rooftop PV model are presented in report format. The user determines the geographic extent for the results by using an analysis area drawn on the map or

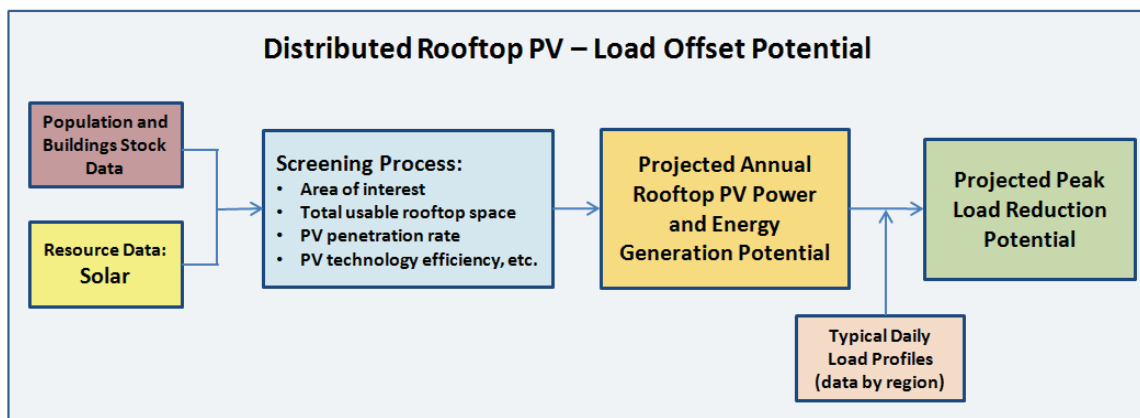


Figure 2-2 Methodology for Identifying Rooftop Solar PV Resource Potential

by choosing a pre-existing boundary such as a county or state. Pre-computed results of the model are then summarized in the report, by county, including different efficiency levels based on current and future panel efficiency and on the inverter efficiency to transform direct current (DC) power to alternating current (AC).

Annual insolation during a typical year in the area selected for analysis is also used for the calculations. The annual energy estimates draw on NREL's data for solar resource potential. This particular dataset assumes that PV panels are installed facing south and tilted at an angle equal to the latitude of the site. Rooftop availability data are from work conducted at ORNL.

The report includes:

- Rooftop PV power potential (megawatt [MW] capacity),
- Peak load reduction potential (MW contribution to peak), and
- Annual energy generation (megawatt hours per year [MWh/yr]).

The methodology for this task is not intended to evaluate the solar capabilities of a specific site. Rather, its purpose is to estimate load reduction from rooftop PV generation across a larger jurisdiction, aggregated on a per-county level.

2.2 GIS-Based Multi-Criteria Decision Support System (EZ Mapping Tool)

A web-based mapping tool (EZ Mapping Tool) was developed during the project as part of this EZ Study. This web-based tool is a GIS-based, Multi-Criteria Decision Support System (MCDSS), with a set of operation options to guide the analysis. The analytical process involves a number of steps which may also be customized by the user depending on the type of clean energy resource being analyzed, the area of interest, and other user-specified parameters. This will allow for an analysis that can be tailored to the specific needs of each user and will result in customized maps of areas suitable for clean energy resource development. The MCDSS methodology and the EISPC EZ Mapping Tool are not intended to provide the means for a detailed siting analysis of any specific clean energy project. Rather, the intention is to enable stakeholders to identify clean energy resource areas that could have the potential to be developed as EZs in a map form.

2.3 Single-Resource Analysis

To identify areas suitable for the development of a specific clean energy technology, the user can perform a screening process using the web-based EISPC EZ Mapping Tool (Figure 2-3). Starting with the energy resource a user can, in order to focus only on areas which satisfy certain economic or technical criteria, define which thresholds of the resource are suitable for the technology of interest. Other screening criteria are then applied to filter out areas unsuitable for resource development because of land use, ecological, and other constraints. For example, these types of criteria might exclude areas with high topographic slope, high population density, protected lands such as national and state parks, and sensitive habitat areas. Then, a customized map is computed using a geometric mean calculation based on the layers selected and layer

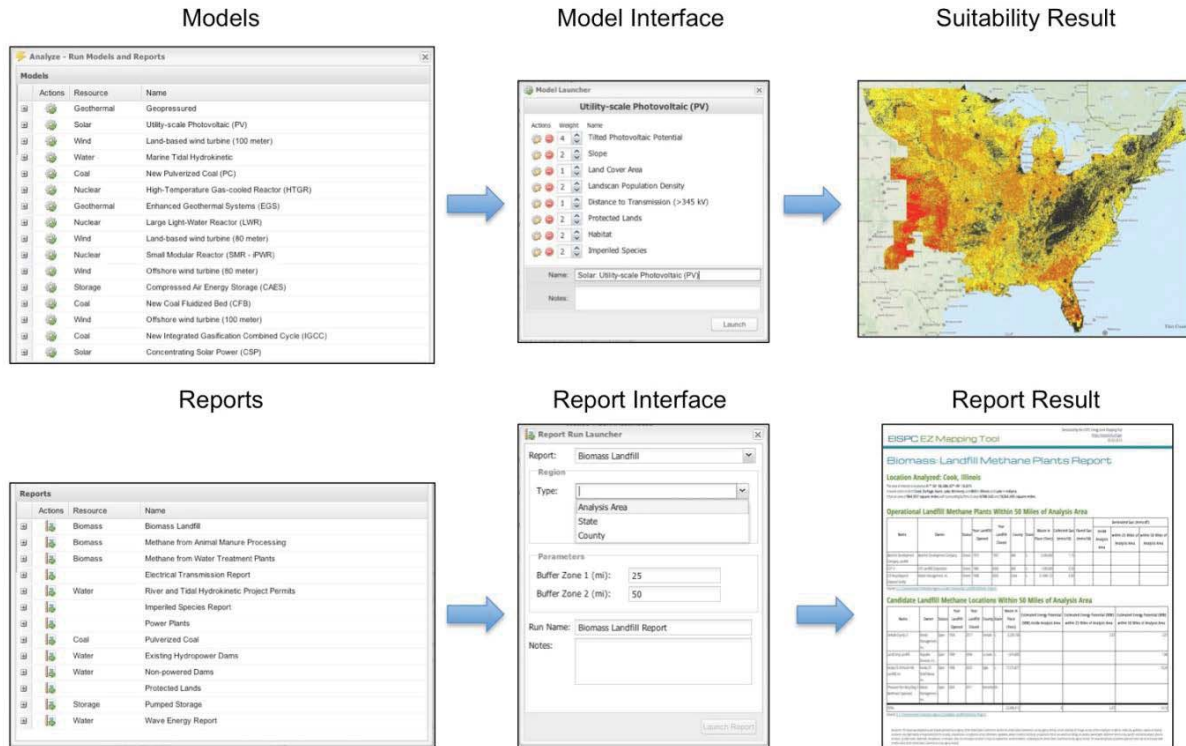


Figure 2-3 General Methodology for a Single-Resource Analysis Model (top) and Report (bottom)

parameters. Figure 2-4 provides an example of sample input mapping layers for the utility-scale PV model. The resulting suitability map is depicted as a range of high to low suitability levels to highlight the areas most suitable for developing the selected clean energy resource. These suitability levels for clean energy resource development are illustrated in the maps using a gradation of colors. For example, the areas with highest suitability for solar PV development are shown in red, while those with the lowest suitability are shown in black.

Maps of energy infrastructure facilities (e.g., transmission grid, pipeline network) can be superimposed on the model results to show the proximity of the energy infrastructure to high-suitability areas.

2.3.1 Single-Resource Suitability Modeling

Single-resource analysis begins with the selection of one of the technologies listed in Figure 2-5. For most of these technologies, the system will then display a dialog similar to the one in Figure 2-6, which shows an example of a land-based wind turbine (100-meter [m]) model. The dialog will default to predetermined energy resource and screening layers, with predetermined suitability levels; however, users have the ability to add or remove screening layers, adjust the weights for the layers, and edit the suitability values within particular layers. For the energy resource, a minimum threshold level can be specified, such as the following examples:

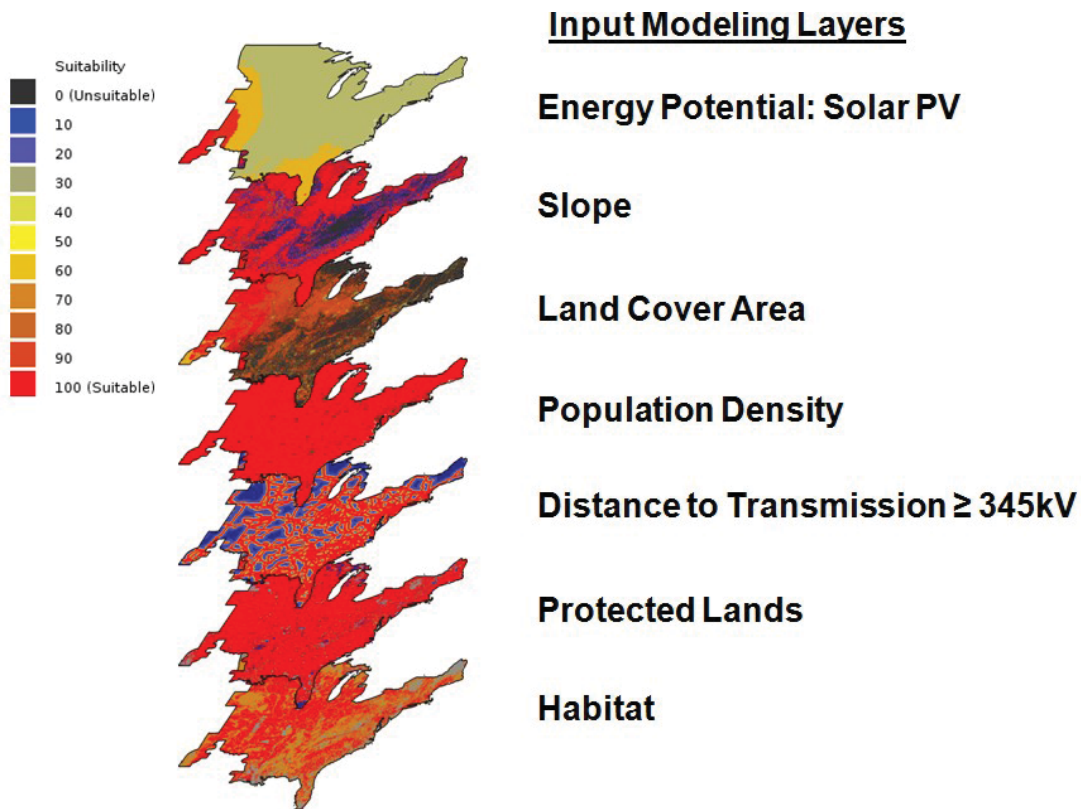


Figure 2-4 Sample Input Layers for Utility-Scale Solar PV Modeling

- Land-based wind turbine: wind gross capacity factor $\geq 30\%$ at turbine height of 80 or 100 m,
- Concentrating solar: > 5.0 kilowatt hours per square meter per day ($\text{kWh}/\text{m}^2/\text{day}$) annual average direct normal solar resource, or
- Enhanced geothermal: Favorability class \geq Medium (on a scale with 5 levels).

See Appendix A for additional details about screening factors.

For biomass technologies, there are many potential fuel sources, and the U.S. Department of Energy (DOE) Billion-Ton Study database used in the project includes annual estimates from the present to 2030, which allows the user to choose the fuel sources and year of interest.

The interface allows the exclusion criteria for each screening layer to be adjusted. Figure 2-7 shows an example window for adjusting the suitability of each resource interval (left) and a non-resource layer (right), which uses categorical intervals. For some layers, the user may specify a specific threshold value that will delineate clearly suitable and non-suitable areas, while other layers may have gradations of suitability. Screening layers can be removed from the model by clicking an icon next to the layer, and layers may also be added from the modeling layer catalog if desired.

Models			
	Actions	Resource ▲	Name
+		Biomass	New Biomass-fired Plant with Traditional Combustion
+		Biomass	Biomass Co-Fire With Existing Coal Plant
+		Coal	New Pulverized Coal (PC)
+		Coal	New Coal Fluidized Bed (CFB)
+		Coal	New Integrated Gasification Combined Cycle (IGCC)
+		Geothermal	Geopressured
+		Geothermal	Enhanced Geothermal Systems (EGS)
+		Natural Gas	New Combined-Cycle Gas Turbine (CCGT)
+		Nuclear	High-Temperature Gas-cooled Reactor (HTGR)
+		Nuclear	Large Light-Water Reactor (LWR)
+		Nuclear	Small Modular Reactor (SMR - iPWR)
+		Solar	Utility-scale Photovoltaic (PV)
+		Solar	Concentrating Solar Power (CSP)
+		Storage	Compressed Air Energy Storage (CAES)
+		Water	Marine Tidal Hydrokinetic
+		Wind	Land-based wind turbine (100 meter)
+		Wind	Land-based wind turbine (80 meter)
+		Wind	Offshore wind turbine (80 meter)
+		Wind	Offshore wind turbine (100 meter)

Figure 2-5 Resource Technology Model Options

Model Launcher

Land-based wind turbine (100 meter)

Actions	Weight	Name
	5	Wind Turbine Gross Capacity Factor (100m)
	2	Slope
	2	Land Cover Area
	1	Population Density (with 2 mile buffer)
	1	Distance to Major Road
	2	Distance to Airport Runway
	3	Distance to Transmission (>345 kV)
	3	Protected Lands
	2	Habitat
	3	Imperiled Species

Name: Wind: Land-based wind turbine (100 meter)

Notes:

Launch

Figure 2-6 User Interface for Land-Based Wind Turbine (100 m) Model

The figure shows two side-by-side windows from a software application. The left window is titled 'Suitability Adjustment: Wind Turbine Gross Capacity Factor (100m)'. It contains a table with two columns: 'Suitability' and 'Range in % of Maximum Feasible Turbine'. The 'Suitability' column has values 0, 1, 10, 30, 50, 60, 70, 80, 90, 100. The 'Range in %' column has corresponding ranges: 0 - 5, 6 - 10, 11 - 15, 16 - 20, 21 - 25, 26 - 30, 31 - 35, 36 - 40, 41 - 45, 46 - 50, 51 - 55, 56 - 60, 61 - 65, 66 - 70, 71 - 75, 76 - 80, 81 - 85. Each value/range is next to a small up/down arrow icon. At the bottom are 'Cancel' and 'Save' buttons. The right window is titled 'Suitability Adjustment: Land Cover Area'. It contains a table with two columns: 'Suitability' and 'Category'. The 'Suitability' column has values 0, 50, 100. The 'Category' column lists various land cover types: Offshore Area, Unclassified, Open water, Perennial snow/ice, Developed, open space, Developed, low intensity, Developed, medium intensity, Developed, high intensity, Barren land, Deciduous forest, Evergreen forest, Mixed forest, Shrub/scrub, Herbaceous, Hay/pasture, Cultivated crops, Woody wetlands, and Emergent herbaceous wetlands. Each value is next to a small up/down arrow icon. At the bottom are 'Cancel' and 'Save' buttons.

Suitability	Range in % of Maximum Feasible Turbine
0	0 - 5
0	6 - 10
0	11 - 15
1	16 - 20
10	21 - 25
30	26 - 30
50	31 - 35
60	36 - 40
70	41 - 45
80	46 - 50
90	51 - 55
100	56 - 60
100	61 - 65
100	66 - 70
100	71 - 75
100	76 - 80
100	81 - 85

Suitability	Category
100	Offshore Area
100	Unclassified
0	Open water
0	Perennial snow/ice
100	Developed, open space
50	Developed, low intensity
0	Developed, medium intensity
0	Developed, high intensity
100	Barren land
50	Deciduous forest
50	Evergreen forest
50	Mixed forest
100	Shrub/scrub
100	Herbaceous
100	Hay/pasture
100	Cultivated crops
0	Woody wetlands
0	Emergent herbaceous wetlands

Figure 2-7 Suitability Adjustment Window for an Interval-Based Resource Layer (left) and Categorical Screening Layer (right)

When the screening layers, weights, and parameters have been set, the user can run the model. All settings and customizations are saved for retrieval and possible modification later. The model computes a composite suitability value for each of the 250-m × 250-m cells in the EISPC region using a geometric mean operation and the user-specified settings. The result is a suitability map with values ranging from 0 to 100. Values of no suitability will occur when one or more input layers have a suitability value of 0 defined. Values of 100 represent the highest suitability. Suitability values under 50 are considered to be below the minimum level necessary for an EZ to be viable. The model results are displayed on the map with a gradational color scheme. Model output maps function as any other layer in the mapping tool, including zooming in and out, adjusting transparency, and retrieving a cell's value with the information tool. The screening layers and any other layer in the EISPC catalog can be superimposed over the model results to examine the contributing factors for high- or low-suitability areas, or to look up other contextual information on the feature. Two methods exist for this; adding the actual modeling layer that the model uses from the "model layer catalog," or adding the raw data from the "map layer catalog."

2.3.2 Modeling Resources with Specific Existing Facilities

Several of the technologies included in the project are associated with specific existing facilities, or are new technologies in early stages of development and lacked sufficient available data for meaningful suitability models to be developed. The analysis approach for these technologies was therefore based on existing studies and inventories rather than suitability modeling. These technologies include:

- Methane extraction from
 - Landfills,
 - Wastewater treatment, and
 - Animal manure processing;
- Retrofitted pulverized coal (PC) with clean coal technology;
- Pumped storage hydroelectric (PSH);
- Additional power output from existing hydropower dams (NPDs);
- New output from existing non-powered dams;
- River and tidal hydrokinetic project permits; and
- Wave energy.

For these technologies, the locations of existing facilities or sites are available in the GIS database, or basic data are available about the energy resource. Reports can be run for analysis areas input on the map (Section 2.3.3) or a state or county of interest (Figure 2-8). The reports provide useful information pertaining to the technology that can help guide EZ planning.

2.3.3 Creating Analysis Areas

The Analysis Areas tool allows areas of interest to be drawn on the map for further analysis. The suggested approach is to use models to identify regions with high suitability for specific technologies and then to sketch areas on the map for further analysis. The EZ Mapping Tool

The screenshot shows a software window titled "Report Run Launcher". It contains several input fields and a button. The "Report:" dropdown menu is set to "Pumped Storage". Under the "Region" section, the "Type:" dropdown is set to "County", "State:" is set to "Delaware", and "County:" is set to "New Castle". In the "Parameters" section, "Buffer Zone 1 (mi):" is set to 25 and "Buffer Zone 2 (mi):" is set to 50. The "Run Name:" field contains the text "Biomass Landfill Report". There is a "Notes:" label followed by a large empty text area. At the bottom right, there is a "Launch Report" button.

Figure 2-8 Interface for Running a Pumped Storage Hydroelectric Report

interface is shown in Figure 2-9 with a hypothetical clean energy analysis area. Clicking “New Analysis Area” will allow a new area to be sketched on the map, given a name, and added to the list. Clicking the Actions icon to “Run a Report on this Area” for an analysis area opens the Report Run Launcher shown in Figure 2-8. Additional actions include hiding the area on the map; zooming the map to the full extent of the analysis area; or renaming, editing, or deleting the analysis area. Analysis capabilities are further described in Section 2.3.5.

2.3.4 Checking Relevant Energy Policies and Laws

The EZ Mapping Tool contains an inventory database of laws, regulations, incentives, and other policies in the EISPC states related to clean energy electricity generation. The database connects to and incorporates other online databases through NREL’s Open Energy Information (Open EI). The tool incorporates the database with a tab in the main navigation bar that allows the user to search for the policies and regulations by any combination of four main query boxes: political entity, policy type, implementation sector, and affected technologies. The search results are provided and include state-level summaries of the applicable policies.

Before developing the policy database, the Clean Energy States Alliance (CESA) requested input from a representative sample of more than 30 state policymakers, industry representatives, and non-governmental organization (NGO) stakeholders on what information to include in the inventory and EZ Mapping Tool and how to present it. CESA’s work to populate the inventory for all of the selected technologies and the full EISPC region included compiling export market information about all of the state Renewable Portfolio Standards (RPSs) for which generation in a specific location can qualify; information that significantly impacts a project’s potential revenue stream but is not published elsewhere. The inventory work included reviewing websites of individual states and provinces and compiling information on economic development policies, environmental regulations, forestry policies, and climate plans. To ensure the accuracy and

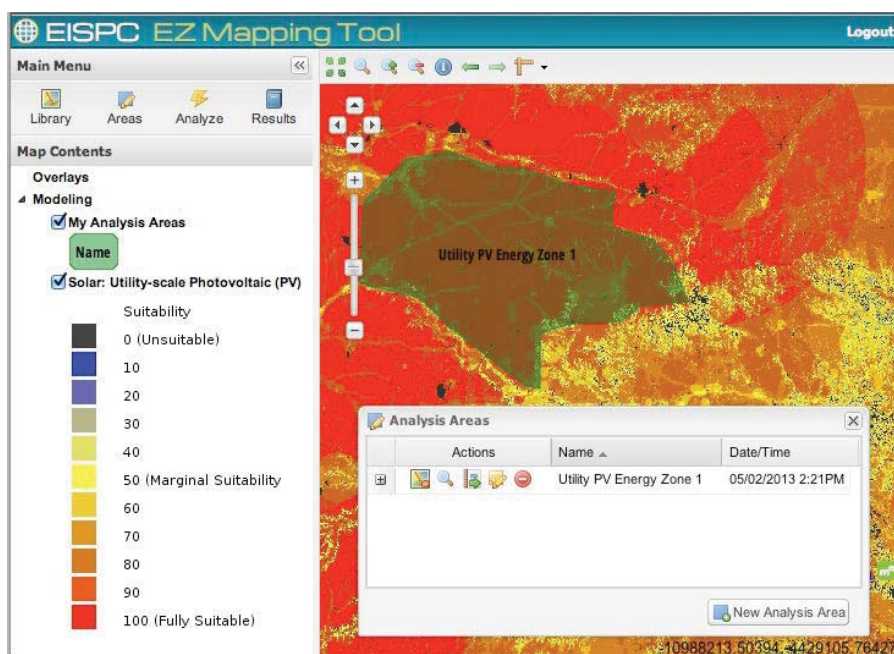


Figure 2-9 Main Dialog for Creating an Energy Zone or Analysis Area

appropriateness of the information contained in the policy inventory, CESA asked representatives of state and provincial governments to review the entries in the inventory and provide edits as necessary. Representatives of public utility commissions, renewable energy programs, and economic development agencies provided valuable information for the database. A detailed discussion of policy considerations is provided in Section 5.1.

2.3.5 Energy Infrastructure Map Overlays

The tool includes energy infrastructure layers from Platts/Bentek Energy shown in Figure 2-10. They are accessible as part of the same EZ Mapping Tool catalog as the rest of the GIS layers and are useful for evaluating the proximity of high suitability areas to existing energy infrastructure. The layers contain detailed information about the features such as transmission line voltage and pipeline diameter. This information can be accessed with the Identify tool.

A user may superimpose energy infrastructure layers over a model's suitability results by using the map layer catalog to show the available layers and clicking the Actions icon "Add this layer to the map." Metadata for each of the layers, which include detailed descriptions of attributes, can be accessed by clicking the Actions icon "View the metadata for this layer."

2.3.6 Model Results Report

The Model Results Report is very useful for understanding the results of any suitability model for an analysis area and documenting the specific layers and settings that were used in the model. It displays results for the composite model output and each model input layer. The first graph shows the mean and total range of suitability values in the model output and each input layer for the analysis extent for which it was run (Figure 2-11). In this example, the overall output in the analysis area was marginally suitable (mean of approximately 60) and ranged from unsuitable (0) to about 80. Contributions to the score of each input can be rapidly assessed. Those with higher means were generally more favorable (such as population density), and those with lower means

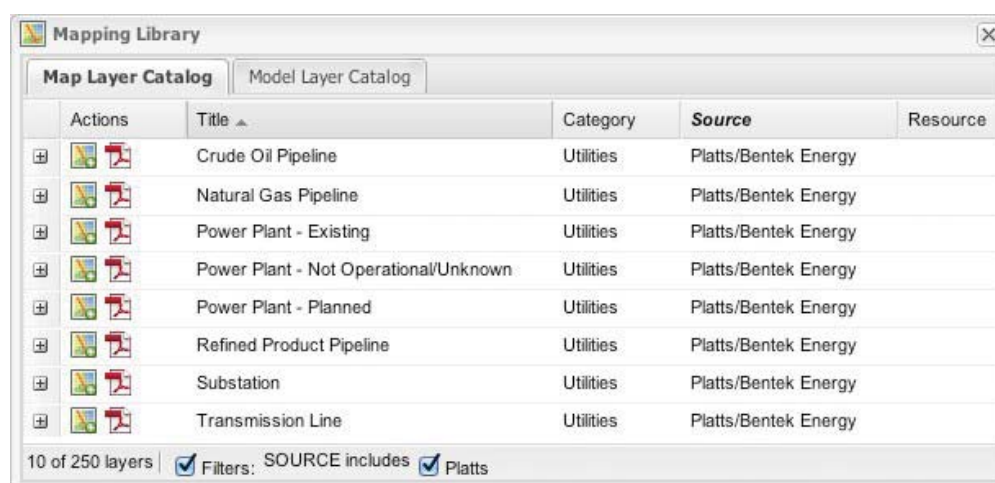


Figure 2-10 Energy Infrastructure Layers from Platts/Bentek Energy within the Map Layer Catalog

Suitability Range With Average (Mean)

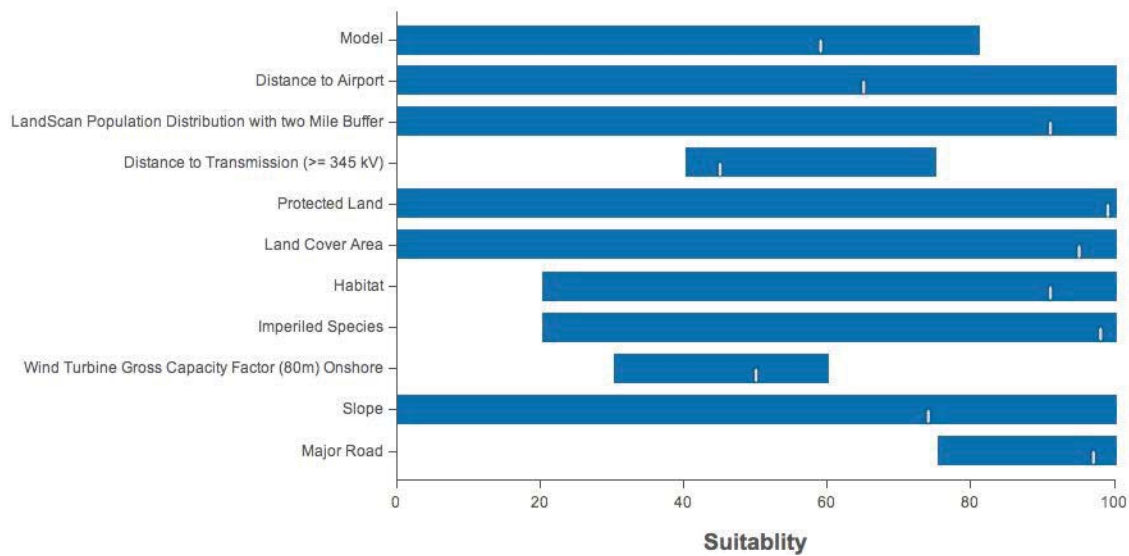


Figure 2-11 Chart Displaying the Range of Suitability Values That Are Found in the Model Result Report

(such as transmission proximity and wind turbine gross capacity factor) were generally less favorable. With one of the most important factors of wind turbine gross capacity factor being low to marginally suitable for this location, it is doubtful that this region would be advantageous for siting wind turbines.

To provide more detail for the model output and each input layer, the report provides a histogram showing the data distribution across the range of suitability (Figure 2-12). In this example, the majority of the analysis area is suitable (100) in terms of proximity to airports, but portions of it are marginally suitable (50) or lower (5 and lower). For further analysis, this and other layers can be viewed on the map to see how they contribute to the suitability of the area.

The final section of the report lists each input layer, its overall weight in the model, and the suitability values settings within the layer—all the settings entered into the model when it was originally run.

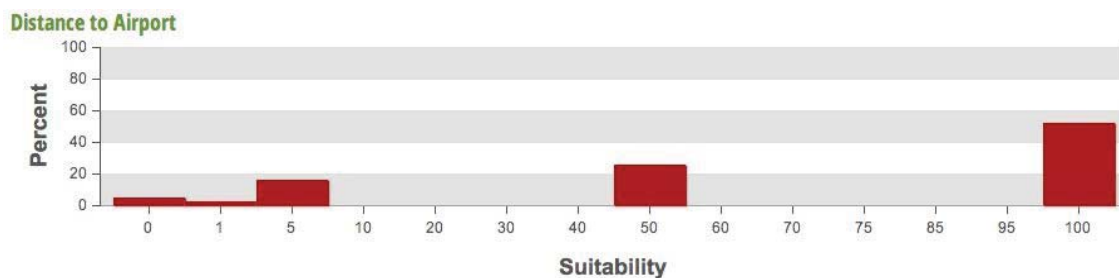


Figure 2-12 Chart Displaying a Histogram of Suitability Values within One Model Input Layer for a Specific Analysis Area of Interest

Running model result reports to compare different analysis areas is useful in understanding the complex mix of siting factors contributing to the model results, contrasting pros and cons among the analysis areas, and considering the broad implications of developing energy zones in each location.

2.4 Synergy Analysis

Figure 2-13 illustrates the methodology and process for synergy analysis. The main objective of the synergy analysis is to integrate the results of “single-resource” analyses for two or more resource technologies and to produce a map showing the resulting concentrations, or clustering, of selected clean energy resources. In this process, the suitability maps developed during the single-resource analysis are used to develop a composite image showing the resulting areas suitable for the development of multiple energy technologies (Figure 2-14). Methods for weighting the layers and computing the results are the same as single-resource models, and the output is a composite map with the same 0 to 100 scale of suitability levels. Results are based on the energy technologies selected by the user and the weight assigned to each technology. This approach also allows for favoring one or more technologies if desired. The resulting map provides visual information of highly suitable areas which could be considered for further analysis.

In the next step, the user may input an area of interest for possible development of a clean EZ. First, the analysis will include examining potential co-location compatibility of different energy technologies within the selected area, mainly with regard to the land use (e.g., wind and biomass could be co-located using the same land area, as described in Section 3.10). Next, other potential compatibility or competing issues need to be identified, especially if two or more technologies are competing for the same resource (e.g., cooling water). Lastly, it should be checked if there are potential impacts of non-zonal technologies, such as the smart grid, energy efficiency, and demand response. In some cases, these non-zonal technologies may provide some positive synergies and enable wider penetration of certain clean energy resources (e.g., smart grid technology may support and accelerate the growth of rooftop solar generation).

The review of the results will provide information for which parts of the selected area of interest are most favorable for the development of multiple clean energy resources. This information may serve for the identification of potential clean EZs with multiple technologies co-existing.

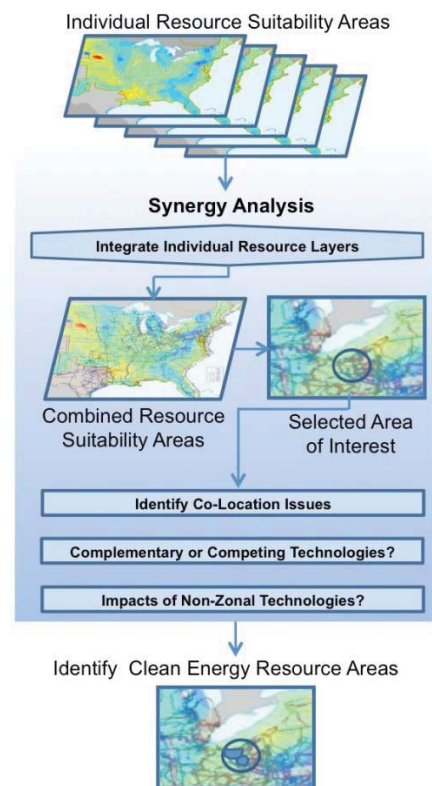


Figure 2-13 Methodology and Process for Synergy Analysis

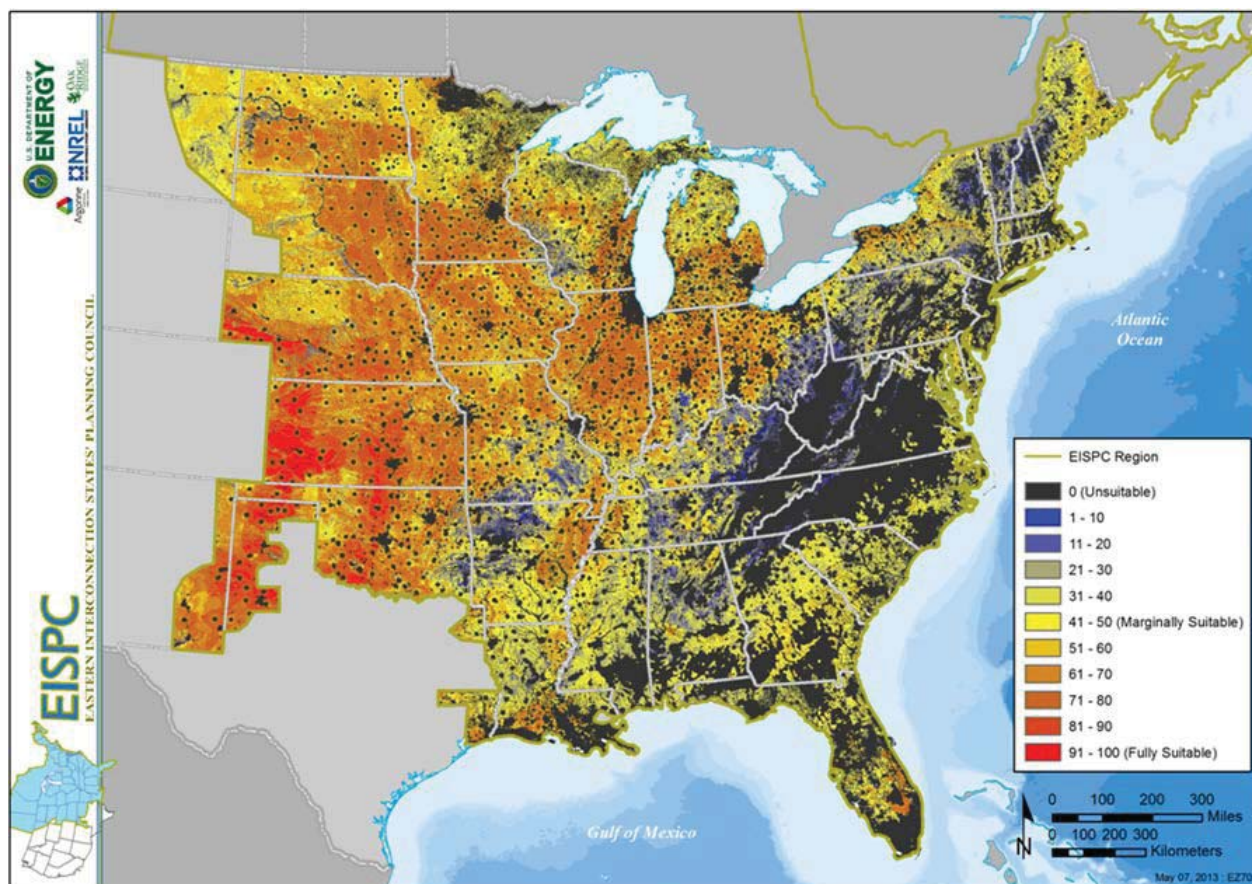


Figure 2-14 Synergy Results of Equally Weighted Solar PV and 80-m Land-Based Wind Models

2.5 Corridor Analysis

Corridor reports offer a screening-level assessment of key factors for planning an electrical transmission or pipeline corridor. Similar to defining an analysis area, corridors are sketched on the map; in this case, by clicking along the corridor centerline, then entering a total width in feet and name when prompted. Figure 2-15 shows a hypothetical corridor and its corresponding entry in the Analysis Areas and Corridors dialog.

By running the report on this corridor, the information below is generated, and listed by milepost along the corridor centerline:

- States and counties
- Populated places
- Elevated profile
- Topographic slope
- Major roads
- Railroads
- Rivers
- Water bodies
- Electrical substations
- Pipelines
- Military installations
- Airports
- Estimated peak horizontal ground acceleration
- Protected lands
- Habitat
- Imperiled species

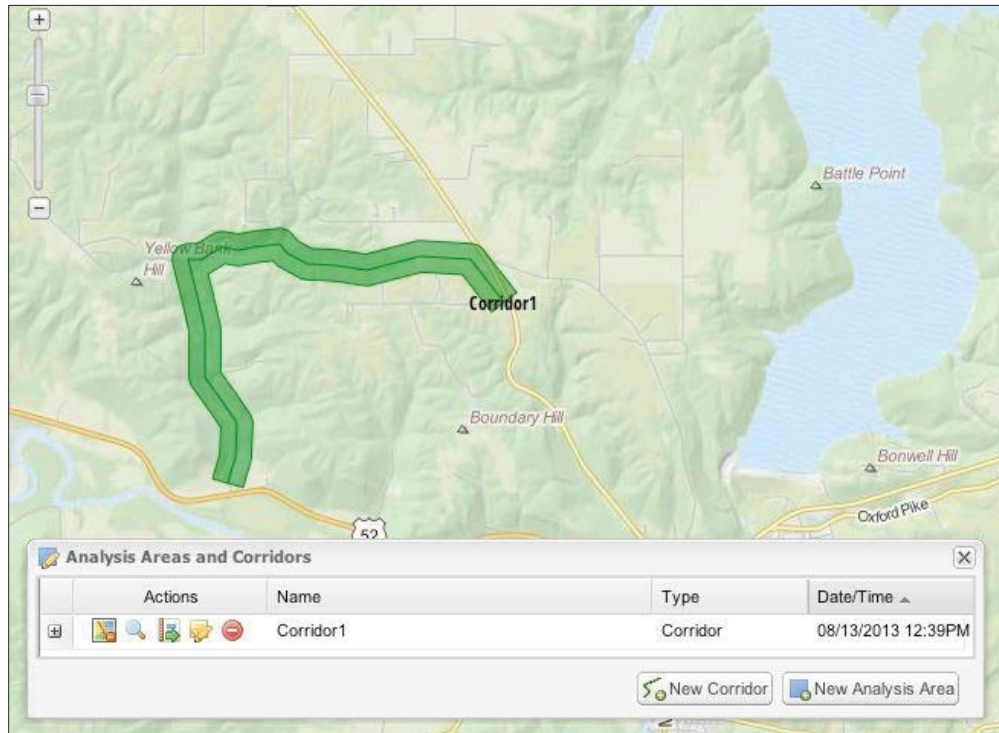


Figure 2-15 Map Showing a Hypothetical Corridor

Figure 2-16 shows typical content for a corridor report section listing crossings of areas (states and counties in this case) and part of the topographic profile section.

States and Counties Crossed, by Milepost

From Milepost (mi)	To Milepost (mi)	State Name	County Name	Area Within Corridor (sq mi)
0.00	10.21	Indiana	Rush	0.08
10.21	31.25	Indiana	Decatur	0.16
31.25	39.52	Indiana	Jennings	0.06
39.52	57.69	Indiana	Ripley	0.14
57.69	79.65	Indiana	Dearborn	0.17
79.65	93.82	Indiana	Franklin	0.11
93.82	94.29	Indiana	Union	0.00
TOTAL				0.74

Source: U.S. Census Bureau; et al (County Boundary (Generalized)) not available.

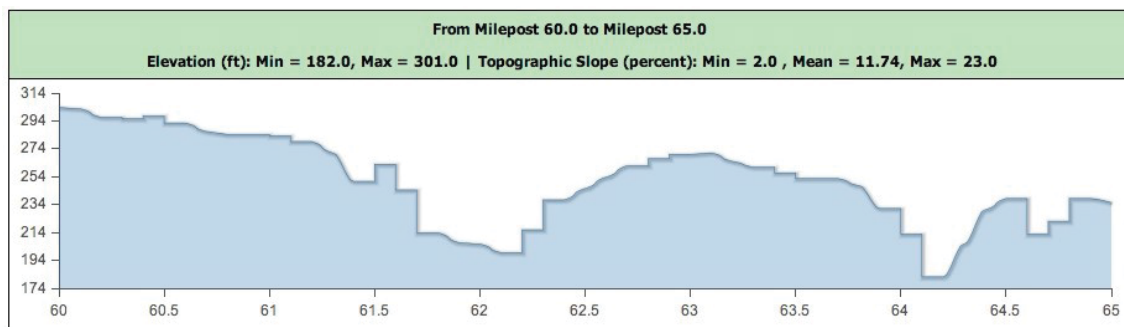


Figure 2-16 Corridor Report Example Content Showing States and Counties Crossed (top) and an Elevation Profile for the Corridor from Milepost 60 to 65

To investigate an alternate route for part of a corridor, a copy of the corridor can be created and revised to reroute around areas identified as having significant issues.

3 Clean Resource/Technology Options

The following sections describe the nine Clean Energy Resource categories that fall within the scope of the EZ Study, the resource characteristics and availability, the conversion technologies, the screening factors considered, and the data sources. The nine clean energy resource categories included in the EZ Study are (1) biomass, biopower, and biogenetic fuels; (2) clean coal with CCS; (3) geothermal; (4) natural gas; (5) nuclear; (6) solar; (7) storage; (8) water; and (9) wind.

3.1 Biomass, Biopower, and Biogenetic Fuels

3.1.1 Introduction

Conversion of light into plant materials through photosynthesis is a fundamentally important energy resource essential for life on earth. Since the 1970s, researchers have been investigating photosynthesis as an energy resource for the industrialized world and the potential of biomass to substitute for fossil fuels (Schneider 1973; Botlon and Hall 1979).

Biomass resources are plant-derived materials that store light energy that has been converted through photosynthesis. Depending on the type and composition of the plant matter, this energy may be stored as simple sugars, as starch, or as the more complex structural compounds cellulose,¹ hemicellulose,² and lignin (collectively known as lignocellulose).³ Sugars and starches are primarily used for food, while lignocellulosic materials are used primarily as construction materials and for energy. Biomass is unique among renewable energy resources in that it consists of basic and complex hydrocarbons and can be converted to carbon-based fuels and chemicals as well as electric power. Biopower generally refers to the generation of electricity from biomass directly; biogenic fuels (biofuels) are generally refined fuels created from biomass. Methane from various wastes, biodiesel from oil seed plants, and ethanol converted from corn sugars and sugar cane are the most common biofuels.

Biomass resources are present in many areas of the Eastern Interconnection. Figure 3-1 illustrates biomass crop residue resources.

In 2012, 57.6 terawatt hours (TWh) of biopower generation came from about 11 gigawatts (GW) of capacity, making biopower the third-largest form of renewable electricity generation after hydropower and wind energy (Augustine et al. 2012).⁴ Of this capacity, 7.0 GW was derived from the forest product industry and agricultural residues, 3 GW was derived from municipal solid waste (MSW), and about .5 GW from other sources such as landfill gas. The

¹ Cellulose is a carbohydrate that is the principal constituent of wood and other biomass and forms the structural framework of the wood cells.

² Hemicellulose consists of short, highly branched chains of sugars. In contrast to cellulose, which is a polymer of only glucose, hemicellulose is a polymer of different sugars. Hemicellulose is more easily hydrolyzed than cellulose.

³ Lignin is the major non-carbohydrate, polyphenolic structural constituent of wood and other native plant material that encrusts the cell walls and cements the cells together. Lignocellulose refers to plant materials made up primarily of lignin, cellulose, and hemicellulose.

⁴ Data originate from the Energy Information Administration.

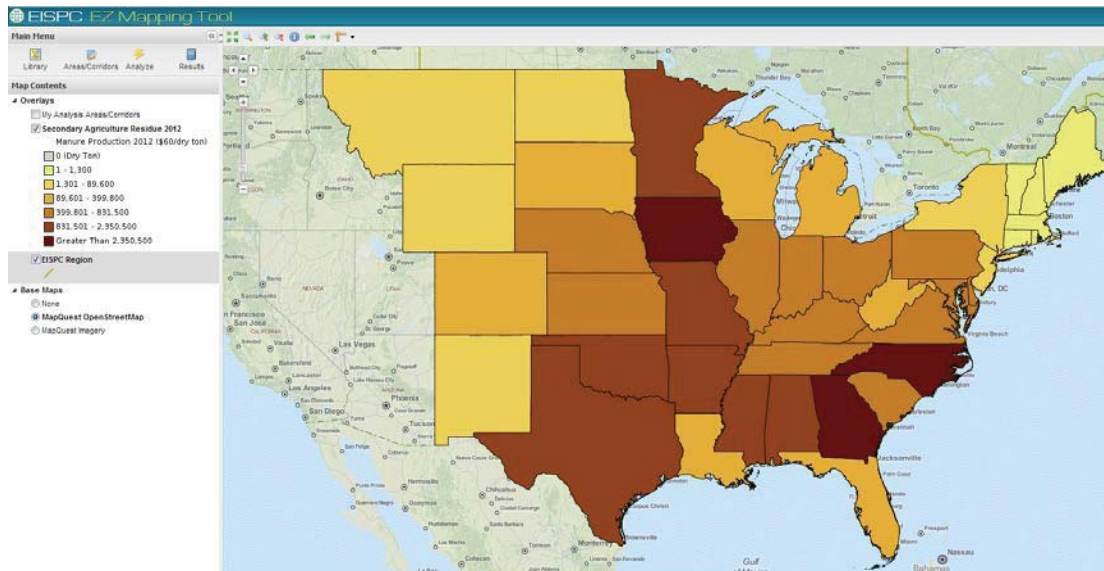


Figure 3-1 Secondary Agriculture Residue 2012 (Source: EISPC EZ Mapping Tool)

biopower generation in the electric sector in 2012 represents approximately 1.4% of the total electricity generated

Sections 3.1.2 through 3.1.7 discuss the scope of the biomass resources in the EZ Study, describe biomass technologies, describe conversion technologies, list screening factors considered, and provide data sources for the resources and screening factors.

3.1.2 Scope

Biomass resources are suitable for direct combustion through co-firing in coal plants or dedicated biomass-to-electricity-conversion facilities. While other biomass applications exist, they are out of scope for the purposes of this analysis. These out-of-scope applications include the conversion of the various biomass resources to biofuels (e.g., ethanol and biodiesel), any process involving algae, and charcoal production. Three sources of biomass-derived methane (landfill gas, wastewater treatment, and animal manure processing) are included as informational layers in the EISPC EZ Mapping Tool.

The following primary categories of biomass resources were examined for this study:

- Biomass
 - Forest biomass and wood waste,
 - Agricultural biomass and waste resources, and
 - Dedicated energy crops.
- Biofuels
 - Methane from landfills,
 - Methane from wastewater treatment, and
 - Methane from animal manure processing.

3.1.3 Resource Description

Biomass resources are very complex and diverse ranging from forest products to municipal or urban wastes. Several biomass resource assessments for the United States have been completed in recent years, as illustrated in Figure 3-2. While each study used different methodologies and assumptions, most of the results fall into a similar range: between 400 and 700 million tons per year. Data from the Billion-Ton Study (refer to DOE 2011 Base in Figure 3-2) were chosen for this project because it is the most recent analysis completed and also provides future projections. An excerpt from the Billion-Ton Study related to data uncertainty and model estimates states: “Although an attempt was made to use the best available data, there is still a great deal of uncertainty that cannot be overcome without a concerted effort to develop new data; for example...through the development of new data sources (e.g., use of remotely sensed data). Finally, the POLYSYS model⁵ is deterministic and thus does not allow one to provide confidence intervals around model output. Results are thus presented as point estimates and should be interpreted with all the appropriate caveats related to data uncertainty.”

3.1.4 Conversion Technologies

The two conversion technologies relevant to this study include dedicated biomass conversion via direct combustion and co-firing of the biomass materials in a coal plant. Within each biomass resource category there are many variations in the possible plant designs.⁶

For utility-scale power generation from biomass, direct combustion has long been the technology used in the United States. Almost all dedicated biomass power plants in the United States rely on direct combustion technology. Because biomass has lower sulfur content, coal-fired power plants that co-fire biomass can reduce sulfur dioxide (SO₂) emissions. Biomass gasification is an emerging technology that can be used in advanced power cycles such as integrated gasification combined cycle (IGCC) power plants.

In direct combustion, the biomass is fed into a boiler with excess air to generate hot flue gas, which then generates steam in the heat-exchange section of the boiler. The steam is used in a steam-Rankine cycle, with a resulting turning turbine shaft that is connected to a generator producing electricity. This process is illustrated in Figure 3-3.

The process shown represents a simplified generic direct combustion plant. This generic process diagram is similar to any steam cycle power plant, although the details of the plant design would have to accommodate the characteristics of the biomass feedstock. As the biomass materials have lower and more variable heating value than most coals and may have high moisture content, the plant design needs to accommodate these differences. The volumetric heat released by direct

⁵ The Policy Analysis System (POLYSYS) is a simulation model of the U.S. agriculture sector, which can incorporate agricultural supply and demand and related modules to estimate agricultural production response, resource use, price, income, and environmental impacts of projected changes from an agricultural baseline.

⁶ Additional information about biopower technologies is available from the DOE Biomass Program at <http://www1.eere.energy.gov/biomass/>.

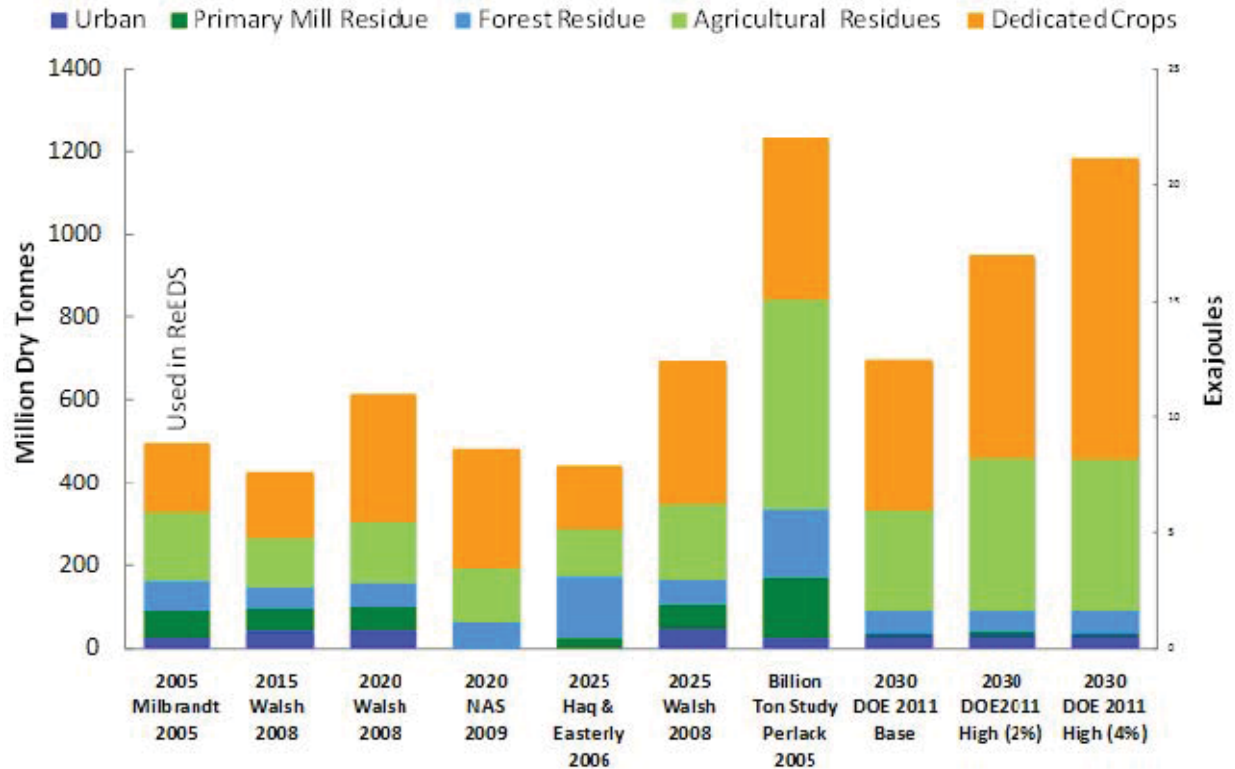


Figure 3-2 Potential Biomass Supply (Source: Augustine et al. 2012)

Exajoule = 10^{18} Joule
 Quadrillion Btu (quad) = 10^{15} Btu
 Quad = 1.055 Exajoule

Assumed dry biomass heating value (lower heating value basis)
 Woody biomass = 18.6 GJ/tonne
 Agricultural residues and biogenic MSW = 18.0 GJ/tonne where 1 tonne = 1.1023 short ton; MMBtu = 1.055 GJ

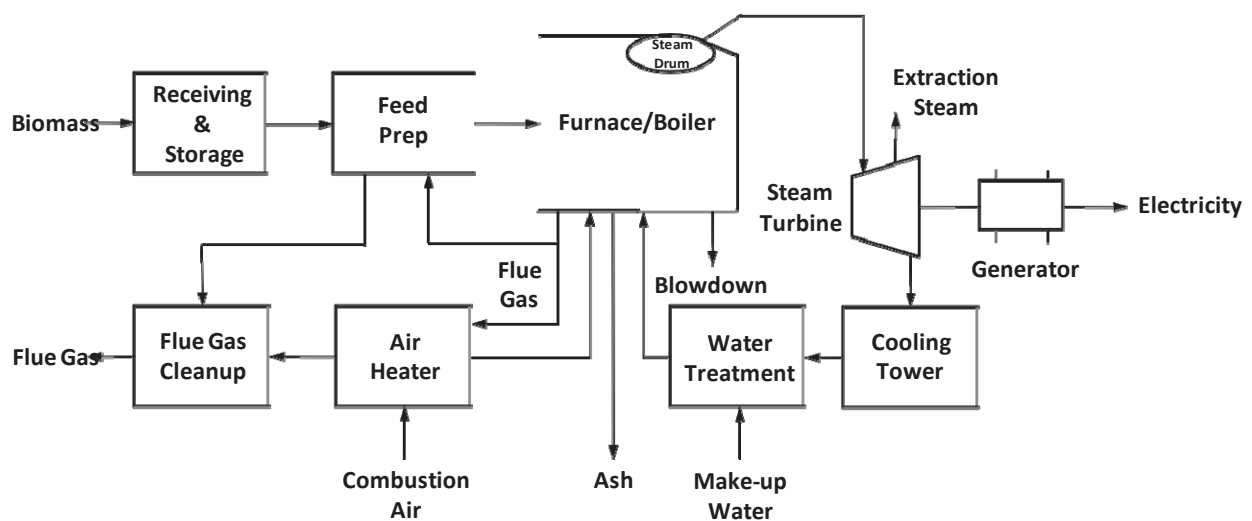


Figure 3-3 Schematic of a Direct-Fired Biopower Facility (Source: Augustine et al. 2012)

combustion of biomass is typically two-thirds of the volumetric heat released by coal combustion, because of the lower heat content and higher moisture content in biomass. Typical biomass combustion plants operate at lower steam conditions and thus lower energy efficiencies than modern coal plants.

Biomass-fired steam cycle plants typically use single-pass steam turbines. However, efficiency and design features previously found in only large-scale steam turbine generators have been transferred to smaller capacity units. These designs include multi-pressure, reheat, and regenerative steam turbine cycles as well as supercritical steam turbines.

The addition of dryers in the pretreatment of the biomass materials and the incorporation of more complex steam cycles can raise the efficiency of direct combustion systems (McGowin 2007).

Co-firing is the practice of introducing biomass as a supplemental source of energy or fuel in coal-fired boilers. Co-firing is a commercial technology that has been in use for decades in the pulp and paper industry and adopted by utilities in recent decades in high-efficiency coal-fired steam plants by supplementing the normal coal feed with available solid biomass fuels. Co-firing with coal in existing boilers is the lowest-cost biopower option because existing boilers and generating equipment are used, and the investment required is incremental as it is largely restricted to modifying storage, preparation, and feed systems. Investments are facility specific, and minor modifications of boilers may be required for separate injection of biomass into a coal boiler. In addition to the relatively limited capital investment required, the co-firing with coal achieves a higher efficiency than the typical dedicated biomass plant, since modern coal plants have efficiencies in the range of 32% to 38%. The disadvantage is that the supplemental biomass feed is limited to a small fraction of the fuel energy input (typically 3% to 15%).

3.1.5 Screening Factors

Screening factors relate to both the availability of the resource and specific needs of the energy conversion technology. For the purpose of this analysis, the screening factors used to screen areas for the specified biomass conversion technologies (in addition to the resource availability) are listed in Table 3-1. The specific default suitability criteria and ranges for each screening parameter are listed in Appendix A. The Protected Land, Habitat, and Imperiled Species screening parameters are discussed in Section 4. Informational layers may also be useful for additional analysis by overlaying them onto the suitability model results. Appendix B includes the extensive list of EZ Mapping Tool informational layers.

Co-firing with coal is generally relevant to existing plants and future plants, including those that might use CCS. For existing coal plants, the feasibility of co-firing is very plant specific and depends on design details and the type of biomass material that is available in the local region. Many of the clean energy resource development areas and exclusion areas relevant to coal will be applicable to dedicated biomass plants with the recognition that the plant size will typically be far smaller.

Table 3-1 Biomass Technology Screening Factors

Biomass Technology	Screening Parameter
New biomass-fired plants with traditional combustion	Population density Slope Distance to rivers (>2,000-gpm) Distance to railroad Distance to major road 100-yr flood zone Distance to port (barge locations) Proximity to transmission (>220 kV) Protected Land Habitat Imperiled Species
Biomass co-fire with existing coal plant	Distance to coal plants suitable for co-firing Population density Slope Distance to rivers (>2,000-gpm) Distance to railroad Distance to major road 100-yr flood zone Proximity to transmission (>220 kV) Protected Land Habitat Imperiled Species

3.1.6 Data and Sources

The biomass resource data are from a recent update of “The Billion-Ton Study: Biomass Supply for a Bioenergy and Bioproducts Industry,” a study led by ORNL and published in 2011 (DOE 2011). The models and reports are supplemented with resource data from the U.S. Environmental Protection Agency (EPA) and other sources listed in Table 3-2. Publicly available data to construct the screening factors for biomass technologies are available from a variety of sources listed in Table 3-3. The Protected Land, Habitat, and Imperiled Species screening layers are discussed in Section 4.

Landfill gas, wastewater treatment, and animal manure-processing-generated methane data are included as informational layers in the EZ Mapping Tool, and reports can be generated to summarize the availability of this resource data in an area of interest. The source of these data layers is listed in Table 3-2.

Table 3-2 Biomass Data and Sources^a

Resource	Data and Source
Forest biomass, agricultural biomass and waste, dedicated energy crops	2011 U.S. Department of Energy (DOE), [https://bioenergykdf.net/http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf]
Landfill gas	2013 U.S. Environmental Protection Agency (EPA), [http://www.epa.gov/lmop/]
Wastewater treatment methane	2012 EPA Wastewater Treatment Facility Capacity
Animal manure methane	Existing digesters: 2012 EPA, [http://www.epa.gov/agstar/projects/index.html#database] Potential resource: 2012 National Renewable Energy Laboratory (NREL), [http://www.nrel.gov/gis/data_biomass.html]
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

Table 3-3 Biomass Screening Factor Data and Sources^a

Factor (Parameter)	Data and Source
Population density	LandScan™, http://www.ornl.gov/sci/landscan/
Slope	2012 National Geospatial-Intelligence Agency (NGA) Digital Terrain Elevation data/ calculated and resized for 250-m cells
Distance to rivers/surface water flow	2012 U.S. Geological Survey (USGS), National Hydrography data (Version 2)
100-yr flood zone	2011 Federal Emergency Management Agency (FEMA) National Flood Hazard data http://www.msc.fema.gov
Distance to railroad	2012 Federal Railroad Administration (FRA) data
Distance to major road	2012 National Transportation Atlas Database
Distance to port	2012 U.S. Army Corps of Engineers (USACE)
Electric transmission data	2012 Bentek Energy/Platts
Coal plants for co-firing	2011 EPA
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

3.2 Clean Coal with Carbon Capture and Sequestration

3.2.1 Introduction

The United States has the largest demonstrated reserve base of coal in the world with recoverable reserves estimated at 258 billion tons out of a demonstrated resource base of 483 billion tons (EIA 2012c). Based on 2011 production levels of 1.1 million tons (including exports), U.S. supplies would last more than 200 years (EIA 2012a). However, growth in global demand may accelerate the point of peak production to an earlier year. Coal is currently mined in 27 states, though 90% of the confirmed coal reserves are concentrated in 10 states. Approximately 72% of current production originates in five states: Wyoming, West Virginia, Kentucky, Pennsylvania, and Montana (EIA 2012a). There are roughly 1,300 coal mines in the United States. Approximately 60% of the coal is mined at the surface, and the remaining 40% is

mined underground (EIA 2012b). Coal is readily available as a power resource from diverse supply locations.

Burning coal accounted for 45% of the electricity generated in the United States in 2010 at more than 1,400 coal-fired thermoelectric power plants (EIA 2012b). This is more than any other single power source and reflects the fact that coal is plentiful and relatively inexpensive in the United States. The use of natural gas as an electricity power source is expected to displace some use of coal in the future, with the amount of displacement dependent on fuel prices and the level of environmental controls required. With advanced environmental controls, coal-fired power plants can have a long-term role to play in the net energy production in the United States for the foreseeable future. Sections 3.2.2 through 3.2.7 discuss the clean coal with CCS technologies in scope for the EZ Study, describe clean coal technologies, describe conversion technologies, list screening factors considered, and provide data sources for the resources and screening factors.

3.2.2 Scope

Three types of advanced clean coal plants were considered in this study: (1) (PC oxycombustion power plants; (2) IGCC plants; and (3) coal fluidized bed (CFB) plants. In addition, the retrofit of existing coal plants with CCS technology is also included in this study. For this study, “clean coal” includes CO₂ capture, not just other pollutants.

Underground coal gasification technology was deemed to be out of scope for this study.

3.2.3 Resource Description

Coal is a combustible black or brownish-black sedimentary rock. A harder form of coal, such as anthracite coal, has the highest carbon content, the fewest impurities, and the highest calorific value of all types of coals. Bituminous coal is softer than anthracite coal and contains a tarlike substance called bitumen. Sub-bituminous coal has a somewhat lower heat content and higher moisture content than bituminous coal but can be lower in sulfur. Lignite, often referred to as brown coal, is the softest fuel with characteristics similar to peat and is considered the lowest rank of coal. Figure 3-4 is a resource map for the various varieties of coal in the United States. Because of the abundant availability, most coal-fired power plants use bituminous or sub-bituminous coal. All coal is composed primarily of carbon, along with variable quantities of other elements—chiefly hydrogen, sulfur, oxygen, and nitrogen. When coal is burned to produce electricity in a thermoelectric power plant without any controls or scrubbing of the stack gases, CO₂, carbon monoxide (CO), sulfur oxides (SO_x), nitric oxides (NO_x), particulate matter (PM), and trace metals (including mercury) are released to the atmosphere. Burning coal accounted for 37% of the total United States emissions of CO₂ in 2010 (EIA 2012a). Coal combustion produces higher amounts of CO₂ per unit of energy than either oil or natural gas combustion. By retrofitting existing coal plants with CCS technology, coal-related emissions can be greatly reduced.

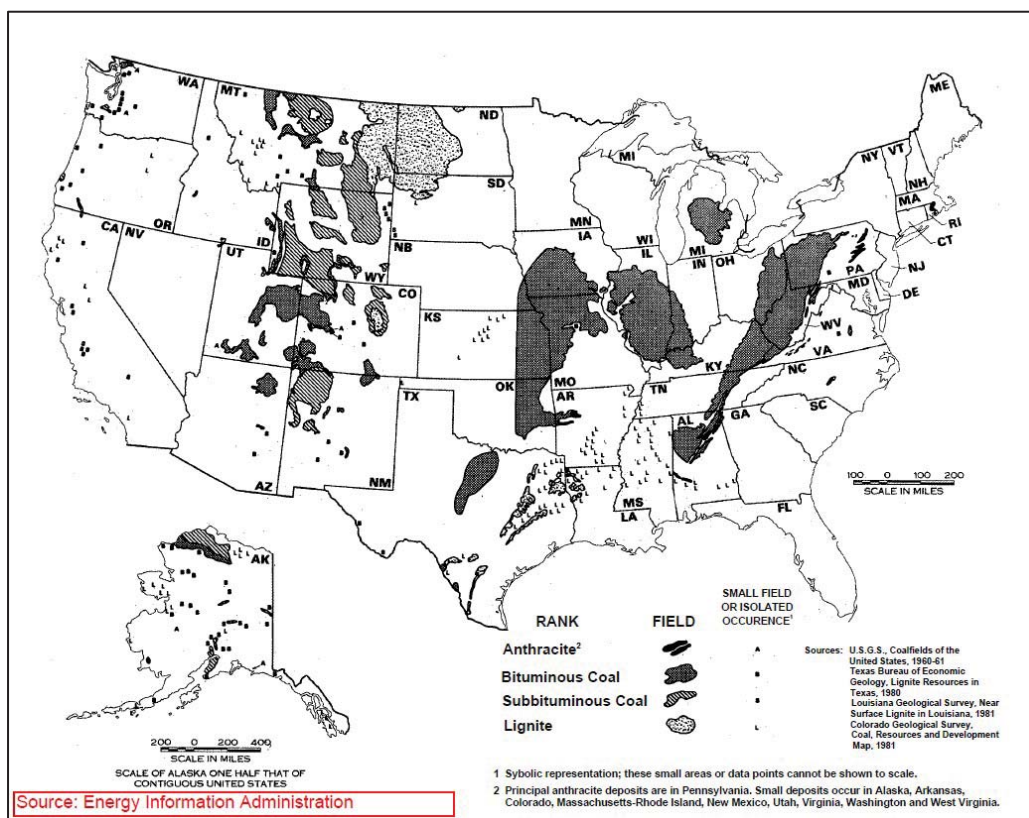


Figure 3-4 Coal Resource Map (Source: EIA undated)

3.2.4 Conversion Technologies

New PC oxycombustion, IGCC, CFB power plants, and retrofitted existing PC coal plants with sequestration equipment can convert coal resources into thermal energy.

In a PC power plant, raw coal is milled into a fine powder in a pulverizer that increases the surface area for combustion and allows the coal to burn faster. The powdered coal is blown into a boiler and burnt at a high temperature. Water circulating in tubes in the boiler is converted to high-pressure steam, which subsequently turns a turbine shaft at high speeds. The turbine shaft is connected to a generator, which produces electricity. A typical PC plant with pollutant control technologies uses limestone to capture the SO_x . Selective catalytic reduction reduces NO_x and fabric filters, or electrostatic precipitators control particulates and assist in the control of mercury (NETL 2008a).

A PC oxycombustion power plant uses oxygen diluted with recycled flue gases in the combustion process. This produces a flue gas stream of CO_2 and water. The water can be removed, leaving a nearly pure stream of CO_2 . The CO_2 is compressed to approximately 2,200 pounds per square inch (psia) and transported via a pipeline to a geological formation where it is stored (NETL 2008a). Geological formations that are typically considered for storage are deep saline formations and partially depleted oil fields. Figure 3-5 is a schematic of a basic PC plant.

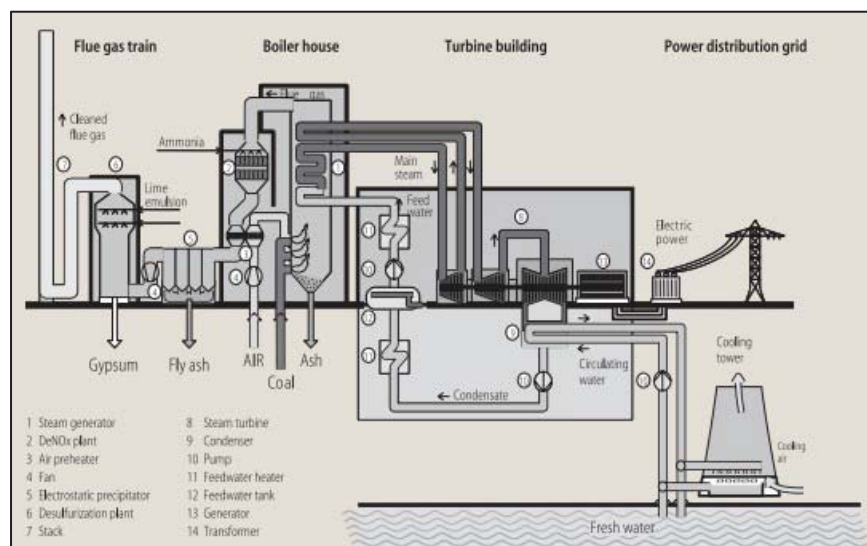


Figure 3-5 Basic Advanced, Low-Emissions PC Plant
(Source: Katzer et al. 2007)

In an IGCC power plant, coal is gasified in a high-pressure, high-temperature reactor called a gasifier. Under the low oxygen conditions in a gasifier, coal sulfur forms hydrogen sulfide (H_2S), which can be removed to extremely low concentrations by chemical-absorption processes. This is an advantage over conventional combustion, which forms SO_2 that must be removed by post-combustion scrubbing of the high volume of flue gas produced. Inorganic materials that form particulates and slag in a conventional furnace are removed from the gasifier as slag. The resulting raw gas product consists primarily of CO and steam, with small amounts of methane, hydrogen, and trace constituents. This synthetic gas has a very low heating value and is often upgraded by converting the CO in the raw syngas to CO_2 in a process called a shift reaction. The shift reaction simultaneously converts reagent steam to hydrogen, thus increasing the heating value of the synthetic gas. The CO_2 is separated from the syngas, pressurized, and sequestered similar to the PC plant process. However, the relatively high concentration of CO_2 in the syngas makes capture more economical in the gasification case. The raw syngas is typically burned locally as is or it may be methanized into substitute natural gas and subsequently fired in a gas turbine or introduced into the natural gas pipeline network. The heat of the gas turbine exhaust is used to create steam to run a steam turbine in a combined-cycle process that has a higher efficiency than a PC plant. Plant efficiencies of up to 60% are possible with IGCC plants compared to efficiencies of less than 40% in PC plants. By removing emission-forming constituents from the syngas before burning, the SO_2 and NO_x emissions are greatly reduced. Other IGCC feedstocks are possible as well, including biomass, petroleum coke, MSW, chemicals, and sludge (DOE 1999). Figure 3-6 is a schematic of a basic IGCC plant.

In a CFB power plant, a limestone or dolomite sorbent is mixed with the coal to capture the SO_2 released by the coal combustion process. Particulate and NO_x emission removal is similar to a PC plant. Air suspends the mixture of burning coal and sorbents in a combustion chamber such that the fluidized mixture can be circulated. The hot combustion gases with entrained solids exit at the top of the combustion chamber into a hot cyclone. The cyclone separates the solids from the combustion gases and returns the solids, including any unburned solid fuel, through a

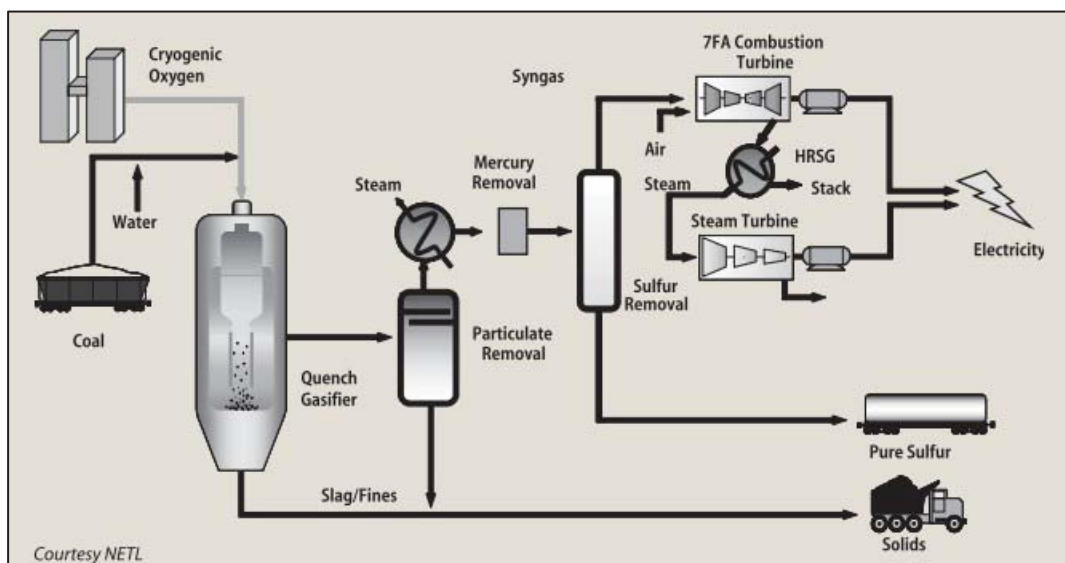


Figure 3-6 Basic IGCC Plant Coal and By-product Flow (Katzner et al. 2007)

non-mechanical loop seal to the combustion chamber where they mix with incoming fresh fuel. The long residence time of solids at combustion temperature and the continuous recirculation of the solids ensure high combustion efficiencies and sulfur capture. The heat of the combustion process is used to create superheated steam to run a steam turbine that has a higher efficiency than a PC plant. The CFB SO_2 and NO_x emissions are about one-tenth those of an uncontrolled PC plant and are comparable to those of a PC plant with a scrubber (<http://www.power-eng.com/articles/print/volume-111/issue-3/features/comparing-emissions-pc-cfb-and-igcc.html>). The CO_2 emissions can be sequestered similar to the PC plant process. Figure 3-7 is a schematic of a basic CFB plant.

Existing coal-fired power plants may be able to cut CO_2 emissions by retrofitting control and sequestration equipment onto an existing PC power plant. The carbon scrubbing and control equipment will require a substantial footprint on the plant site, which may preclude some sites from consideration. In addition, a net loss in power to the grid occurs to account for the parasitic loads associated with operating the emission control and sequestration equipment. This will eliminate the consideration of small coal plants for retrofit. In addition, the age or remaining life of an existing coal plant must be factored into any decision to retrofit a plant.

3.2.5 Screening Factors

Screening factors relate to both the availability of the resource and the specific needs of the energy conversion technology. For the purpose of this analysis, the screening factors used to screen areas for the specified coal conversion technologies (in addition to the resource availability) are listed in Table 3-4, and the specific default suitability criteria and specific ranges for each screening parameter are listed in Appendix A. The Protected Land, Habitat, and Imperiled Species screening parameters are discussed in Section 4. Informational layers may also be useful for additional analysis by overlaying them onto the suitability model results. The extensive list of EZ Mapping Tool informational layers is included in Appendix B.

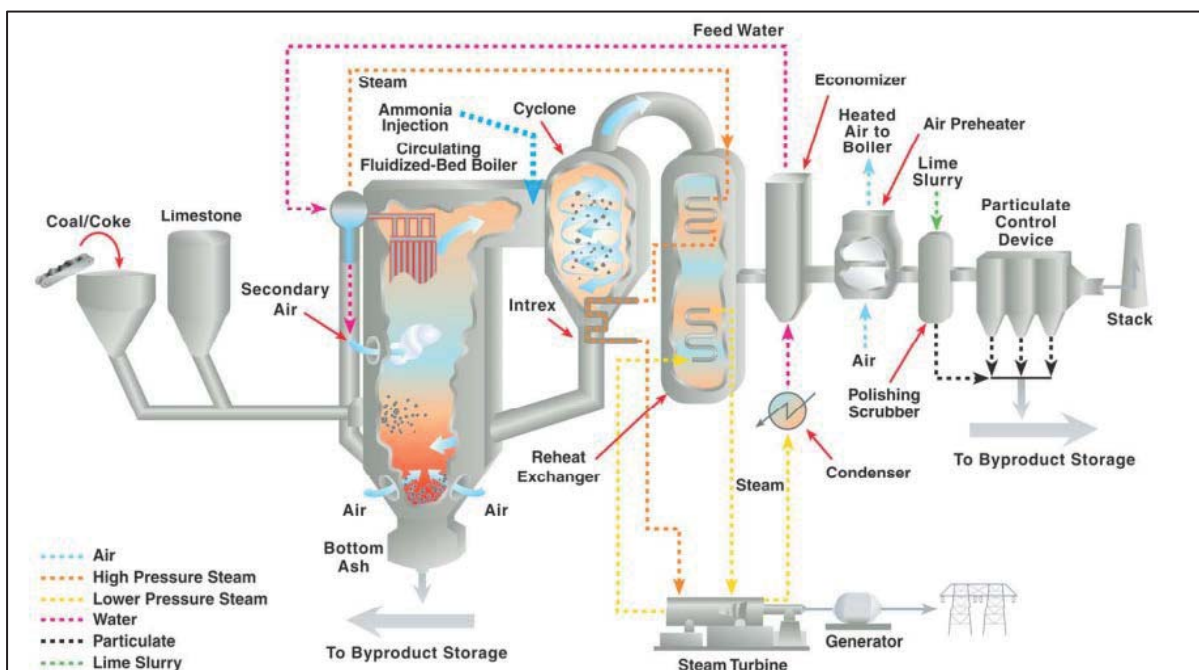


Figure 3-7 Basic CFB Plant Coal and By-product Flow (Source JEA 2003)

The screening factors for many thermoelectric power plants are similar, with varying values for the individual factors. While siting of advanced coal plants is not held to the same regulatory rigor as nuclear power plant siting, many of the screening factors are very similar between the two plant types.

ORNL has developed a tool, OR-SAGE (Oak Ridge Siting Analysis for power Generation Expansion) (Mays et al. 2012) for applying GIS and spatial modeling techniques for evaluating siting options for nuclear power and has extended that capability for other electric power plants, including, for example, solar and clean coal. A further description of the siting methodology is provided in Section 3.5.5, since the tool was originally formulated for evaluating nuclear plant siting. Its methodology for coal plants siting criteria is the foundation for the coal technology evaluation described below.

Since population density of greater than 500 people per square mile begins to transition into an urban setting, new advanced coal plants in these areas are excluded based on anticipated available space and zoning restrictions. However, there is no need to include a buffer for public safety as there would be for nuclear power plants. Engineering judgment indicated that screening factors, such as avoiding wetlands and open water, protected land, excessive slope, and floodplains, should be considered for areas suitable for clean coal technology development.

Available water for cooling is a common need for all thermoelectric power plants. A DOE/National Energy Technology Laboratory (NETL) report provided water consumption factors for IGCC, supercritical PC, and subcritical PC plants using carbon capture technology (NETL 2008b). The subcritical PC plant had the highest water consumption factor, including carbon capture technology; thus this plant type was conservatively used to establish the water

requirements for the PC plant. The IGCC plant uses less than half the water of the PC plant on a gallons per MWh basis. Water usage at a CFB plant is assumed to be similar to an IGCC plant, adjusted for differences in thermal power produced.

Expected PC plant parameters were provided in a DOE/NETL report (NETL 2008a). This report indicated that the expected average advanced PC plant is situated on 300 acres and that the gross output is 750 megawatts electric (MW(e)). This report also indicated that reasonable access to coal delivery was a necessary requirement. The expected average IGCC plant was assumed to be 600 MW(e) based on an Energy Information Administration report (EIA) (2010). Likewise, the expected average CFB plant was assumed to be 400 MW(e) based on a CFB plant demonstration project in Jacksonville, Florida. The plant output was factored into the advanced coal-fired plant water requirement calculation for each plant type. For an older coal-fired PC plant retrofitted with CCS technology, only the additional water requirements of the CCS technology would need to be factored. This would vary depending on the capacity of the plant to be retrofitted. In all cases, it is assumed that water can be economically piped up to 20 miles (mi) from an existing water source. As a general rule, no more than 10% of the available water supply at any given location is assumed to be available for a new power plant.

The report *Pulverized Coal Oxycombustion Power Plants* also indicated that CO₂ could be piped up to 50 mi to a saline aquifer formation (NETL 2008a). ORNL expertise indicated that this distance could be pushed to a higher value with certain provisions, such as avoiding high slopes, faults, and crossing of protected land. Consultations with Carnegie Mellon University researchers in December 2010 confirmed this assumption. The distance to an acceptable geologic storage formation for carbon is a unique screening factor for the consideration of advanced coal plant siting. Saline formations assessed for storage are restricted to those where the following basic criteria for the storage are met: (1) pressure and temperature conditions in the saline formation are adequate to keep the CO₂ in dense phase (supercritical) or liquid phase, (2) a suitable seal is present to limit vertical flow of the CO₂ to the surface, and (3) salinity in the saline formation is >10,000 parts per million (ppm) total dissolved solids. For the purposes of this study, a depth of 2,500 feet (ft) below surface was accepted as a reasonable proxy for these criteria to be met (NETL 2010). Geological storage capacity and carbon injection rates are noted as issues for the use of advanced coal technology. However, no publicly available GIS data are currently available to permit the inclusion of these issues as additional advanced coal evaluation criteria.

Other informational data that may make one candidate area superior to another candidate area include access to transportation, access to the electrical transmission network and load centers, and EPA air pollution standards for a given area. These factors should not be used to initially factor out an area but provide useful additional knowledge about candidate areas.

Table 3-4 shows the screening criteria for the expected average clean coal technologies that include CCS positioned on 300 acres of land.

Table 3-4 Advanced Coal Technology Screening Factors

Clean Coal-Technology	Screening Parameter
Pulverized coal	Distance to saline formation for carbon storage Population density Slope Land cover area 100-yr flood zone Distance to rivers (>125,000 gpm) Distances to railroad Distance to port (barge locations) Proximity to electric transmission (>345 kV) Protected Land Habitat Imperiled Species
Integrated gasification combined cycle	Distance to saline formation for carbon storage Population density Slope Land cover area 100-yr floodplain Distance to rivers (>45,000 gpm) Distance to carbon storage Distance to railroad Distance to port (barge locations) Proximity to electric transmission (>345 kV) Protected Land Habitat Imperiled Species
Coal fluidized bed	Distance to saline formation for carbon storage Population density Slope Land cover area 100-yr flood zone Distance to rivers (>30,000 gpm) Distance to carbon storage Distance to railroad Distance to port (barge locations) Proximity to electric transmission (>345 kV) Protected Land Habitat Imperiled Species

3.2.6 Data and Sources

The coal resource data were obtained from the EIA (2007). Publicly available data to construct the screening factors for clean coal technologies that include CCS are available from a variety of sources listed in Table 3-5. The Protected Land, Habitat, and Imperiled Species screening layers are discussed in Section 4.

Table 3-5 Clean Coal Screening Factor Data and Sources^a

Parameter/Information	Data and Source
Population density	LandScan™, http://www.ornl.gov/sci/landscan/
Slope	2012 NGA Digital Terrain Elevation data/calculated and resized for 250-meter (m) cells
Land cover area	2011 USGS
100-yr flood zone	2011 FEMA National Flood Hazard data
Distance to rivers/surface water flow	2012 USGS/National Hydrologic data (Version 2)
Saline aquifer data (carbon storage)	2013 NETL saline aquifers data
Distance to railroad	2012 FRA data
Distance to port	2012 USACE
Transmission data	2012 Bentek Energy/Platts
Potential retrofitted PC plant (existing PC plants)	2012 Bentek Energy/Platts
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

Existing PC plant data are included as an informational layer in the EZ Mapping Tool, and reports can be generated to summarize the inventory of existing PC plants (location and generation rate) for an area of interest. The source of this data layer is listed in Table 3-5.

3.3 Geothermal

3.3.1 Introduction

Geothermal energy resources exploit thermal energy of the Earth's core where geologic features bring these resources close to the surface. This thermal energy is a combination of that available when the planet was formed and the decay of radioactive elements that are a natural constituent of the materials which formed the planet. Consequently, geothermal energy, like solar energy, is broadly available. However, unlike solar, geothermal is a possible source of baseload electric generation because of its constancy as opposed to wind or solar, which has natural variability. Geothermal energy is widely used today in two forms: (1) hydrothermal resources, hot water or steam accessed through deep wells that tap naturally occurring reservoirs for the extraction and use of the heat and/or generation of electricity, and (2) ground-source heating and cooling technologies that use the shallow ground near the Earth's surface that maintains a relatively constant temperature in the range of 40 to 60 degrees Fahrenheit (°F) year round.

Current commercial geothermal power plants use thermal energy produced from reservoirs of steam or hot water found several thousand feet below the Earth's surface to produce electricity. As the hot water⁷ or steam is available directly, they are referred to as hydrothermal. These hydrothermal reservoirs have sufficient naturally occurring thermal energy, in situ water, and permeability for development of geothermal electricity. Hydrothermal resources are localized

⁷ The water, or geothermal fluid, at a particular site may contain salts and minerals and should be more appropriately referred to as brine.

geologic anomalies that require site-specific characterization. As will be discussed later, no significant hydrothermal resources have been identified within the Eastern Interconnection. Hydrothermal is discussed here as it is the common commercial technology.

The three categories of commercial geothermal power plants are defined by a combination of the type of geothermal resource and the conversion technologies: dry steam, flash steam, and binary cycle. The dry and flash steam directly use the geothermal fluid in the power cycle, while the binary cycle uses a secondary fluid, thus the term binary (Figure 3-8).

To explore the potential for geothermal energy in the Eastern Interconnection, a broader range of geothermal resources and conversion technologies need to be considered. Research over the last decades has identified additional geothermal resources available within the footprint of the Eastern Interconnection, including enhanced geothermal systems (EGSs), geopressured reservoirs, and co-production of geothermal energy from oil and gas wells.

EGSs (Figure 3-9) are resources with a large amount of thermal energy but lack sufficient in situ water, permeability, or both, so that the reservoir must be engineered to extract the thermal energy. EGS resources are divided into (1) near-hydrothermal field EGS resources located near conventional hydrothermal fields, and (2) deep EGS resources, which in theory can be developed anywhere by drilling deep enough to access high-temperature reservoirs.⁸ Because EGSs are still primarily in demonstration, estimates of the potential of this resource are subject to considerable uncertainty. The vast majority of the geothermal potential for EGSs within the contiguous United States is located in the western portion of the country. However, even the Eastern Interconnection has enormous potential for EGS development.

Geopressured resources are found in highly pressurized⁹ shale and sandstone formations that contain high-temperature brine with dissolved methane; their energy potential includes both thermal energy and the methane stored in reservoirs. The best geopressured reservoirs are generally located along the Texas and Louisiana Gulf Coast (Figure 3-10).

It is estimated that about 20 billion barrels (bbl) of water is co-produced during onshore oil and gas operations annually (Veil and Clark 2009). Some of this water is at a high enough temperature that it could be used to generate electricity. Co-production of geothermal energy from oil and gas wells consists of electricity generated from geothermal energy contained in fluids co-produced with oil and gas (or from abandoned oil and gas wells) using binary (organic Rankine cycle) power plants.

⁸ “In theory” as temperature increases with depth, but is limited in practice to the current state of drilling technology and affordability.

⁹ The geopressured reservoir pressures exceed the hydrostatic head, and both the mechanical and thermal energy can be utilized in generating electricity.

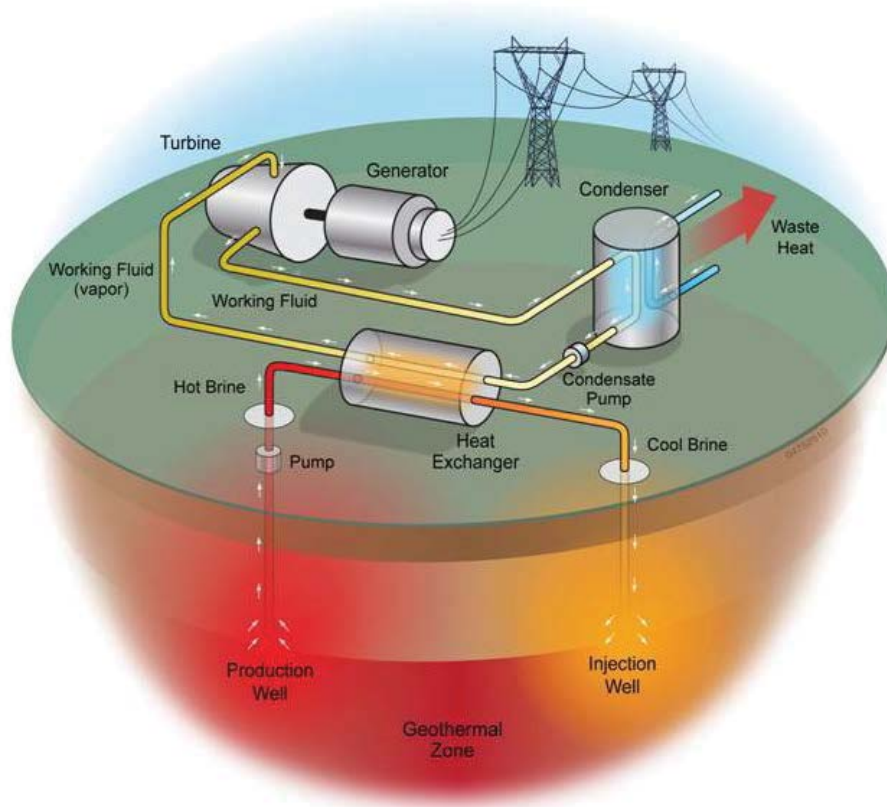


Figure 3-8 Schematic of a Hydrothermal Binary Power Plant
(Source: Augustine et al. 2012)

3.3.2 Scope

As the hydrothermal resource is not known to be available in the Eastern Interconnection, the EISPC EZ Mapping Tool focuses on EGS and geopressed reservoirs for production of electricity from these geothermal resources.

In addition to these geothermal resources, there is the potential to use the thermal energy in oil and gas reservoirs for the co-production of electricity. Because of the geographically distributed nature of oil and gas wells, co-production systems are expected to consist of small (<1 MW), modular units. However, these resources are more appropriately considered a distributed energy resource and are not included in the EISPC EZ Mapping Tool.

Although it is also possible to produce water from abandoned oil and gas wells, the additional costs to generate electricity from these wells, including well workover costs and transmission infrastructure costs, would result in less favorable economics than actively producing wells. These costs would be almost entirely allocated to geothermal electricity generation as little oil or gas would be expected to be recovered. In addition, since the wells are designed for oil and/or gas production, the maximum flow rate that can be achieved from these wells is limited to values lower than those typically achieved for geothermal electricity generation. It should be noted that

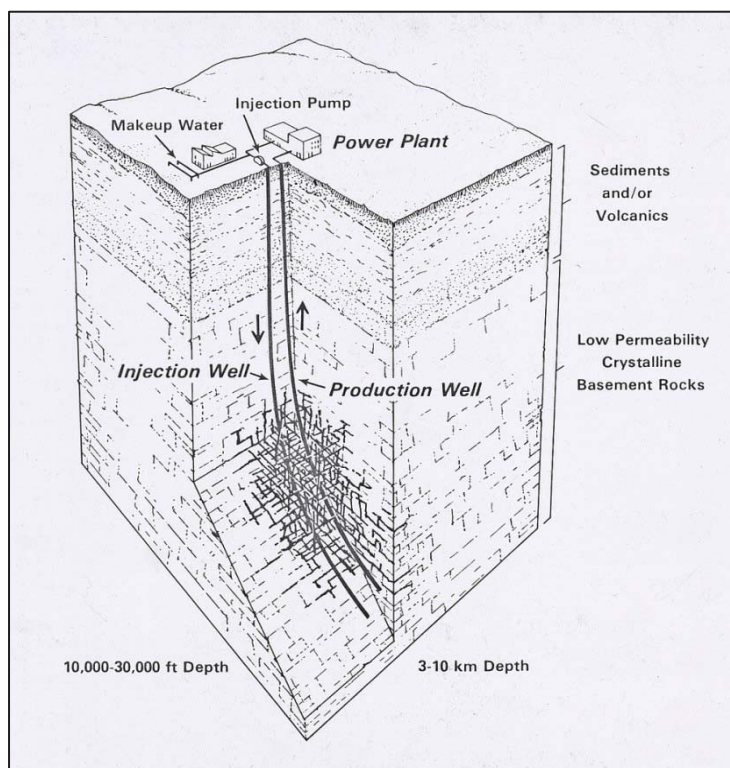


Figure 3-9 Schematic of a Two-Well EGS in Hot Rock
(Source: MIT 2006)

the EGS resource estimate essentially captures the geothermal resource potential in sedimentary basins, where oil and gas production originates. Since that estimate does not distinguish between the rock type at depth, whether it be in sedimentary basins or in granitic basement rock, the thermal resources that could be tapped from re-opening abandoned oil and gas wells is implicitly included in the EGS resource potential estimate.

3.3.3 Resource Description

EGS expands the potential of geothermal energy by orders of magnitude. The traditional geothermal approach relies on finding naturally occurring pockets of steam and hot water. The EGS process, by comparison, replicates these conditions by fracturing hot rock, circulating water through the system, and using the resulting hot fluid to produce electricity in a conventional flash or binary power cycle, depending on its temperature. The water is then re-injected back into the rock, where the cycle begins again in a closed loop (Figure 3-9).

Large zones of hot, highly pressurized fluids occur in deep strata under the Gulf Coast (Figure 3-11). This so-called “geopressured-geothermal” resource was studied extensively in the 1970s and 1980s, and DOE operated a test well near Houston, Texas. Typically, geopressured zones are at depths on the order of 15,000 ft and the fluid itself is a hot (about 300°F), high-pressure brine with methane dissolved in it. Interest in the resource may be driven as much by the potential methane recovery as by its geothermal energy (Texas State Energy Conservation Office undated).

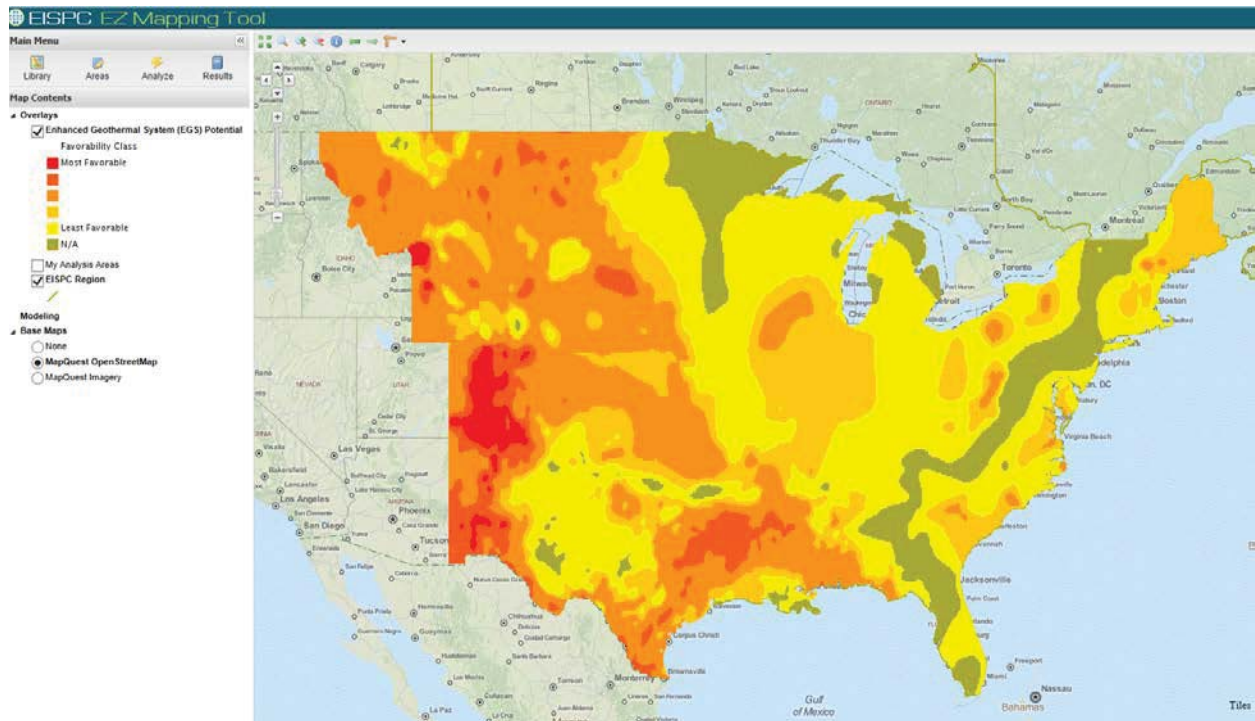


Figure 3-10 EGS Resources in the Eastern Interconnection (Source: EISPC EZ Mapping Tool)

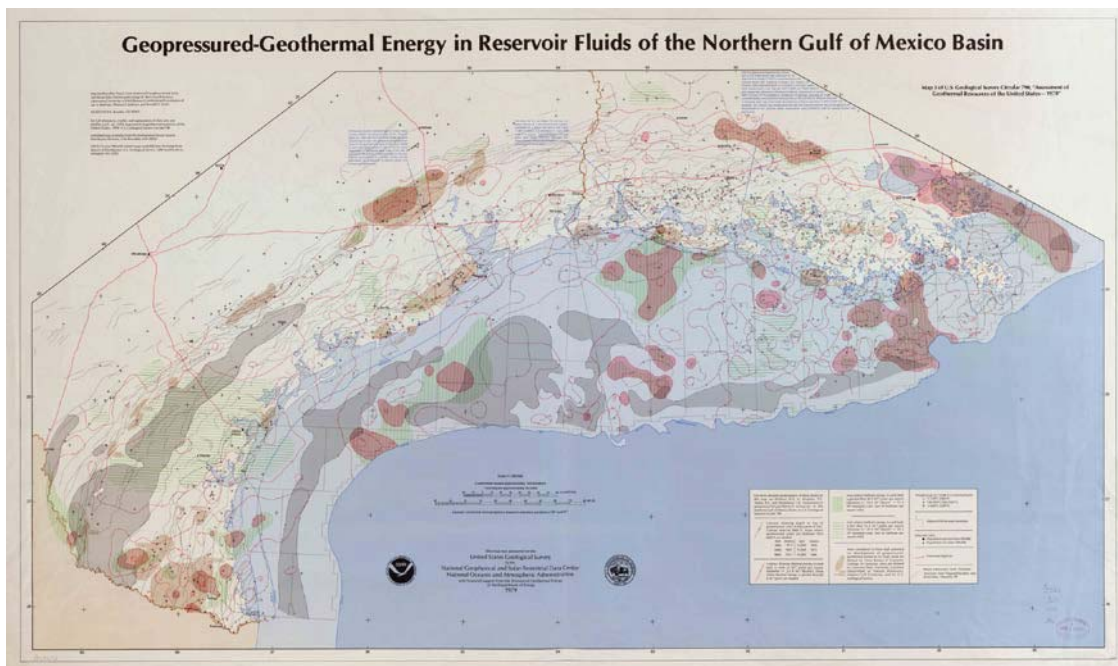


Figure 3-11 Geopressured Geothermal Resources in the Northern Gulf of Mexico (Source: National Geophysical and Solar-Terrestrial Data Center 1979)

3.3.4 Conversion Technologies

The conventional flash steam power plants used with hydrothermal resources use geothermal reservoirs of water with temperatures greater than 360°F (182°C). This hot water flows under its own pressure from the wells. As it flows upward, the pressure decreases and some of the hot water boils into steam. The steam is then separated from the water and used to power a turbine/generator. The water and condensed steam are injected back into the reservoir, making this a renewable resource. It is expected that most of the EGS resources will use binary cycle power plants. Binary cycle plants use the hot water resource to boil a working fluid, usually an organic compound with an appropriate boiling point. The water and the working fluid are kept separated during the whole process. The working fluid is vaporized in a heat exchanger and used to turn a turbine. The water is then injected back into the ground to be reheated.

Many of the technologies required for EGS, such as drilling and power plant technologies, are commercially available and already used in the hydrothermal or oil and gas industry. The technologies to create artificial geothermal reservoirs and manage these reservoirs over their lifetime are the major technical challenge. Technical feasibility of EGS concepts were first demonstrated at Fenton Hill in New Mexico in the late 1970s (MIT 2006, p. 4–5); however, the technology remains commercially immature. Key performance issues that must be addressed to enable commercialization include the techniques for creating the artificial reservoir of adequate size and flow characteristics so that significant thermal “drawdown” does not occur over the lifetime of the reservoir, achieving adequate flow connectivity to avoid excessive pressure losses in the reservoir, and preventing or repairing fluid circulation short circuits in the reservoir (MIT 2006). Demonstration projects are currently under way in the United States, Europe, and Australia.

Geopressured geothermal systems are closely related to the technology that can be used in co-production from oil and gas wells. They operate under the same principle but use wells drilled into naturally pressurized sedimentary reservoirs in which natural gas is dissolved in a high-temperature brine.¹⁰ Although neither technology has been deployed on a commercial scale, both technologies have been successfully demonstrated by DOE-funded projects (Johnson and Walker 2010; Campbell and Hattar 1990), and there are no major technical barriers to either technology system. Because of the distributed nature of the resource, co-produced and geopressured power plants are expected to consist of small, modular units ranging in size from 0.25 to 10 MW. The larger geopressured systems may be aggregated into “geothermal farms.”

3.3.5 Screening Factors

Screening factors relate to both the availability of the resource and specific needs of the energy conversion technology. For the purpose of this analysis, the screening factors used to screen areas for the specified geothermal technologies (in addition to the resource availability) are listed in Table 3-6, and the specific default suitability criteria and specific ranges for each screening parameter are listed in Appendix A. The Protected Land, Habitat, and Imperiled Species screening parameters are discussed in Section 4. Informational layers may also be useful for

¹⁰ Not all geopressured reservoirs are necessarily at high temperatures.

Table 3-6 Geothermal Screening Factors

Geothermal Technology	Screening Parameter
Enhanced geothermal system	Population density Slope Land cover area Distance to rivers (>130,000 gpm) Proximity to electric transmission (>220 kV) Protected Land Habitat Imperiled Species
Geopressured geothermal	Slope Land cover area Protected Land Habitat Imperiled Species

additional analysis by overlaying them onto the suitability model results. The extensive list of EZ Mapping Tool informational layers is included in Appendix B.

3.3.6 Data and Sources

Table 3-7 lists the geothermal resource data and sources. Publically available data to construct the screening factor layers for geothermal technologies are available from a variety of sources and are listed in Table 3-8. The Protected Land, Habitat, and Imperiled Species screening layers and data sources are discussed in Section 4.

3.4 Natural Gas

3.4.1 Introduction

Natural gas is a highly abundant fuel. Exploration and the development of new extraction technologies have increased the potential supply. A well-developed pipeline system already exists to transport the fuel. Natural gas is essentially methane, a carbon compound, that releases CO₂ and water vapor when combusted. The CO₂ release from natural gas per million British thermal units (Btu) produced is approximately 55% of the release from coal combustion, and it does not contain the ash or sulfur content of coal, which eliminates the need for SO₂ scrubbers and material handling of collected pollutants. Technological developments have enhanced the efficiency of generation with natural gas to further reduce the carbon emission of gas-fired generation. Combined-cycle plants have nearly double the efficiency of conventional steam turbine plants.

Table 3-7 Geothermal Data and Sources^a

Resource	Data and Source
Enhanced geothermal systems	NREL analysis of EGS favorability (Augustine 2011) based on temperature at depth maps from Southern Methodist University (SMU). Latest temperature-at-depth data could not be procured from SMU, thus analysis could not be updated.
Geopressured resource data	Data on the geopressured resource are available from Map 3 of USGS Circular 790 report, "Assessment of the Geothermal Resources of the United States – 1978," L.J.P. Muffler, Editor (1979). Map has been digitized, and shape files of the following information from the map have been created: Thermal energy in sandstone layers (contours) Depth to geopressured zones
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

Table 3-8 Geothermal Screening Factor Data and Sources^a

Factor (Parameter)	Data and Source
Population density	LandScan™, http://www.ornl.gov/sci/landscan/
Slope	2012 NGA Digital Terrain Elevation data/calculated and resized for 250-m cells
Land cover area	2011 USGS
Distance to rivers/surface water flow	2012 USGS/National Hydrologic data (Version 2)
Electric transmission data	2012 Bentek Energy/Platts
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

3.4.2 Scope

The scope of this analysis focused on combined-cycle gas turbine (CCGT) central generating stations of at least 500-MW capacity, underground storage of compressed natural gas, and aboveground storage of liquefied natural gas (LNG).

The use of natural gas to displace the use of oil and coal in conventional generation is not in the scope of this study. Exclusion of plant fuel conversions does not exclude the concept of adopting sites of retired plants for construction of new combined-cycle plants.

3.4.3 Resource Description

In 2011, 22.9 trillion cubic feet (Tcf) of dry natural gas (about 94% of consumption) was produced in the United States (EIA 2013a). Texas produced the greatest percentage (30%), and the next highest states included Louisiana (13%), Wyoming (9%), and Oklahoma (8%). Gas was produced in 32 states plus the Outer Continental Shelf. The majority was recovered from conventional reservoirs (i.e., from natural gas wells [43%] or co-existing with crude oil [21%]) (Figure 3-12).

However, the lower 48 states also contain substantial amounts of gas in unconventional reservoirs such as shale formations, 470 Tcf (see Figure 3-13); coal bed formations, 90 Tcf (Figure 3-14); and tight gas formations, 357 Tcf (Figure 3-15). Future production profiles will be

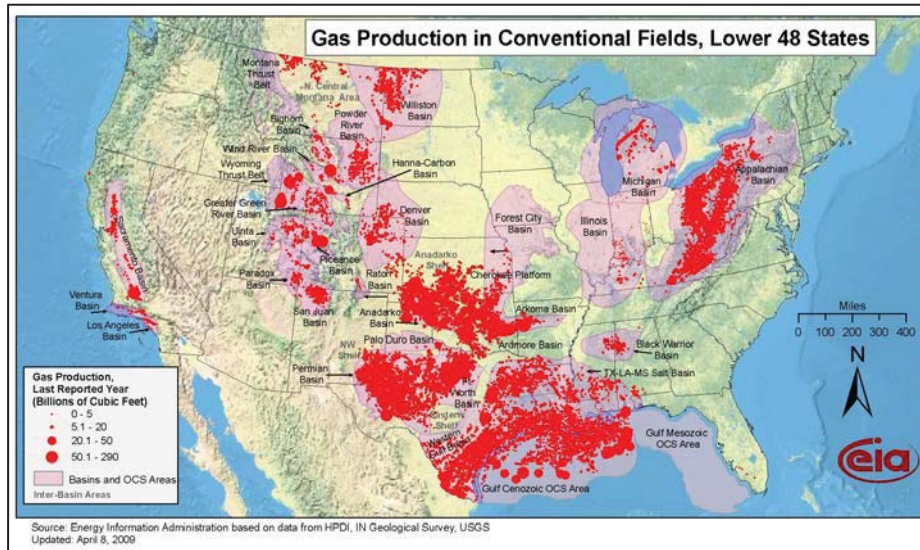


Figure 3-12 Conventional Natural Gas Production Fields
(Source: EIA 2009a)

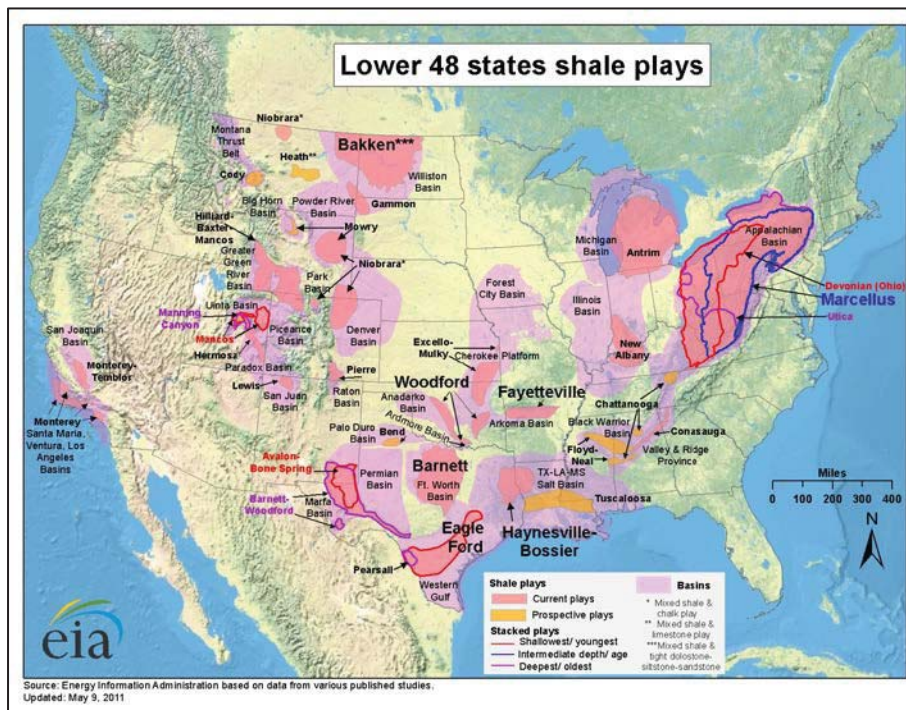


Figure 3-13 Shale Gas Plays in the Lower 48 States (Source: EIA 2011)

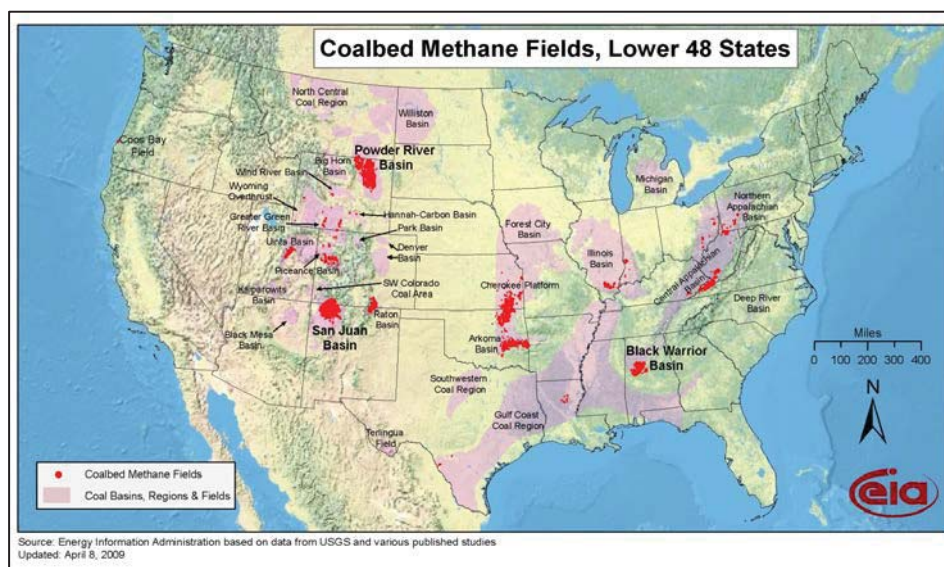


Figure 3-14 Coal Bed Methane Gas Fields in the Lower 48 States (Source: EIA 2009b)

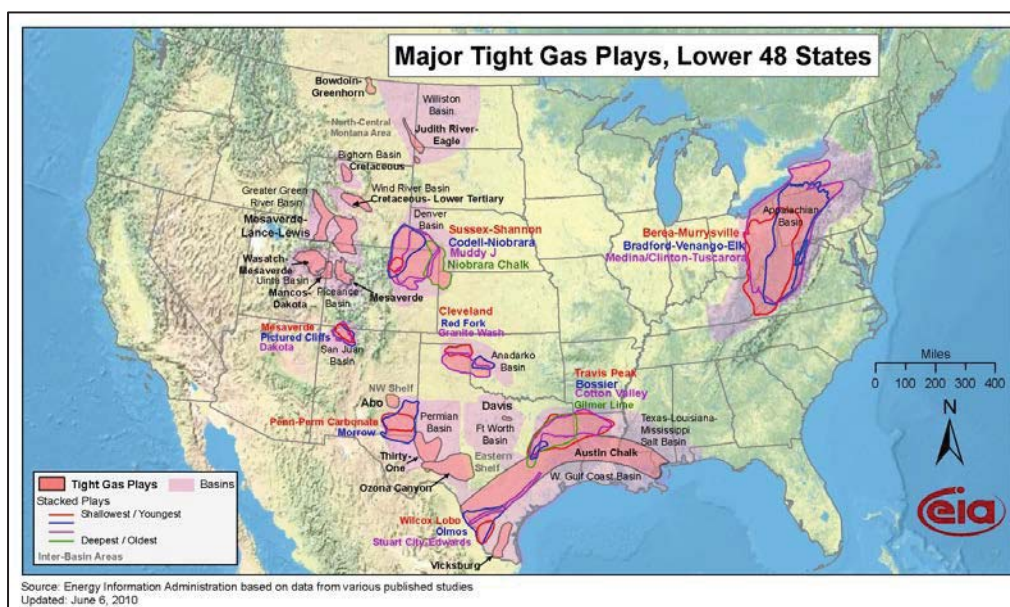


Figure 3-15 Major Tight Gas Plays in the Lower 48 States (Source: EIA 2010)

influenced greatly by the introduction of new unconventional supplies, including, for example, the initially estimated 500 Tcf of recoverable gas in the Marcellus Shale Gas Play, part of the Devonian Black Shale Succession (Figure 3-16). Shale gas production has grown from 0% in 2006 to 30% of total production in 2011 (EIA 2013a).

More recent estimates anticipating the application of technological advancements developed in gas recovery from shale formations in Texas place the total amount of recoverable gas as high as

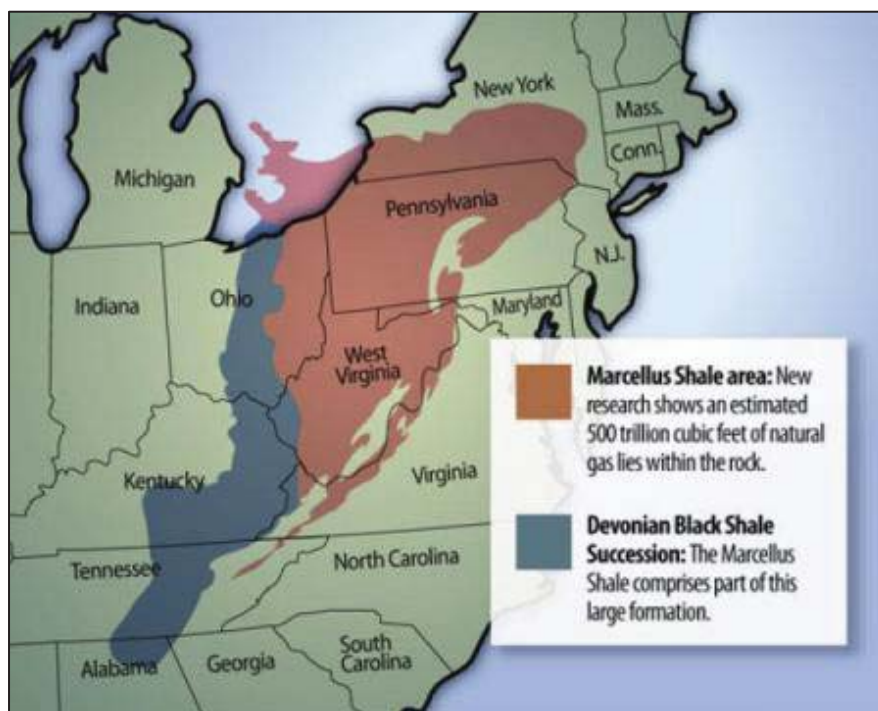


Figure 3-16 Marcellus Shale and the Devonian Black Shale Areas
(Source: Weber 2010)

1.3 quadrillion cubic feet (Qcf). In response to these estimates, as many as 24 pipeline expansion projects have been announced by companies with existing pipeline infrastructures in the vicinity of the formation to bring gas from this formation to market (Weber 2010). The EIA, in its Annual Energy Outlook 2013 release overview, projects that production of gas from shale formations will increase from approximately 23.0 Tcf/yr in 2011 to 33.0 Tcf/yr by 2040 (EIA 2012a).

The U.S. natural gas pipeline network is a highly integrated transmission and distribution grid that can transport natural gas to and from nearly any location in the lower 48 states (Figure 3-17). For more details on the interstate and intrastate pipelines, state-to-state capacity, and pipeline projects, see the web links in the references in Section 9.

On the basis of data generated from the 2009 annual report to the Pipeline and Hazardous Materials Safety Administration (PHMSA) from pipeline operators (<http://primis.phmsa.dot.gov/comm/PipelineBasics.htm?nocache=699>), the network includes approximately:

- 321,000 mi of onshore and offshore gas transmission and gathering pipelines,
- 2,066,000 mi of gas distribution mains and service pipelines, and
- 114 active LNG plants connected to U.S. gas transmission and distribution systems.

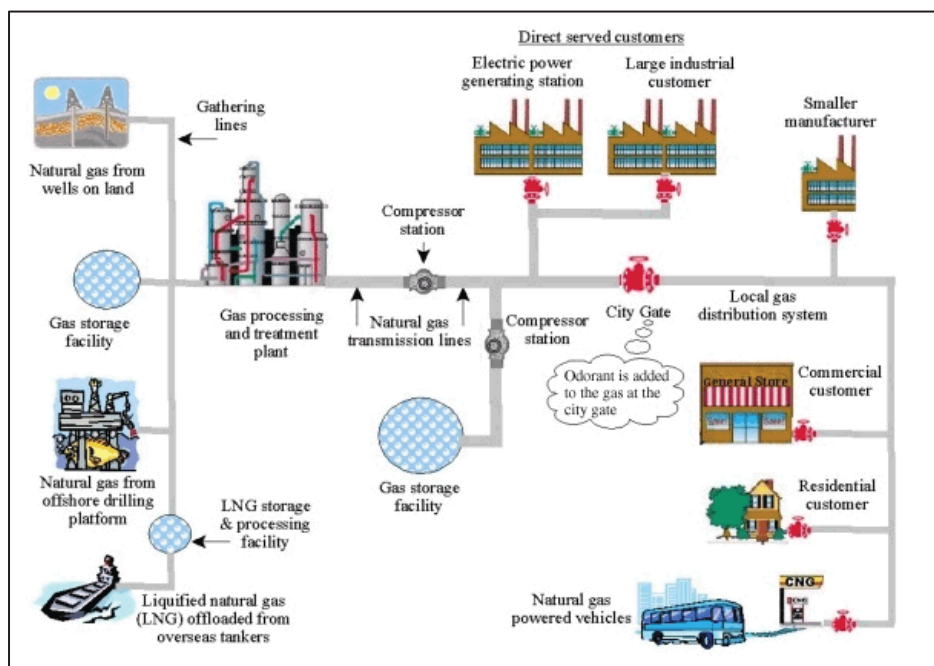


Figure 3-17 Natural Gas Pipeline System (Source: PHMSA 2005–2011)

The ability to transport natural gas from producing regions to consumption regions also affects the availability of supplies to the marketplace. The interstate and intrastate pipeline infrastructure in essence provides a “ceiling” for the amount of natural gas that can reach the market. The EIA estimates daily delivery capacity of the pipeline grid to be 148 billion cubic feet (Bcf) [<http://www.naturalgas.org/business/supply.asp#liquifiedng>]. Despite a relatively abundant supply of natural gas at the wellhead and shale gas play due to the proliferation of wells seeking to exploit unconventional resources, gas supply is still constrained by pipeline capacity. (For more information about these constraints, see Skutnik 2013 and EIA 2013b).

In addition, the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) (formerly the U.S. Department of Interior’s (DOI’s) Minerals Management Service [MMS]) provided the forecast for Gulf of Mexico gas production during the period 2007 to 2016 based on existing shallow and deep water operator commitments. BOEMRE estimates that Gulf of Mexico gas production could exceed 9 Bcf/day (Karl et al. 2007).

3.4.3.1 Underground Storage

Natural gas can be stored underground or aboveground in a number of different ways. It is most commonly held in inventory underground and under pressure in three types of facilities: (1) depleted reservoirs in oil and/or gas fields, (2) aquifers, and (3) salt cavern formations. Each storage type has its own physical characteristics (porosity, permeability, and retention capability) and economics (site preparation and maintenance costs, deliverability rates, and cycling capability) which govern its suitability to particular applications. Two of the most important characteristics of an underground storage reservoir are its capacity to hold natural gas for future use and the deliverability rate at which the gas inventory can be withdrawn.

Most existing gas storage in the United States is in depleted natural gas or oil fields that are close to consumption centers. Conversion of a field from a production to storage state takes advantage of existing wells, gathering systems, and pipeline connections. Depleted oil and gas reservoirs are the most commonly used underground storage sites because of their wide availability and economics.

In some areas, most notably the Midwestern United States, natural aquifers have been converted to gas storage reservoirs. An aquifer is suitable for gas storage if the water-bearing sedimentary rock formation is overlaid with an impermeable cap rock. While the geology of aquifers is similar to depleted production fields, their use in gas storage usually requires more base (or cushion) gas and greater monitoring of withdrawal and injection performance. Deliverability rates may be enhanced by the presence of an active water drive.

Salt caverns provide very high withdrawal and injection rates relative to their working gas capacity. Base gas requirements are relatively low. The large majority of salt cavern storage facilities have been developed in salt dome formations located in the Gulf Coast states. Salt caverns have also been leached from bedded salt formations in Northeastern, Midwestern, and Southwestern states. Cavern construction is more costly than depleted field conversions when measured on the basis of dollars per thousand cubic feet of working gas capacity; however, the ability to perform several withdrawal and injection cycles each year reduces the per-unit cost of each thousand cubic feet of gas injected and withdrawn.

Efforts have been made to use abandoned mines to store natural gas, with at least one such facility having been in use in the United States in the past. Further, the potential for commercial use of hard-rock cavern storage is currently undergoing testing. None are commercially operational as natural gas storage sites at the present time. Figure 3-18 is a stylized representation of the various types of underground storage facilities, while Figure 3-19 shows the locations of underground storage facilities in the lower 48 states.

3.4.3.2 Aboveground Storage of LNG

LNG is natural gas that is cooled to -260°F until it becomes a liquid and then stored at essentially atmospheric pressure. Converting natural gas to LNG, a process that reduces its volume by about 600 times, allows it to be transported internationally by specialized tankers with insulated walls. It is kept in liquid form by auto refrigeration, a process in which the LNG is kept at its boiling point, so that any heat additions are countered by the energy lost from LNG vapor that is vented out of storage and used to power the vessel. Once delivered to its destination in the United States or abroad, the LNG is warmed back into its original gaseous state so that it can be used just like existing natural gas supplies, by sending it through pipelines for distribution to homes and businesses. The LNG supply chain includes natural gas exploration/production, liquefaction, shipping, and regasification/storage. Figure 3-20 shows an LNG storage and peak shaving facility, and Figure 3-21 shows the locations of U.S. LNG peak shaving and import terminal facilities.

Imported LNG accounts for slightly more than 1% of natural gas used in the United States. According to the EIA, the United States imported 0.41 Tcf of natural gas in the form of LNG in 2010. However, because of increased domestic production, LNG imports are expected to

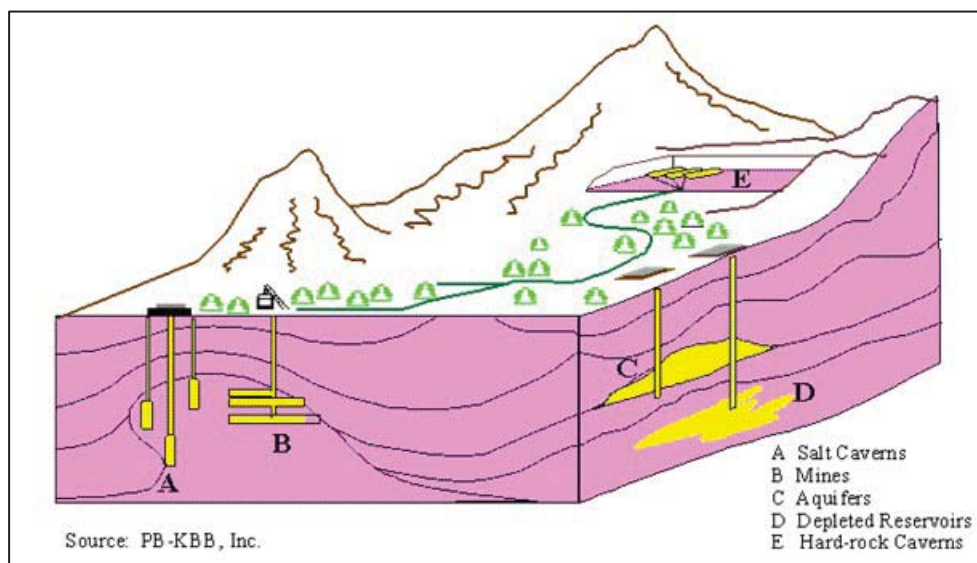


Figure 3-18 Types of Underground Natural Gas Storage Facilities
(Source: EIA 2004)

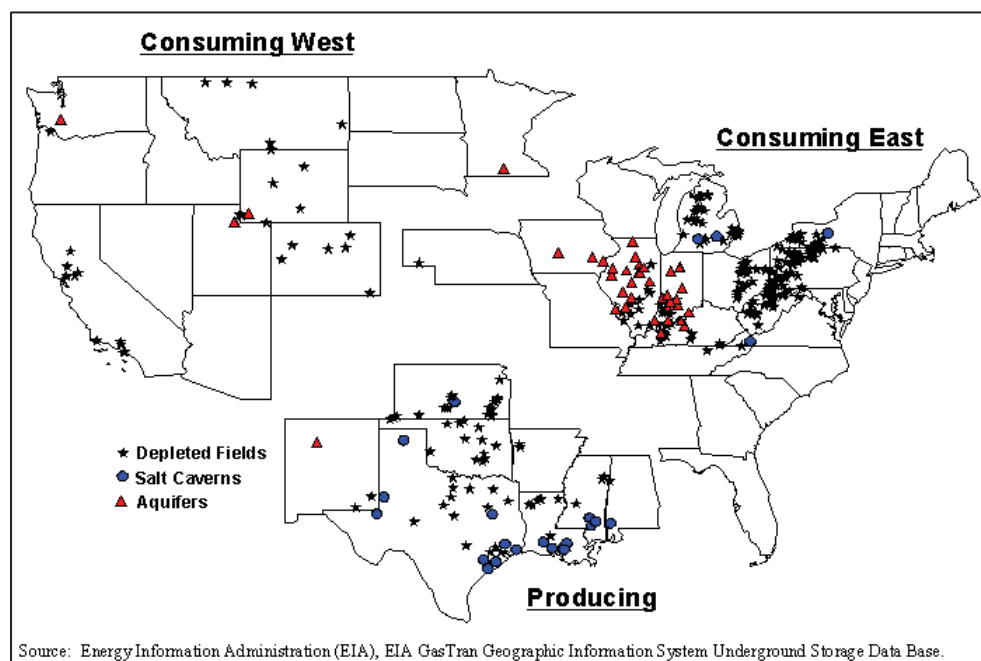


Figure 3-19 Underground Natural Gas Storage Facilities in the Lower 48 States
(Source: EIA 2004)



Figure 3-20 LNG Storage and Peak Shaving Facility (Source: DOE 2005)

decrease by an average annual rate of 4.1%, to levels of 0.14 Tcf of natural gas by 2035. More recent EIA projections show a reversal in the market due to the availability of large amounts of unconventional natural gas. The United States is projected to be a net exporter by 2021 (EIA 2012a). LNG imports represent an important part of the natural gas supply picture in the United States. LNG takes up much less space than gaseous natural gas, which allows it to be shipped much more efficiently. The United States gets a majority of its LNG from Trinidad and Tobago, Qatar, and Algeria, and also receives shipments from Nigeria, Oman, Australia, Indonesia, and the United Arab Emirates (<http://www.naturalgas.org/business/supply.asp#liquifiedng>).

As with any industry, LNG operators must conform to all relevant national and local regulations, standards, and codes. The four requirements for safety—primary containment (safe storage and isolation of LNG), secondary containment (leaks or spills contained and isolated), safeguard systems (minimize release of LNG and mitigate the effects of a release), and separation distance (LNG facilities must be sited at a safe distance from adjacent industrial, communities and other public areas)—apply across the LNG value chain, from production, liquefaction, and shipping, to storage and re-gasification (Michot Foss 2012). DOE helps to coordinate across federal agencies that have regulatory and policy authority for LNG, while the Federal Energy Regulatory Commission (FERC) is responsible for permitting new onshore LNG regasification terminals and ensuring safety at these facilities. The U.S. Department of Transportation (DOT) regulates offshore terminals and LNG tanker operations, and the United States Coast Guard (USCG) is responsible for assuring the safety of all marine operations at all LNG terminals and on tankers

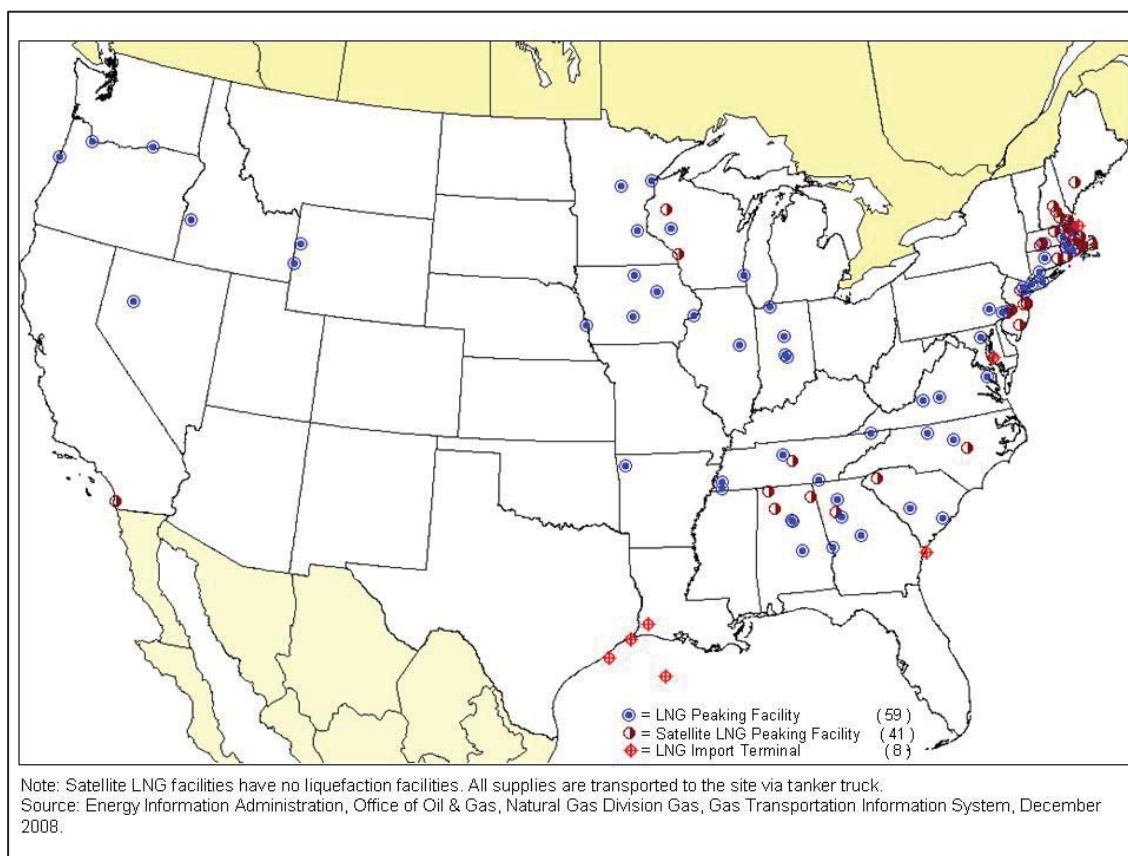


Figure 3-21 U.S. LNG Peak Shaving and Import Facilities (Source: EIA 2008)

in U.S. coastal waters. The EPA and state environmental agencies establish air and water standards with which the LNG industry must comply. Other involved agencies include the U.S. Army Corps of Engineers (USACE); U.S. Fish and Wildlife Service (USFWS); BOEMRE (formerly MMS is responsible for offshore activities); National Oceanic and Atmospheric Administration (NOAA); and state, county, and local (municipal) agencies. All have key roles in ensuring safe and environmentally sound construction and operation of LNG industry facilities (Delano 2004).

3.4.4 Conversion Technologies

CCGT is the dominant gas-based technology for intermediate and baseload power. A review of the Platts database revealed 194 operating combined-cycle plants greater than 500 MW in the Eastern Interconnection. Heat recovery steam generators (HRSGs) are usually built for horizontal gas flow, thus increasing the area required when compared to a conventional fossil-fueled steam plant. However, gas plants do not require acreage for coal storage and coal train unloading, nor for dewatering ponds for ash and slag, and do not need space for sulfur scrubbers and other types of pollution control technology. Assuming that the steam cycle would employ cooling towers for the steam condensers, a 500-MW plant would require about 100 acres.

A CCGT plant is a dual-cycle plant that consists of one or more gas turbine electricity generators; the second part of the CCGT is equipped with HRSGs to capture heat from the gas turbine exhaust (Figure 3-22). It takes advantage of the energy in the exhaust gases to create steam with recovered waste heat. The HRSGs may be equipped with a bypass damper that allows the gas turbine to operate independently from the steam cycle, which makes plant operation more responsive and flexible. Steam produced in the HRSG powers a steam turbine generator to produce additional electric power (WSU undated). The combustion turbine will produce 60% to 70% of the electric output, with the balance created by the steam turbine.

The efficiency of a simple cycle steam plant, based on current design technology, is approximately 35%. The hot gases of combustion in the steam boiler leave the smokestack at 300°F, accounting for 15% of the loss. The balance of the waste energy is lost during the phase change of the steam exhaust from the turbine. The combustion turbine combined cycle can achieve efficiency of 60%.

3.4.5 Screening Factors

Screening criteria for coal and nuclear technology were used as a basis for developing the natural gas screening factors (Table 3-9). The criteria were modified on the basis of the unique characteristics of natural gas technologies. The specific default suitability criteria and specific ranges for each screening parameter are listed in Appendix A. The Protected Land, Habitat, and Imperiled Species screening parameters are discussed in Section 4.

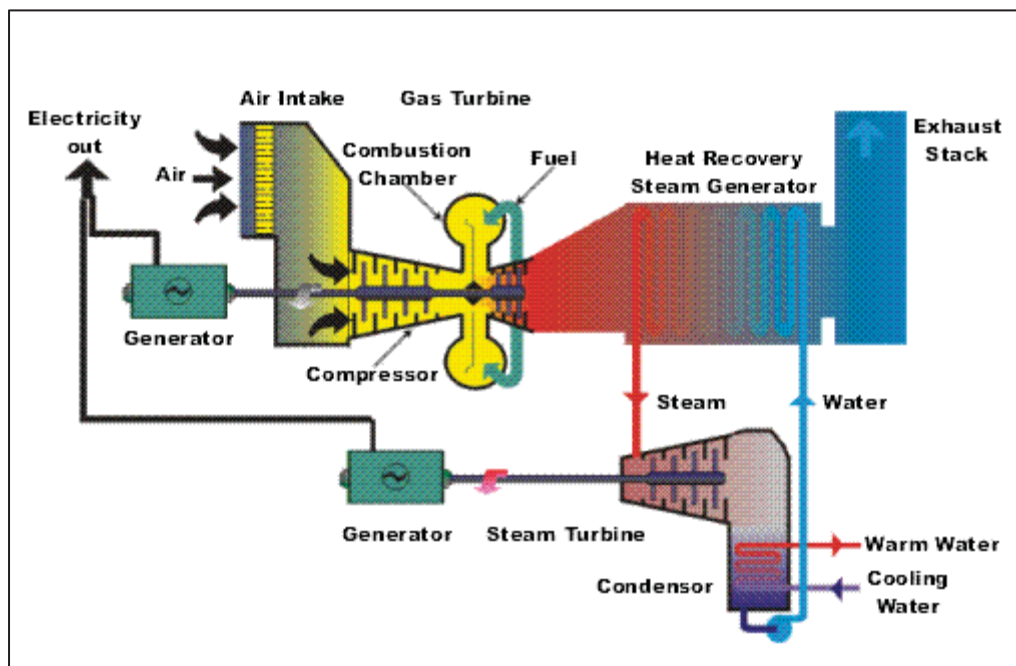


Figure 3-22 Schematic of Combined-Cycle Plant Process (Source: Nooter Eriksen undated)

Table 3-9 Natural Gas Screening Factors

Natural Gas Technology	Screening Parameter
Combined-cycle gas turbine power plant	Distance to natural gas transmission pipeline (≥ 12 in) Population density Slope Land cover area Distance to rivers ($> 100,000$ gpm) 100-yr flood zone Distance to railroad Distance to port (barge locations) Proximity to electric transmission (≥ 100 kV) Protected Land Habitat Imperiled Species
Underground natural gas storage	Distance to natural gas transmission pipeline (≥ 12 in) Aquifer area Distance to domal salt formation Population density Land cover area 100-yr flood zone Distance to railroad Distance to major road Proximity to electric transmission (> 100 kV) Protected Land Habitat Imperiled Species
Aboveground natural gas storage (LNG)	Distance to natural gas transmission pipeline (≥ 12 in) Population density Slope Land cover area 100-yr flood zone Proximity to electric transmission (> 100 kV) Protected Land Habitat Imperiled Species

Population density of greater than 1,000 people per square mile begins to transition into a highly urban setting, thus new combined-cycle power plants in these areas are not likely based on anticipated available space and zoning restrictions. Review of the inventory of existing CCGT plants of 500 MW or more confirms this conclusion. LNG facilities require a very low population density, since a buffer exclusion zone is required for safety reasons. Numerous overlapping jurisdictions must be addressed to develop an LNG storage site, based on federal, state, and local legislation. The criteria presented for LNG only provide a broad interpretation of these concerns.

Construction of a gas power plant requires building a lateral pipeline from a major natural gas pipeline in order to operate. For this reason, it is assumed that the gas power plant will interconnect with a pipeline. The same consideration is assumed to apply to both underground

storage and aboveground LNG storage. Access to high-voltage transmission for an outlet of the power produced is essential for the CCGT. It is also highly desirable to provide service to the storage facilities, even though they may self-generate.

Available water for cooling is a common need for all thermoelectric power plants. A report prepared by NETL for DOE provides water consumption factors (NETL 2008). Water is also required at storage facilities, but it is assumed that the much lower required volumes can be supplied from wells.

In all categories, protected land is excluded, including parks, schools, airports, wildlife, and conservation areas. In the case of underground storage, the footprint of the storage field belowground will vary. The identified zone will only address the storage access point and not the entire formation.

The application of ground slope is completely based on industry experience. Because there is a tradeoff between cost and the severity of terrain, mild slope is always desirable but not an exclusion criterion. However, locating tanks for LNG would seem prudent only in areas of mild slope.

The transportation of large components by rail, road, or barge is deemed an important practical consideration for the construction of a CCGT plant as well as storage facilities, with the associated compression, expansion, and treatment equipment needed.

Informational layers may also be useful for additional analysis by overlaying them onto the suitability model results. The extensive list of EZ Mapping Tool informational layers is included in Appendix B.

3.4.6 Data and Sources

Publicly available data to construct the screening factors for natural gas technologies are available from a variety of sources (Table 3-10). The Protected Land, Habitat, and Imperiled Species screening layers are discussed in Section 4.

3.5 Nuclear

3.5.1 Introduction

Currently, 65 commercial nuclear power plants with 104 reactors (nuclear units) are licensed by the U.S. Nuclear Regulatory Commission (NRC) to operate in the United States.¹¹ These plants represent a highly reliable baseload electric power source across several large regions of the country. They constitute nearly 20% of the electricity generated and more than 70% of the country's "zero-carbon" electricity capacity. For 2011, nuclear power plants generated approximately 790 billion kWh.

¹¹ Utilities have recently opted to permanently shut down 4 of the 104 licensed reactors.

Table 3-10 Natural Gas Data and Sources^a

Parameter/Information	Data and Source
Distance to natural gas transmission pipeline	2012 Bentek Energy/ Platts
Population density	LandScan™, http://www.ornl.gov/sci/landscan/
Slope	2012 NGA Digital Terrain Elevation data/calculated and resized for 250-m cells
Distance to rivers/surface water flow (>100,000 gpm)	2012 USGS/National Hydrography Data (Version 2)
Land cover area	2011 USGS
100-yr flood zone	2011 FEMA National Flood Hazard, http://www.msc.fema.gov
Distance to railroad	2012 FRA data
Distance to port	2012 USACE
Distance to major road	2012 National Transportation Atlas Database, www.bts.gov/publications/national_transportation_atlas_database/2012
Electric transmission data	2012 Bentek Energy/Platts
Aquifer areas	2011 USGS
Salt caverns	2012, 2013 ORNL
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

Five new plants are presently under construction—two in Georgia (Vogtle 3 and 4), two in South Carolina (Summer 2 and 3), and one in Tennessee (Watts Bar 2)—totaling approximately 5,000 MW(e) of new generation capacity.

Thirty-one states have one or more operating commercial nuclear power plants. For 2011, nuclear power composes the largest percentage of electric power generated for seven of these states:

- Vermont 72.5%
- New Jersey 52.1%
- South Carolina 51.2%
- Illinois 48.2%
- Connecticut 47.4%
- New Hampshire 41.5%
- Virginia 38.1%

These generating statistics and data were summarized from information contained at the Nuclear Energy Institute's website (NEI 2012). Figure 3-23 shows the location of each of the nuclear plants. The top five states for nuclear generation in 2011 were Illinois, Pennsylvania, South Carolina, New York, and North Carolina.

Sections 3.5.2 through 3.5.6 provide descriptions of the types of reactors that were considered for potential siting, illustrations of several reactor types, descriptions of the siting screening criteria employed for each type reactor, and data and sources for the screening factors.

3.5.2 Scope

The 104 operating commercial nuclear power units noted above are all light-water reactor (LWR) designs of varying power levels with 35 of them boiling-water reactors (BWRs) and 69 pressurized-water reactors (PWRs). For this study, three different types of reactors were considered: (1) large LWRs like those currently undergoing design certification and combined operating license reviews by the NRC; (2) small modular reactors (SMRs) based on PWR technology whose compact design features are expected to offer a host of safety, siting, construction, and economic benefits as well as ideal for small electric grids; and (3) high-temperature gas-cooled reactors (HTGRs) currently being considered for both electricity and process heat applications.

Advanced power reactor concepts (liquid-metal cooled reactors) and non-light water SMR concepts were considered out of scope for this study.

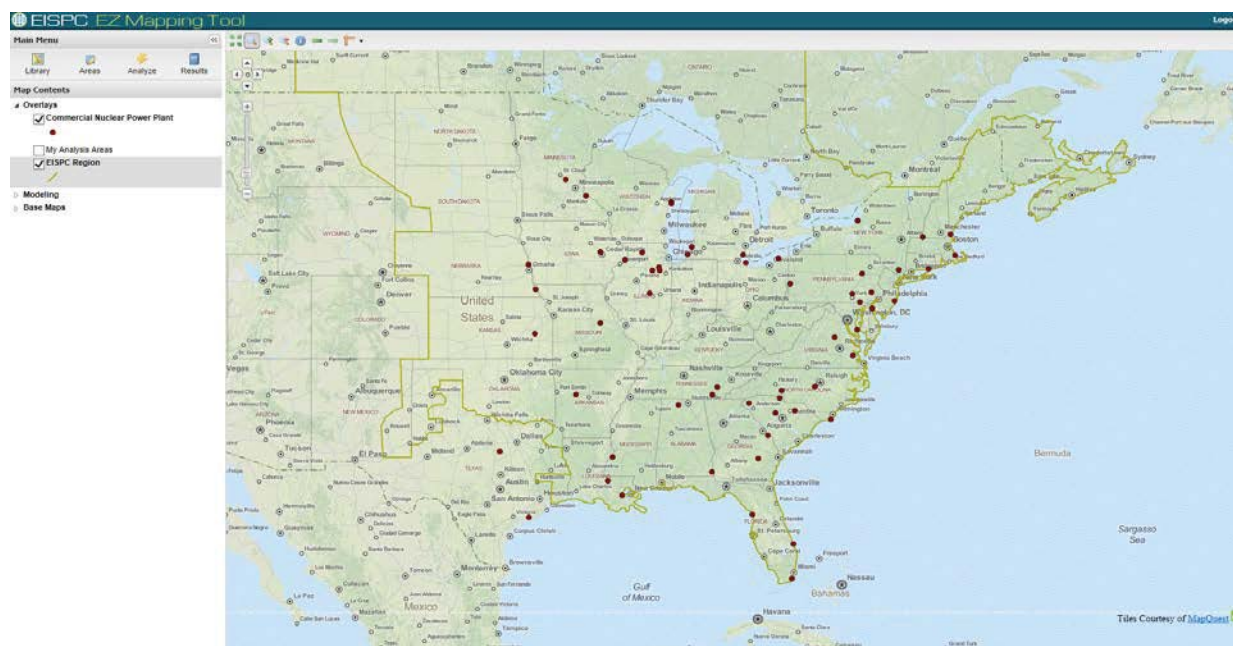


Figure 3-23 Locations of Existing Commercial Nuclear Power Plants in the U.S. Portion of the Eastern Interconnection (Source: EISPC EZ Mapping Tool)

3.5.3 Resource Description

Nuclear power plants, like plants that burn coal, oil and natural gas, produce electricity by boiling water into steam. This steam then turns turbines to produce electricity. However, nuclear plants do not burn anything; rather, they use uranium fuel, consisting of solid ceramic pellets, to produce electricity through a process called fission. Nuclear power plants obtain the heat needed to produce steam through the fission that involves the splitting of atoms of uranium in the fuel of a nuclear reactor.

The uranium fuel consists of small, hard ceramic pellets that are packaged into long, vertical tubes. Bundles of this fuel are inserted into the reactor. Nuclear fuel consists of two types of uranium, ^{238}U and ^{235}U . Most of the uranium in nuclear fuel is ^{238}U , but ^{235}U splits, or fissions. Typical commercial nuclear fuel is enriched to about 5% ^{235}U to achieve a self-sustaining fission process. Figure 3-24 is a schematic of a current generation PWR that illustrates the major systems of PWR nuclear power plants.

Natural gas represents the largest share of electric power generation capacity, followed by coal, nuclear power, and conventional hydropower. Natural gas and coal capacity are each much larger than nuclear capacity. However, for cost and technical reasons, nuclear power plants are generally utilized more intensively than coal or natural gas units. In 2011, the nuclear share of electricity generating capacity was 9%, while nuclear's share of national power generation was 19%. The comparable values were 28% capacity to 42% generation for coal, and 41% capacity to 25% generation for natural gas (EIA 2012).

The above noted “intensity” factor is related to the extraordinarily high-energy density of nuclear fuel relative to fossil fuels and consequent low fuel cost. For example, 1 kilogram (kg) of firewood can produce 1 kWh of electricity. Comparable values for other fossil fuels and nuclear are as follows:

- 1 kg of coal => 3 kWh
- 1 kg of oil => 4 kWh
- 1 kg of uranium => 50,000 kWh

3.5.4 Conversion Technologies

“Large LWRs” are currently undergoing design certification and combined operating license reviews by the NRC and are commonly referred to as Generation III+ (Gen III+) designs, in the 1,100- to 1,600-MW(e) range. Those that are characterized as passive with regard to safety do not require active controls or operator intervention, but instead rely on gravity or natural convection to mitigate the impact of abnormal events and provide emergency cooling. These reactors (both PWRs and BWRs) represent the next evolution of designs beyond those 104 currently operating commercial nuclear power reactors. Examples include Hitachi-GE's Economic Simplified Boiling-Water Reactor (ESBWR), AREVA's European Pressurized Reactor (EPR), Mitsubishi's Advanced Pressurized-Water Reactor (APWR), and

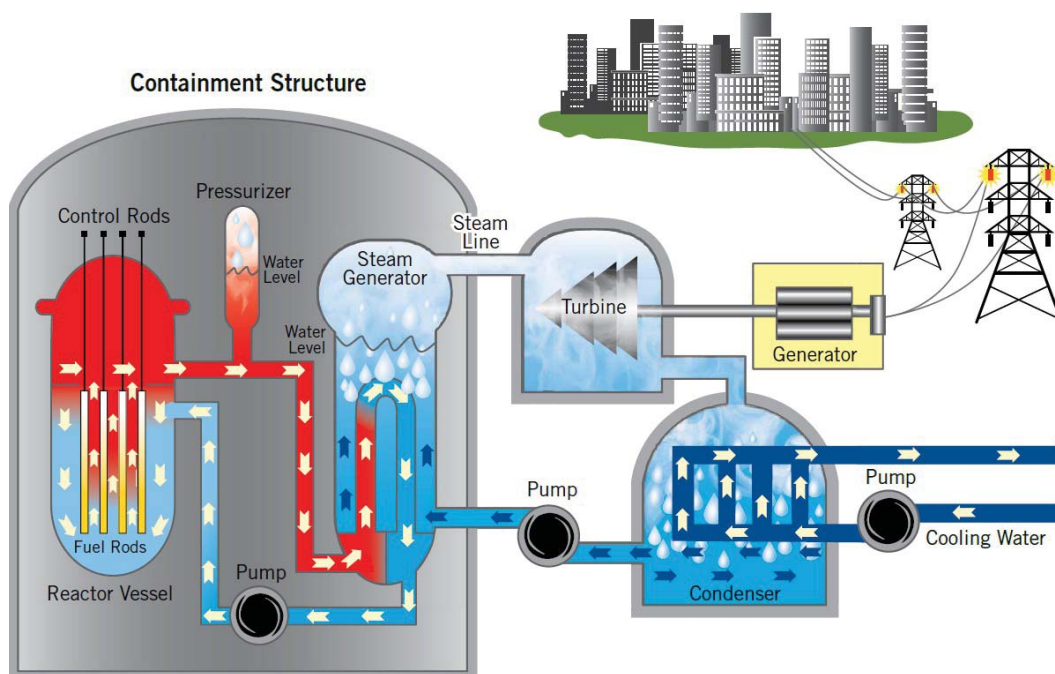


Figure 3-24 Schematic of PWR Illustrating Generation of Electrical Power
(Source: ANS 2013)

Westinghouse's AP1000® PWR. The four reactors that recently received an approved combined operating license (COL) from the NRC and have initiated construction—two in Georgia (Vogtle 3 and 4) received their COL in February 2012 and two in South Carolina (Summer 2 and 3) received their COL in March 2012—are using Westinghouse's approved AP1000 standardized reactor design. Figure 3-25 illustrates the AP1000 PWR plant design.

SMRs have design features that will provide safety, siting, construction, and economic benefits. Furthermore, these smaller plants are ideally suited for small electric grids and for locations that cannot support large reactors, thus providing utilities with the flexibility to scale production as demand changes by adding more modules or reactors in phases. The near term SMR designs are based on existing PWR technology. They are characterized as “integral” PWRs (iPWRs), since these plants will have major equipment such as pumps, steam generators, and pressurizers, all located within the pressure vessel in an integrated, compact design. These designs are typically in the 25 to 250 MW(e) power range. In 2012, DOE initiated an “SMR Licensing Technical Support Program” through a funding opportunity announcement to accelerate the deployment and commercialization of SMR technologies. This program represents a 5-year cost-share industry partnership. In December 2012, the Babcock & Wilcox Generation mPower™ design was selected as part of this program.

Figure 3-26 is a simple illustration of the principal design differences between an iPWR SMR and a loop-type PWR, including the elimination of the two, three, or four loops (only one pictured) for the large PWR, piping diameter size difference, and the major equipment for the iPWR being located within the pressure vessel. Another distinguishing design feature that is not illustrated in Figure 3-26 is the elongated (taller) core design for the iPWR. The vessel height-to-

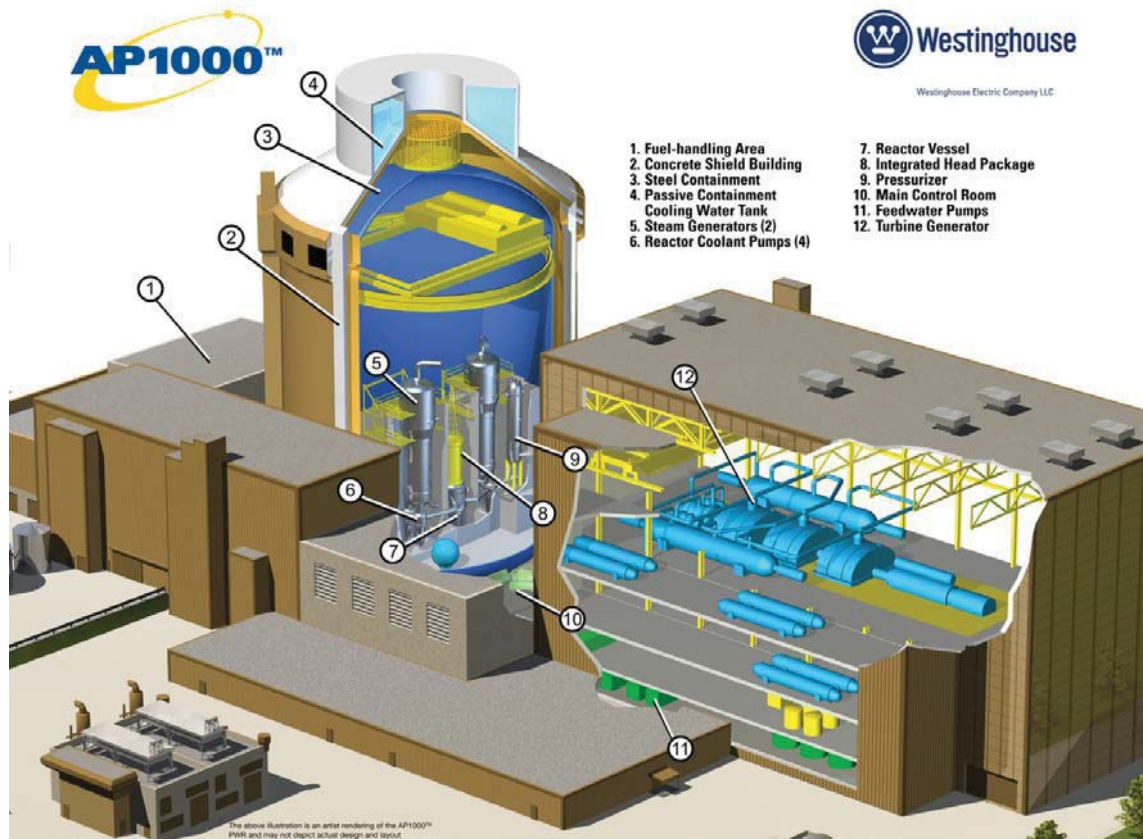


Figure 3-25 Plant Design and Layout of Westinghouse AP1000 PWR (Westinghouse Electric Company LLC 2013)

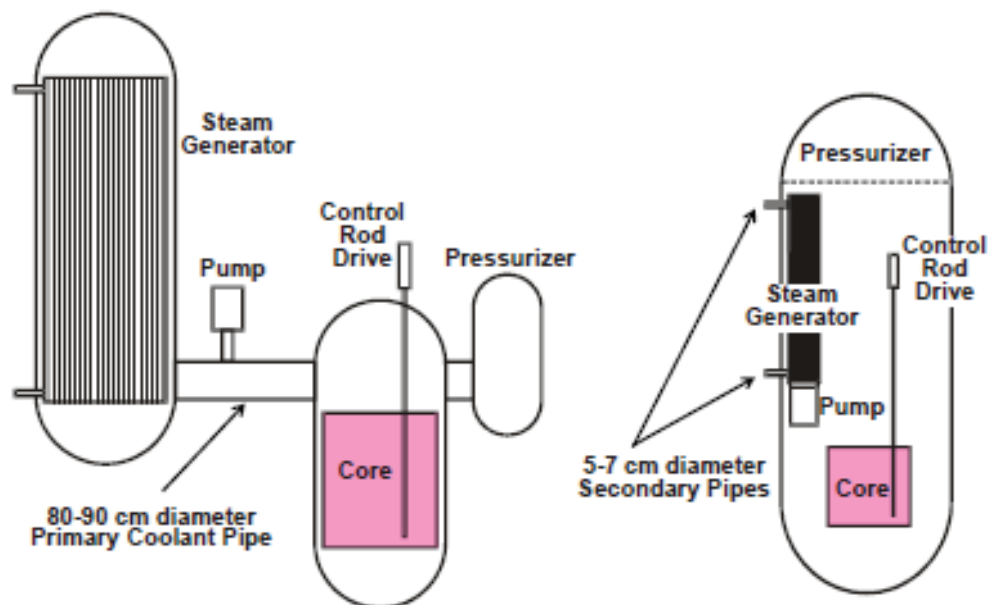


Figure 3-26 Comparison of Large PWR Design with iPWR Design for SMRs (Source: Ingersoll 2011)

diameter ratio for the near-term iPWRs will likely exceed 6.0, while that of a PWR and BWR are on the order of 2.5 and 2.0, respectively. This increase in the aspect ratio greatly facilitates the formation of gravity-driven natural convection circulation of the coolant, which enhances heat removal from the core and allows the plant to cool down safely in the event of a loss of off-site power without a requirement for emergency power (diesels or batteries) to drive circulation pumps (Ingersoll 2011).

The four SMR vendors whose integral designs are based on PWR technology include the following:

1. Babcock and Wilcox's m-Power SMR: 180 MW(e) per reactor module with the plan to deploy two 180-MWe modules/units at a time;
2. NuScale SMR: 45 MW(e) per reactor module with the plan to deploy 6 or 12 modules/units at a time;
3. Westinghouse SMR: 225 MW(e) per reactor with the plan to deploy one or more units individually; and
4. Holtec's SMR-160: 160 MW(e) per reactor with the plan to deploy one unit or multiple units individually.

All of these designs feature underground siting for safety and security reasons. All four vendors presently indicate submitting applications for design certification in the 2013 to 2015 time frame.

As previously stated, HTGRs are currently being considered for both electricity and process heat applications. DOE has been directed under the Energy Policy Act of 2005 (EPAct) to develop a high-temperature reactor under a cost-shared approach with industry. DOE's HTGR program is known as the Next Generation Nuclear Plant (NGNP). NGNPs do not require cooling water requirements like the LWRs and SMRs (some designs use a gas turbine power conversion technology) and could be located near other industrial plants that potentially could utilize the process heat produced by such a reactor. HTGRs in the small-to-medium-sized range are capable of high-temperature operation in excess of 700°C. These plants have the right combination of size, heat output, and passive safety features to make them favorable candidates for use in industrial settings. The referenced NGNP concept includes a helium-cooled, graphite-moderated, thermal neutron spectrum reactor. The reactor core technology will either be a prismatic block or pebble bed concept using multi-layered graphite coated particle fuel. The NGNP will produce both electricity and hydrogen using an indirect cycle with an intermediate heat exchanger to transfer the heat to either a hydrogen-production demonstration facility or a gas turbine. DOE is providing support through NGNP research and development ranging from fundamental nuclear phenomena research to advanced fuels development that could improve the economic and safety performance of these advanced reactors. Figure 3-27 illustrates an NGNP conceptual design deployed with industrial facilities.

In addition to the DOE-funded work in support of NGNP, there is an "NGNP Industry Alliance" composed of Dow, ConocoPhillips, AREVA, Entergy, and other companies that have organized



Figure 3-27 Conceptual Deployment of NGNP with Industrial Facilities (Source: NGNP Alliance 2013)

around the common objective of promoting the development and commercialization of HTGR technologies for high-temperature process heat applications. This group interacts with DOE and its NGNP program.

It is assumed that new large LWR and SMR plants will be deployed using closed-cycle cooling systems and cooling towers as opposed to once-through cooling. For the HTGR, it is assumed that the power conversion system is a gas turbine system and will not include cooling water for screening criteria. However, there would be some nominal water requirements as for any industrial facility.

3.5.5 Screening Factors

The screening factors used for nuclear power were based on work that ORNL conducted previously in support of work done for the Electric Power Research Institute (EPRI) (Mays et al. 2012).

ORNL developed OR-SAGE for applying GIS and spatial modeling techniques for evaluating siting options for nuclear power and has extended that capability for other electric power plants, including solar and clean coal. The earlier ORNL work and the screening criteria presented

herein are based on an EPRI document entitled *Siting Guide: Site Selection and Evaluation Criteria for An Early Site Permit Application* (EPRI 2002). This guide provides the framework for selecting potential sites. It includes approximately 60 categories of screening factors for consideration in developing an “environmental envelope” to support development of an early site permit application for a site pre-approval. Many of these factors are consistent with the information that would be contained in an Environmental Report as part of the full licensing process.

ORNL reviewed these parameters and identified those that were considered most important and would provide sufficient discrimination between and among potential areas suitable for nuclear resource development at an initial screening level. Table 3-11 presents the screening criteria for this study that were derived from this earlier effort. This table presents those factors common to all three types of reactors for determining which areas are most suitable for nuclear power generation. The specific default nuclear suitability criteria and specific ranges for each screening parameter are listed in Appendix A. The Protected Land, Habitat, and Imperiled Species screening parameters are discussed in Section 4. Informational layers may also be useful for additional analysis by overlaying them onto the suitability model results. The extensive list of EZ Mapping Tool informational layers is included in Appendix B.

3.5.6 Data and Sources

The publicly available data sources used in formulating the screening factor layers for nuclear power were collected from a variety of sources listed in Table 3-12. The Protected Land, Habitat, and Imperiled Species screening layer and data sources are discussed in Section 4.

Table 3-11 Nuclear Technology Screening Factors

Nuclear Screening Parameters for Established Reactor Technologies	Large LWR	SMR (iPWR)	HTGR
Primary Screening Parameter			
Population density	✓	✓	✓
Slope	✓	✓	✓
Seismic hazard	✓	✓	✓
Quaternary fault exclusion	✓	✓	✓
Land cover area	✓	✓	✓
Distance to rivers (cooling water) (>200,000 gpm for large reactors/>50,000 gpm for small reactors)	✓	✓	NA
100-yr flood zone	✓	✓	✓
Distance to airports	✓	✓	✓
Distance to military bases	✓	✓	✓
Habitat, Protected Land, Imperiled Species	✓	✓	✓
✓ = include as parameter. NA = not applicable.			

Table 3-12 Nuclear Screening Factor Data and Sources^a

Factor (Parameter)	Data and Source
Population density	LandScan™, http://www.ornl.gov/sci/landscan/
Slope	2012 NGA Digital Terrain Elevation data/ calculated and resized for 250-m cells
Seismic hazard	2012 USGS
Quaternary fault exclusion	2012 USGS
Land cover area	2011 USGS
Distance to rivers/surface water flow	2012 USGS/National Hydrography data (Version 2)
100-yr flood zone	2011 FEMA National Flood Hazard data
Distance to airports	2012 Federal Aviation Administration (FAA) and the Research and Innovative Technology Administration's Bureau of Transportation Statistics
Distance to military bases	2012 Defense Installation Spatial Data Infrastructure Program
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

3.6 Solar

3.6.1 Introduction

Solar energy can be used in a variety of ways to produce heat, light, fuel, or electricity. Solar energy is ubiquitous but is a variable energy source with strong diurnal, seasonal, inter-annual, and geographic patterns. In general, peak energy output for solar energy collectors corresponds well with high energy demand periods (Denholm and Margolis 2007) and can be more closely matched through the use of energy storage techniques. Utility-scale solar energy has been produced in the United States since the mid-1980s, and the EIA reported 987 MW of total solar nameplate capacity in 2010 (EIA 2011). Grid-connected solar capacity is growing rapidly in the United States, amounting to nearly 7,900 MW by the end of 2012 (Sherwood, 2012). Solar energy accounted for less than 1% of the electricity generated in the United States in 2012, excluding off-grid uses (EIA 2012).

Sections 3.6.2 through 3.6.6 discuss the solar technologies in scope for this study, describe solar energy resources, describe available conversion technologies, present screening factors used in the study, and provide data and sources. Section 3.6.4.3 provides details on the rooftop PV solar resource, which differs significantly from the utility-scale solar resources.

3.6.2 Scope

Conventional utility-scale PV and concentrating solar power (CSP) technologies were considered for the EZ Study along with distributed or rooftop PV. The CSP technologies included are parabolic troughs and solar power towers. Dish Stirling and linear Fresnel technologies are not currently proposed for any large-scale developments in the United States and are not included in the EZ Study, though similar considerations apply.

3.6.3 Resource Description

The three basic types of solar resources are direct normal (beam), diffuse (sky), and global (total) irradiance. The direct normal irradiance is the amount of radiation from the “solar disk” (generally defined by a 5.7° field of view) on a surface perpendicular to the Sun’s location in the sky. Concentrating solar collectors are designed to capture this form of solar energy. The diffuse irradiance is the amount of solar radiation reaching the Earth’s surface after being scattered from the direct beam. Diffuse irradiance data are useful for architectural daylighting applications and in photosynthesis. The global (typically global horizontal) irradiance is the geometric sum of the direct normal and diffuse irradiance components and represents the amount of energy available from the entire sky dome on a planar surface. The various collector types require design-specific models to convert the direct and diffuse components to estimates of solar radiation available to each collector type and orientation. Solar resource is typically reported in kilowatt-hours per square meter per day ($\text{kWh/m}^2/\text{day}$) when measured over longer time periods (more than a day), and watts per square meter (W/m^2) when reported at finer time scales.

Figure 3-28 presents the estimated annual average solar resource distribution for utility-scale PV, and Figure 3-29 presents the estimated annual average direct normal solar resource distribution for CSP.

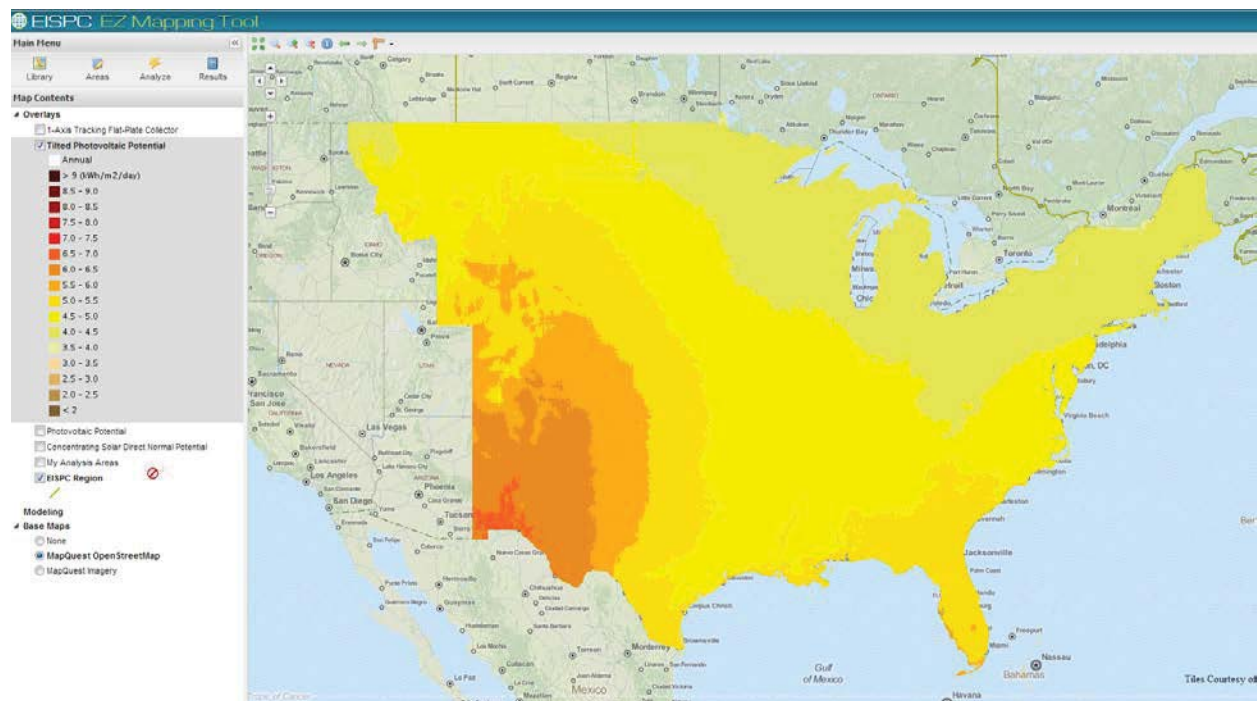


Figure 3-28 Estimated Average Daily PV Solar Resource Potential by Year in $\text{Wh/m}^2/\text{day}$
 (Note: The insolation values represent the average solar energy available to a flat plate collector, such as a PV panel oriented due south at an angle from the horizontal equal to the latitude of the collector location.) (Source: NREL 2007 and EZ Mapping Tool)

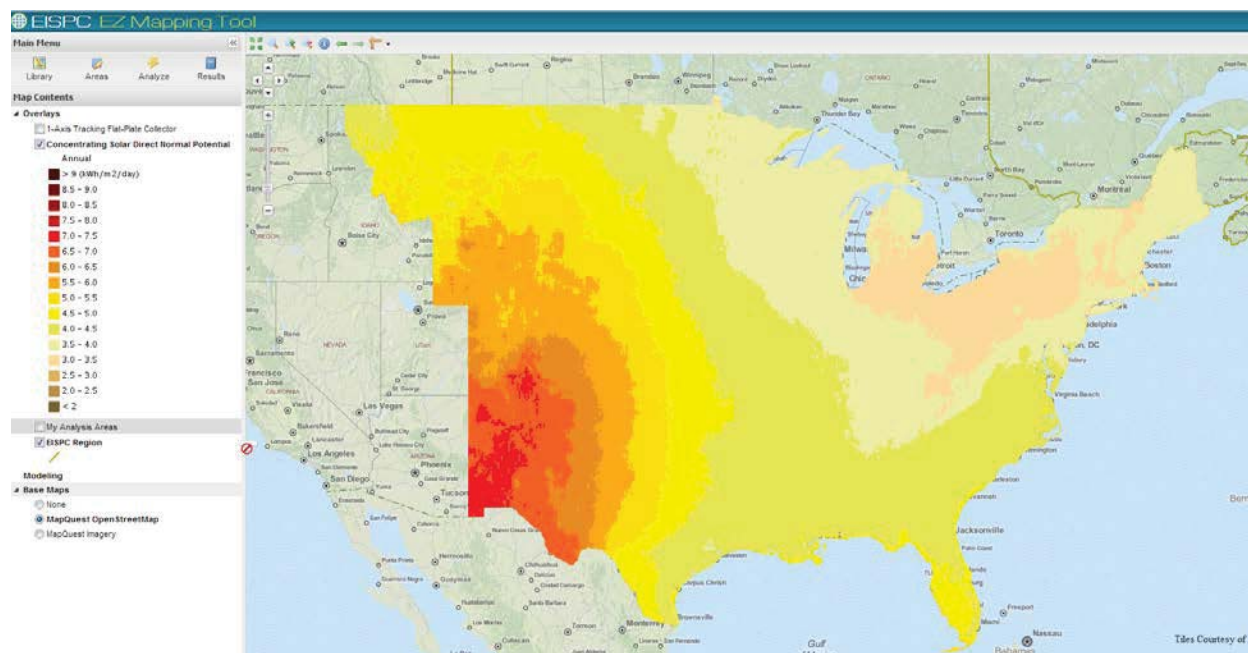


Figure 3-29 Estimated Average Daily CSP Solar Resource Potential by Year in Wh/m²/day
 (Note: The insolation values represent the average solar energy available to a concentrating collector on a 2-axis tracker, such as a dish or a power tower.) (Sources: NREL 2007 and EZ Mapping Tool)

The resource intensity for energy conversion is affected by factors such as site location (latitude, longitude, and elevation), time of day, season, cloud cover, atmospheric constituents that absorb or scatter solar radiation (e.g., water, dust, and ozone), and characteristics of the solar energy collector type. Short-term temporal variability of the solar resource can occur at a single location (Figure 3-30) due to rapid changes in these factors (i.e., passing clouds, storms, and fires) over a wide range of time scales (i.e., minutes to decades). For distances from 10 to 100 kilometers (km), the spatial variability can be relatively low but does increase in areas where terrain amplifies the physical effects, particularly in coastal or mountainous regions or near urban areas where pollutant levels can influence the solar radiation reaching the ground.

All regions of the United States have some solar resource available for power production, although the distribution and intensity vary based on atmospheric conditions and the collector type. The highest solar resource areas in the Eastern Interconnection are generally found in the south, with the most intense solar resource areas falling outside of the Eastern Interconnection in the southwestern portion of the United States. Factors such as the presence of clouds or aerosols in the atmosphere can also influence the regional distribution of a particular type of solar resource. This can be seen by comparing the two solar resource maps shown in Figures 3-28 and 3-29. The same general resource pattern is visible in both maps, but the pattern is stronger in the direct normal resource map because of its sensitivity to the influence of particulates in the atmosphere. The solar resource is lowest in Alaska, the Pacific Northwest, and New England.

The type of solar application also determines the distribution of useful solar resource. High solar resource is needed for cost-effective deployment of concentrating solar technologies (annual

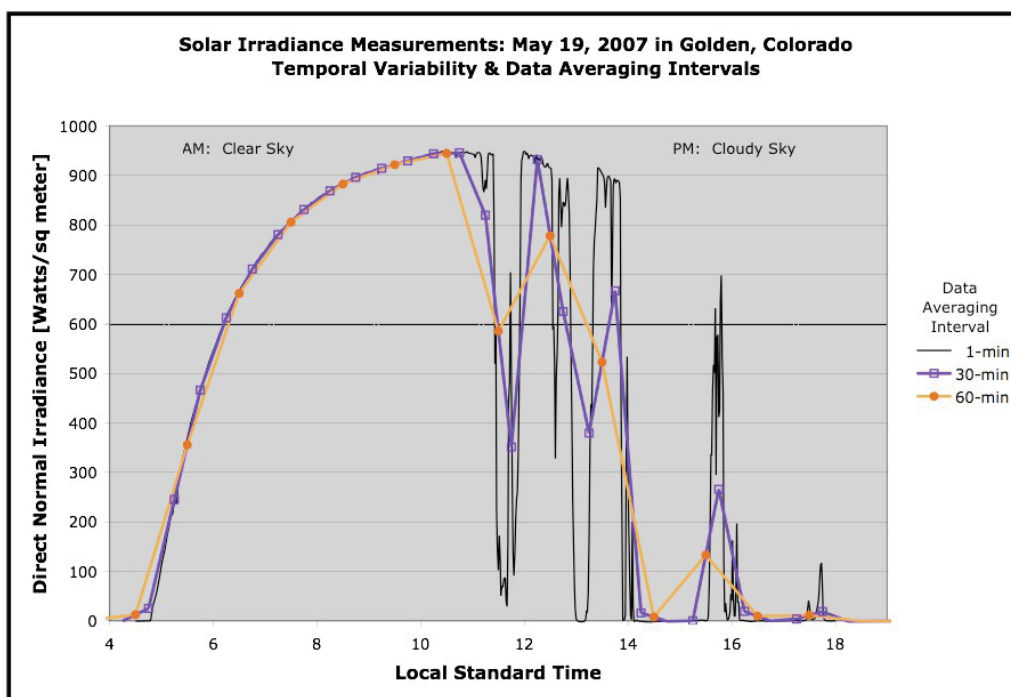


Figure 3-30 Example of Temporal Variability of Solar Irradiance under Clear and Cloudy Sky Conditions and the Effects of Time-Averaging Intervals Based on Measurements Collected Every 4 Seconds (Source: EPAAct 2011)

average resource of 5 kWh/m²/day and greater), which limits the applicable resource area in the Eastern Interconnection to its southwestern reach and small areas within Florida. Rooftop PV applications are not limited to high-resource areas and can be utilized throughout the United States, though with less productivity in northern latitudes.

3.6.4 Conversion Technologies

Utility-scale PV and CSP technologies convert solar resources into electricity. The two most common solar energy conversion technologies are PV and CSP. PV is a direct energy conversion technology that converts sunlight into DC electricity with semiconductor material usually fabricated in a flat panel. The DC is subsequently converted to AC or can be used directly. CSP uses mirrors or other highly reflective surfaces (solar collectors) to concentrate the sun's thermal energy into a small area. Electricity is generated from this concentrated solar thermal energy through a heat engine, commonly a Rankine cycle, which drives an electric generator. Many PV solar collector orientations and configurations are possible based on the parameters being optimized; however, typically fixed flat plate collectors are oriented south and tilted at an angle equal to the site's latitude.

The third conversion technology, rooftop PV, depends on the same fundamental technology as utility-scale PV; however, rather than being a separate facility, the solar panels or PV arrays are mounted on existing structures, primarily roofs of buildings.

3.6.4.1 Concentrating Solar Power

CSP uses reflective surfaces or lenses to concentrate the heat energy in sunlight over a large area to a small area. Different types of concentrators are used; the most common conventional utility-scale technologies are the parabolic trough and solar power tower (also referred to as a central tower or heliostat power plant). Other potential technologies include dish Stirling and linear Fresnel technologies, but these technologies are not currently proposed for large-scale development in the United States.

Parabolic trough collectors are arranged in long rows of curved reflective panel surfaces with a collector tube filled with a heat transfer fluid located at the focal point of the curved surface (Figure 3-31). The heated fluid is transported to a heat engine where the heat can be extracted. The longest operating CSP plants in the United States (solar electric generating system [SEGS] 1–9, totaling 350 MW) utilize this technology. The Solana plant currently under construction in Arizona will be one of the largest solar plants currently in existence (280 MW with 6 hours of thermal storage) when completed in 2013. Several other large parabolic trough projects are under construction or have been proposed. These systems typically cover large areas; Solana, with its oversized field to accommodate thermal storage, is being built on 1,920 acres (Abengoa Solar 2012).

Solar power towers arrange the reflective surfaces in a circular area around a tall central tower. The surrounding mirrored surfaces concentrate the solar beam on a receiver at the top of the tower (Figure 3-32). The heat transfer medium, a molten salt, is located in the tower itself. The molten salt flows into a storage tank where the heat can be efficiently stored. Solar power towers



Figure 3-31 Parabolic Trough Concentrating Solar Collector at Kramer Junction, California (Source: NREL 2012c)



Figure 3-32 Solar Power Tower Collector, Solar Two at Daguerre, California (Source: NREL 2012d)

can operate at higher temperatures than parabolic trough systems, leading to higher system efficiencies and capacity factors. While only 5 MW is currently operational in the United States, construction is underway or under development for nearly 2 GW of additional capacity from solar power towers (NREL 2010).

The collected heat energy from both of these system types is then used to heat steam in a standard steam turbine generator similar to most conventional fuel sources. The heat energy can be stored to provide more flexibility in dispatching the energy produced to the grid and in increasing the overall capacity factor of the solar plant (Denholm and Mehos 2011).

3.6.4.2 Utility-scale Photovoltaics

Utility-scale PV uses arrays of solar panels that convert the solar energy received directly to electricity. The solar panels may be fixed-tilt, single-axis, or two-axis tracking collectors (Figure 3-33). Larger systems are typically ground mounted but may also occur on large commercial buildings or combinations of ground-mounted and rooftop systems. By 2012, the United States had more than 7,300 MW of installed PV capacity, with another 1,300MW under construction (Sherwood, 2012; EIA 2012a). This includes installations in the Eastern Interconnection such as the 32-MW BP Solar Long Island Solar Farm at Brookhaven National Laboratory, completed in 2011 (LIPA 2012).

Individual panels produce DC electricity and are linked in an array by electrical conduit. The DC electricity must be converted to AC electricity before it can be placed on the electricity grid.



Figure 3-33 Utility-Scale PV, Single-Axis Tracking Collector Totaling 2 MW at Prescott, Arizona (Source: NREL 2012e)

3.6.4.3 Rooftop PV

Rooftop PV solar as implemented in the EZ Mapping Tool differs significantly from the utility-scale solar resources, and the EZ Study treats rooftop PV separately.

Examples of rooftop installations are shown in Figure 3-34.

As a distribution-level resource, rooftop PV needs no transmission to connect it to the system. The two aspects that matter the most for system planning are the location of the urban load center on the network and the degree of rooftop PV penetration throughout the load center. More energy produced at the distribution level within the load center reduces what needs to be delivered to the load center via the transmission system.

Trees and other vegetation can obstruct sunlight, which affects the amount of electricity produced throughout the day. The height of neighboring buildings to the south can also limit PV output. The amount of rooftop space containing heating, ventilation, and air-conditioning (HVAC) equipment will also reduce the space available for solar panels. Buildings in warmer climates tend to have more tree shading and more HVAC, resulting in less area available for rooftop PV panels.

While utility-scale solar is a generation resource from the perspective of transmission planning, rooftop PV may be viewed as a load-reducing technology. Location is not the unknown variable. What affects system planning is how much load reduction might occur in a given urban area due to greater rooftop PV deployment.



Figure 3-34 Examples of Rooftop PV on Office Buildings and Residences (Source: NREL 2012f–h)

This analysis only deals with the *aggregate* amount of rooftop PV that might be available in a given load area. It does not address where rooftop PV might be located within the load area. The EISPC EZ Mapping Tool is not designed for analyzing the viability of specific sites or buildings. For a suite of publicly available site assessment tools, see http://www.nrel.gov/analysis/analysis_tools_tech_sol.html.

How much electricity comes from a square meter of rooftop PV will depend on the technology. The efficiency of panels currently in use ranges widely, with silicon technologies—most commonly used in rooftop arrays—ranging between 14% and 21%.¹²

¹² Monocrystalline silicon modules range from 14% to 16%; multicrystalline silicon modules range from 17% to 21%. (DOE 2012, p. 71).

3.6.4.3.1 Estimating Rooftop Area

Estimations of the amount of sunlight falling on rooftops in a given area were derived from the same detailed satellite and ground observation data used to estimate utility-scale solar potential in Section 3.6.3. Most rooftop PV installations are small scale and use fixed mounting. The raw solar potential for rooftop PV in a given area is therefore calculated on the basis of a fixed-mounted panel tilted at an angle equal to the latitude of where the panel is installed. This is the angle that generally captures the most sunshine over the course of a year.

Mapping rooftop solar PV potential involves two analytical components: population and buildings stock (residential, commercial, and industrial) and the amount of sunshine the area has during a typical year. The analysis method in the EZ Mapping Tool relies on a 2008 study by Denholm and Margolis that estimates the building stock rooftop area that is potentially available for rooftop PV (Denholm and Margolis 2008). For a discussion of the methodology used to estimate rooftop area for this analysis, see Section 2, Methodology and Appendix C.

3.6.4.3.2 Peak Load Reduction

As the penetration of rooftop PV increases in a given metropolitan area, county, or state, the reduction in peak demand will become more significant. This is especially true in hot climates where sunny days and high temperatures correlate with greater use of air-conditioning, leading to higher demand for electricity.

Summer electric demand peaks tend to occur in the mid- to late-afternoon hours. PV output peaks around noon and declines in the afternoon as the sun moves lower in the sky, which means that PV's effect on peak demand is actually less than its full rated capacity. It tends to push the net peak to later in the day, which also complicates the task of estimating PV's peak load reduction. The estimate of rooftop PV's impact on an area's annual peak load is based on the analysis of the building estimation methods and solar exposure discussed previously, and on the assumptions on the level of rooftop PV deployment. Details of this analysis are presented in Appendix C.

3.6.5 Screening Factors

Utility-scale PV and CSP have similar screening factors, though the different conversion technologies may mitigate the impact or range of values for specific screening factors. A list of those factors identified for this study is presented in Table 3-13. Some of the screening factors listed are more economic in nature rather than technical limits. As such, local incentives for installing solar systems may influence development decisions. As rooftop PV is installed on built structures, screening factors relate to very specific requirements associated with the building design. In some jurisdictions, local building codes may be the most important factors.

The specific default solar suitability criteria and specific ranges for each screening parameter are listed in Appendix A. The Protected Land, Habitat, and Imperiled Species screening parameters are discussed in Section 4. Informational layers may also be useful for additional analysis by overlaying them onto the suitability model results. The extensive list of EZ Mapping Tool informational layers is included in Appendix B.

Table 3-13 Solar Technology Screening Factors

Solar Technology	Screening Parameter
PV Solar	Population density Slope Land cover area Proximity to electric transmission (>345 kV) Protected Land Habitat Imperiled Species
CSP	Population density Slope Land cover area Distance to rivers (>64,500 gpm) Proximity to electric transmission (>345 kV) Protected Land Habitat Imperiled Species

3.6.6 Data and Sources

Solar data were provided by NREL (2013). The data include monthly average and annual average daily total solar resource for areas of 0.1° in both latitude and longitude (~10 km in size). The data were developed using the State University of New York/Albany (SUNY) satellite radiation model developed by Dr. Richard Perez and collaborators at NREL and other universities for DOE (Perez et al. 2002). The SUNY model uses hourly radiance images from geostationary weather satellites; daily snow cover data; and monthly averages of atmospheric water vapor, trace gases, and the amount of aerosols in the atmosphere to calculate the hourly total insolation (sun and sky) falling on a horizontal surface. A modified Bird model is used to calculate clear sky direct normal irradiance (DNI). This is then adjusted as a function of the ratio of clear sky global horizontal irradiance (GHI) and the model-predicted GHI. Where possible, existing ground measurement stations are used to validate the data. Nevertheless, there is uncertainty associated with the meteorological input to the model, since some of the input parameters are not available at a 10-km resolution. As a result, it is believed that the modeled values are accurate to approximately 15% of a true measured value within the grid cell. The annual average values are calculated using satellite data from 1998 to 2008.

Publicly available data to construct the screening layer for solar technologies are available from a variety of sources and are listed in Table 3-14. The Protected Land, Habitat, and Imperiled Species screening layer and data sources are discussed in Section 4.

Table 3-15 describes additional data needed for estimating the potential of rooftop PV. EZ Mapping Tool reports can be generated to summarize the potential of rooftop PV in an area of interest.

Table 3-14 Solar Technology Screening Factor Data and Sources^a

Factor (Parameter)	Data and Source
Population density	LandScan™, http://www.ornl.gov/sci/landscan/
Slope	2012 NGA Digital Terrain Elevation data/calculated and resized for 250-m cells
Land cover area	2011 USGS
Distance to rivers/surface water flow	2012 USGS/National Hydrologic data (Version 2)
Electric transmission data	2012 Bentek Energy/Platts
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

Table 3-15 Rooftop PV Data and Sources^a

Information	Data and Source
Average number of floors per building type	EIA 2005 Residential Energy Consumption Survey and the 2003 Commercial Building Energy Consumption Survey
Total floor space	McGraw-Hill, FW Dodge Building Stock Database
Solar resource	http://www.nrel.gov/gis/data_solar.html
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

3.7 Storage Technologies

3.7.1 Introduction

To assist in an increased penetration of clean energy technology, the deployment of energy storage infrastructure must control the flow of electricity, match energy supply to energy demand, and improve the economics of the energy supply chain. Storage technologies can be used to provide peaking generating capacity, load shifting, system support, operating reserves, and other ancillary services.

Pumped storage hydro (PSH) is by far the most common form of energy storage in the United States. There is currently about 18 GW of existing capacity, with facility sizes ranging from 28 to 2,800 MW. Proposed PSH plants range from 75 to 1,300 MW. Other energy storage technologies currently exist at a smaller scale in the United States. Batteries are also a common energy storage technology; however, no batteries currently exist for storing more than 10 MWh for a 1-day period and are little used at utility scale. Recent advances in plug-in hybrid electric vehicles are providing additional energy storage capability at the distribution level in a series of U.S. Department of Defense-sponsored demonstration projects. Non-battery-based storage technologies include superconductive magnetic energy storage (SMES), flywheel energy storage, electrochemical capacitors, CAES, and large PSH.

Sections 3.7.2 through 3.7.6 discuss the scope of the study, describe storage resources and available conversion technologies, detail the screening factors used in the EZ Study, and provide data and sources.

3.7.2 Scope

The scope of this study includes PSH and CAES technologies and covers the conventional cycles of these two technologies. Other storage technologies (batteries, flywheels, SMES, and capacitors) are outside the scope of this study because they are not mature enough for analysis and screening criteria development. This study only discusses basic screening criteria and does not discuss the individual CAES and PSH cycles and their differences or the plant parameter envelope for CAES and PSH technologies.

3.7.3 Resource Description

The use of energy storage is fundamental to the generation of electric power. However, to date, the application of energy storage technology for real-time and short-notice (less than a few minutes) support and optimization of the transmission and distribution system has been limited. One reason is the lack of cost-effective options (EPRI 2003). In the United States, large PSH facilities are the major energy storage technology applied for utility-scale applications. At present, about 99% of utility-scale storage capacity in the world is in PSH. A typical PSH plant has a capacity of several hundred megawatts and is typically designed to provide about 8 to 10 hours of generation at full power output. These facilities are primarily used for daily load shifting, but also for regulation control (short-term fluctuations) and spinning reserve applications. In addition, one CAES facility with a capacity of 110 MW for up to 10 hours is available in the United States. Another CAES facility with a capacity of 290 MW is operating in Germany. The benefits from energy storage for utility-scale applications include improved reliability of system operation and reduced customer financial losses due to poor power quality and power outages, better integration of variable energy resources such as wind and solar, load shifting or energy price arbitrage involving charging with low-priced “off-peak” energy for use later when cost is high, and various ancillary services necessary for electric power grid operation.

3.7.4 Conversion Technologies

For the EZ Study, the conversion technologies for CAES and PSH are limited to their respective conventional cycles. Within each technology, there are several variations. For example, in addition to the conventional CAES cycle, there is a recuperated cycle, combined-cycle, steam-injected cycle, compressed air with humidification, and adiabatic CAES cycle. The technical descriptions of the conversion technologies that follow are intentionally abbreviated. Additional information about storage technologies is available from the EPRI (2008).

3.7.4.1 Pumped Storage Hydro

PSH is the longest established technology for utility-scale applications that have been commercially deployed since the late nineteenth century. A PSH facility is typically equipped with pumps and generators connecting an upper and a lower reservoir. Figure 3-35 is a diagram of the Tennessee Valley Authority (TVA) PSH facility at Raccoon Mountain. The pumps use cheap electricity from the power grid during off-peak hours to move water from the lower reservoir to the upper reservoir in order to store energy. During periods of high electricity demand (peak hours), water is released from the upper reservoir to turn the turbines and generate power as it flows back into the lower reservoir.

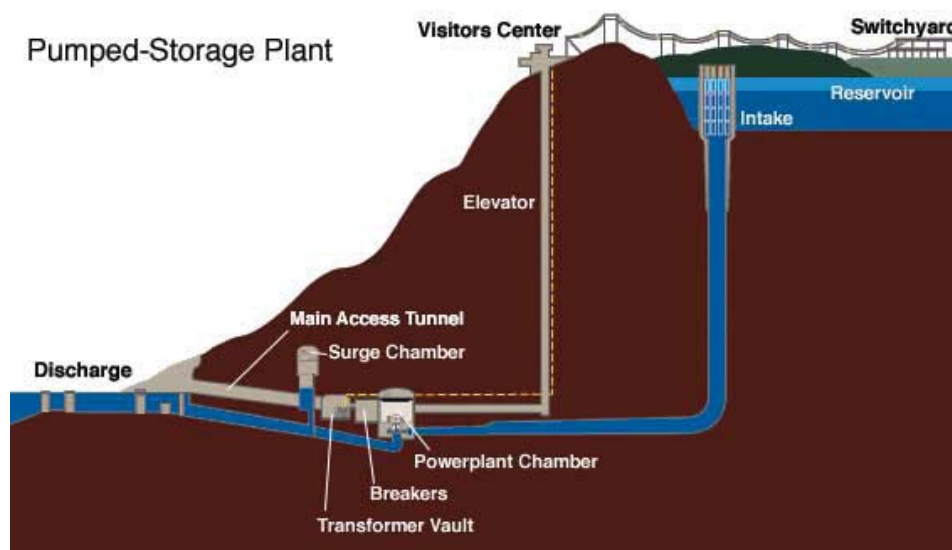


Figure 3-35 Diagram of TVA Pumped Storage Facility at Raccoon Mountain PSH Plant (Source: TVA 2013)

There are two types of PSH facilities—off-stream (closed loop) PSH and pump-back PSH. Off-stream or pure PSH rely entirely on water that was previously pumped into an upper reservoir as the source of energy; whereas, pump-back or combined PSH uses both pumped water and natural streamflow water to generate power. Any site utilizing streamflow water must meet regulations concerning water quality and fish protection. The efficiency of PSH varies significantly because of the long history of the technology and the long life of a facility. At present, the total PSH cycle efficiency is typically between 70% and 85%.

There are currently 26 existing PSH plants in the Eastern Interconnection (16.5 GW capacity); another 16 have been issued preliminary permits (12 GW), and 8 have permits pending (4.7 GW). Figure 3-36 shows the location of these facilities.

3.7.4.2 Compressed-Air Energy Storage (CAES)

For CAES systems that use underground caverns, the suitable geologies can be classified into salt (bedded and dome salt), aquifer, and rock. In general, the geological formation suitable for underground air storage must have sufficient depth to allow safe operation at the required air pressure and must be sufficiently porous to provide the required storage volume at the desired pressure. The formation must also be sufficiently permeable to permit the desired airflow rates, and requires a mineralogy that does not result in rapid chemical consumption of the oxygen in the stored air through oxidation reactions.

Figure 3-37 is a general diagram of a CAES system. In this example, air is compressed and injected into the cavern during times when energy is to be stored. When power is needed, compressed air is released. When the gas expands during release, it cools, and thus a recuperator is used to transfer waste heat from the exhaust of the turbines into the cooled air. In addition, natural gas fuel is added and ignited to increase the temperature and pressure prior to the turbines. The various types of CAES cycles may or may not include, for example, injection of

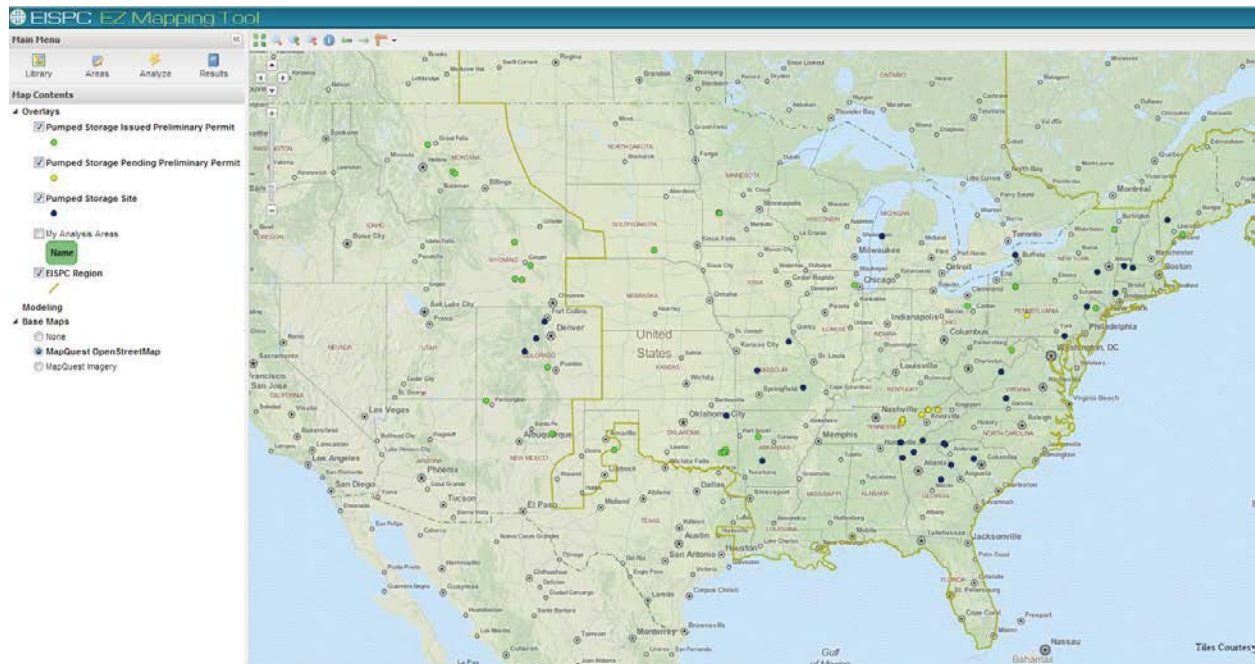


Figure 3-36 Map of Existing Preliminary Permitted and Pending Preliminary Permitted PSH Plants (Source: EZ Mapping Tool)

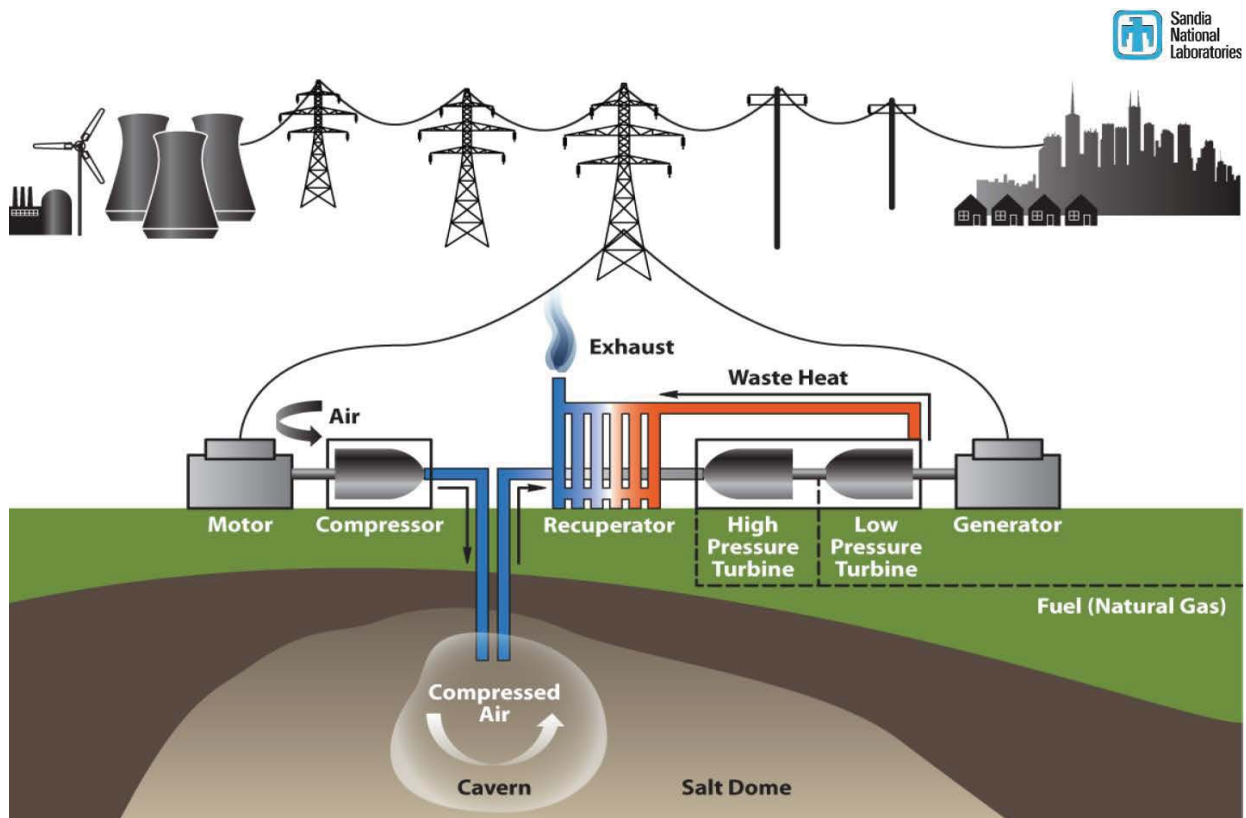


Figure 3-37 Diagram of CAES Operation (Source: Sandia National Laboratory 2013)

natural gas, water, and recuperation of waste heat. This diagram shows a salt dome as the cavern used for the compressed air; however, storage within an aquifer or rock (such as depleted gas wells) is also feasible.

3.7.5 Screening Factors

Many of the screening factors for nuclear power plants were the starting point to establish screening criteria for storage technologies even though storage technology siting is subject to a different regulatory process. For CAES, the technology demands the presence of underground caverns for storing compressed air; therefore, CAES siting is a function of geology. Consequently, suitable areas for CAES could allow for some limited vertical and/or horizontal drilling access to the storage vessel. On the other hand, PSH technology demands an upper and a lower reservoir, which is a function of difference in elevations. Therefore, these facilities will be more closely influenced by the surface features of the area. For screening factors such as seismic and earthquake fault restrictions, it was decided that these facilities do not have any issues beyond what local codes cover. Therefore, factors such as proximity to hazardous facilities and fault lines are not considered applicable to CAES and PSH plant screening.

Because CAES plants generate noise, highly populated areas are excluded from consideration for CAES siting. Similarly, to minimize the risk of a potential PSH reservoir accident on a population, the same factor is applicable to PSH siting. On the basis of engineering judgment, factors such as wetlands and open water, protected land, landslide hazards, and 100-year floodplain areas, should also be excluded for new CAES and PSH plant screening. Table 3-16 lists the final screening factors for CAES and PSH.

The specific default CAES suitability criteria and specific ranges for each screening parameter are listed in Appendix A. The Protected Land, Habitat, and Imperiled Species screening parameters are discussed in Section 4. Informational layers may also be useful for additional analysis by overlaying them onto the suitability model results. The extensive list of EZ Mapping Tool informational layers is included in Appendix B.

3.7.6 Data and Sources

Data used to construct the screening factors for the CAES technology are available from various sources listed in Table 3-17. The Protected Land, Habitat, and Imperiled Species screening layers are discussed in Section 4.

PSH data are included as an informational layer in the EZ Mapping Tool, and a report can be generated to summarize the availability of this resource data in an area of interest. The sources of these data layers are listed in Table 3-18.

Table 3-16 Storage Technologies Screening Factors

Storage Technology	Screening Parameters
Compressed-air energy storage	Aquifer area Distance to domal salt formation Distance to bedded salt formation Population density Slope Land cover area Landslide hazards 100-yr flood zone Land cover area Proximity to electric transmission (all lines) Distance to natural gas pipelines Protected Land Habitat Imperiled Species

Table 3-17 Storage Technologies Data and Sources^a

Factor (Parameter)	Data and Source
Aquifer area	2011 USGS
Geological formations	CAES: the underground portion, http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4113158
Salt caverns	2012, 2013 ORNL
Population density	LandScan™, (http://www.ornl.gov/sci/landscan)
Slope	2012 NGA digital terrain elevation data/calculated and resized for 250-m cells
Land cover area	2011 USGS
Landslide hazard	2001 USGS
100-yr flood zone	2011 FEMA National Flood Hazard data
Electric transmission data	2012 Bentek Energy/Platts
Natural gas lines	2012 Bentek Energy/Platts
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

Table 3-18 PSH Data and Sources^a

Information	Data and Source
Pumped storage site	2011 Argonne
Pumped storage pending preliminary permit	2011 FERC
Pumped storage Issued preliminary permit	2011 FERC
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

3.8 Water

3.8.1 Introduction

The largest renewable energy resource in the United States is hydropower. There are more than 96 GW of hydropower projects operating in the United States, including conventional and pumped storage. Of this installed capacity, about 78 GW is conventional hydropower, which generated 260 TWh of electricity in 2010. Conventional hydropower projects consist of both federal and non-federal projects.

Sections 3.8.2 through 3.8.7 discuss the scope of the study, describe water technologies and conversion technologies, detail screening factors used in the study, and provide data and sources for the water resources and screening factors.

3.8.2 Scope

The technologies included in the EZ Study are additional electrical output from existing hydropower dams, new output from current NPDs, river and tidal hydrokinetic energy, marine tidal hydrokinetic energy, and wave energy.

Metropolitan energy-water systems and irrigation power energy are out of scope because of the lack of available data for GISs on the potential sites in the Eastern Interconnection. New hydropower site development is out of scope due to unreliable data. Hydrokinetic (river and tidal) are too immature technologically to be able to establish adequate screening criteria. However, information layers are provided.

3.8.3 Resource Description

Three available resources that potentially could be used for hydroelectric generation are river systems, ocean tidal currents, and coastal wave action. Currently, only the river systems are used across the United States. Figure 3-38 shows those rivers that have average streamflows greater than 35 cubic feet per second (cfs). Much of the resource is unusable for hydropower because land use surrounding the stream precludes building impoundments, or the possible differential in water height between a high and low pool (the “head”) is too low for economic development.

Another potential source of hydroelectric generation is ocean tidal currents. These provide consistent flows in and out of bays or estuary channels. Technologies are being developed that can exploit the changes in sea level from tides or the currents from tidal forces.

The third hydropower resource is wave action along the coastlines. Waves are largely generated through ocean winds but are much more consistent than onshore wind resources. The eastern United States has relatively low power density from waves; <10 kW/m as shown in Figure 3-39.

The total available wave energy resource along the Outer Continental Shelf (national 200-m depth contour) is presented in Table 3-19, broken down by major coastal region. These results

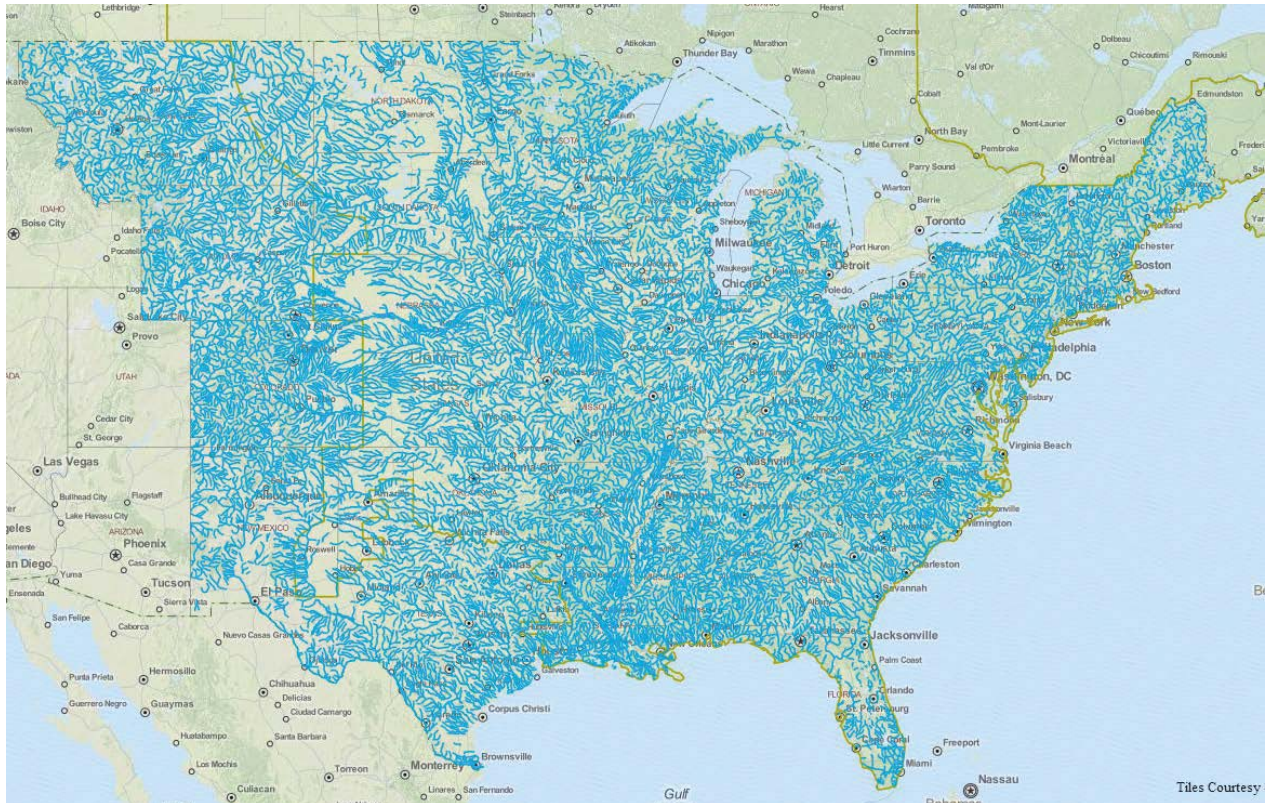


Figure 3-38 Composite Streamflow > 35 cfs (Source: EZ Mapping Tool)

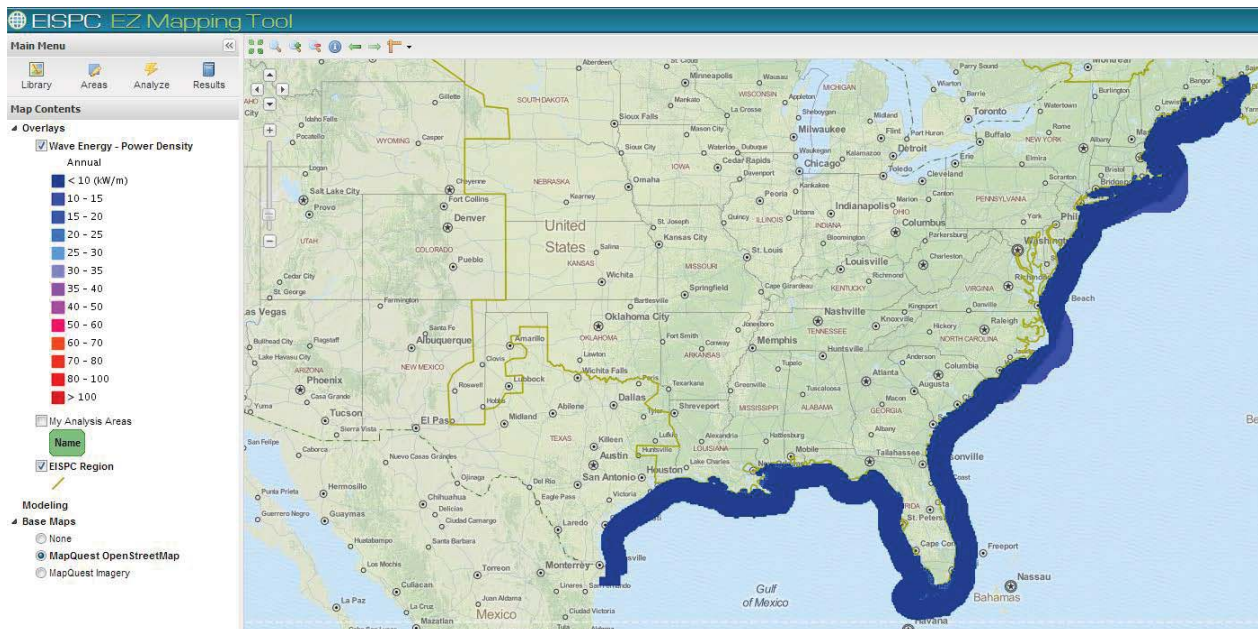


Figure 3-39 Wave Energy Power Density along the Eastern United States (Source: EZ Mapping Tool)

Table 3-19 Total Available Wave Energy Resource Breakdown by Region

Coastal Region	EPRI 2004 Estimate	EPRI 2011 Estimate Outer Shelf ^a
West Coast (WA,OR,CA)	440 TWh/yr	590 TWh/yr (34% greater)
East Coast (ME thru NC)	110 TWh/yr	200 TWh/yr (82% greater)
East Coast(SC thru FL)	Not estimated	40 TWh/yr
Gulf of Mexico	Not estimated	80 TWh/yr
Alaska (Pacific Ocean)	1,250 TWh/yr	1,360 TWh/yr (9% greater)
Alaska (Bering Sea)	Not estimated	210 TWh/yr
Hawaii	300 TWh/yr	130 TWh/yr (not comparable ^b)
Puerto Rico	Not estimated	30 TWh/yr
Total =	2,100 TWh/yr	2,640 TWh/yr (26% greater)
^a Rounded to nearest 10 TWh/yr for consistent comparison with EPRI 2004 estimate.		
^b EPRI's 2004 estimate for Hawaii was along the northern boundary of the U.S. Exclusive Economic Zone, as far west as the Midway Islands. The present estimate extends only as far west as Kauai and encompassed the entire islands (not just their northern exposures).		

(EPRI 2011) are compared with an early preliminary estimate made by EPRI during its first offshore wave energy conversion feasibility study in 2004.

3.8.4 Conversion Technologies

3.8.4.1 Additional Output from Existing Hydropower Dams

Conventional hydropower refers to traditional project designs that utilize a combination of hydrostatic head and flow through turbines to generate electricity. There are significantly more non-federal projects than federal projects, but federal projects are on average larger in size. Some of the smaller, lower-impact, non-federal projects are exempt from FERC licensing but are still subject to mandatory permitting from state and federal resource agencies. Approximately 80 FERC-licensed projects are located at USACE dams but consist of powerhouses built and operated by non-federal developers.

Federal hydropower consists of projects built and operated by three agencies: USACE, DOI's Bureau of Reclamation (Reclamation), and the TVA. The USACE has the most projects, followed by Reclamation and then TVA. USACE currently owns and operates 75 power plants with a total rated capacity of 21.5 GW. In addition to those federally owned power plants, there are another 90 non-federal power plants located at USACE dams that have an additional 2.3 GW of capacity.

Non-federal hydropower is regulated by FERC under authority defined in the Federal Power Act. Ownership of non-federal projects is very diverse, ranging from large, public utilities to small rural electric cooperatives and independent power producers.

More than 50% of the hydropower equipment (turbine, generator, rotors, stators, etc.) are older than 40 years. The efficiency and capacity of aging turbine units have declined as their physical conditions have deteriorated over time. Advances have been made in materials and hydro-

mechanical designs that improve efficiency and performance of turbines and other components of hydropower systems since these aging plants and equipment were commissioned. Many plants in the United States hydropower fleet are operating under a different set of constraints than those existing at the time of commissioning, resulting in reduced energy production and services for the electric power system. DOE recognized a significant opportunity to increase the capacity, annual generation, and value of hydropower at existing U.S. hydropower facilities through the identification and implementation of improvements and developed the Hydropower Advancement Project (HAP) with ORNL.

The main objective of HAP is to demonstrate the potential increases in U.S. hydropower asset performance and value. Performance in this broad context includes hydropower asset reliability, availability, production, capacity, and water-use efficiency. The specific objectives of the HAP are as follows:

- Provide a fact-based quantitative estimate of additional energy available through improvements and expansions of all U.S. hydropower assets.
- Identify barriers to implementation of hydropower asset improvement and expansions.
- Prioritize research that would accelerate increases in hydropower asset performance and value.
- Develop and disseminate Best Practices, Assessment, and Analysis Tools to stimulate and accelerate increases in hydropower asset performance and value.

The overall potential increase in power generation efficiency is about 5% for units with Francis turbines built before the 1980s. An adequate estimate for total potential power generation increase should be obtained from meaningful statistics based on more sample assessments for the representative plants in the nationwide existing hydropower fleet.

The websites for the National Hydropower Asset Assessment Program and HAP are <http://nhaap.ornl.gov/> and <http://hydropower.ornl.gov/HAP>.

3.8.4.2 New Output from Existing Non-powered Dams

The United States has produced clean, renewable electricity from hydropower for more than 100 years, but hydropower-producing facilities represent only a fraction of the infrastructure development that has taken place on the nation's waterways. In contrast to around 2,500 dams which provide 78 GW¹³ of conventional and 22 GW of pumped-storage hydropower, the United States has more than 80,000 NPDs. These are dams that do not produce electricity but provide a variety of services ranging from water supply to inland navigation. The monetary costs and environmental impacts of dam construction have already been incurred at NPDs. Adding power to the existing dam structure can be achieved at lower cost, with less risk, and in a shorter

¹³ 1 gigawatt (GW) = 1,000 megawatts (MW). On an annual basis, 1 MW of hydropower produces enough electricity to power nearly 400 U.S. homes. Each gigawatt could power up to 400,000 homes.

time frame than development requiring new dam construction. Their abundance, cost, and environmental favorability, combined with the reliability and predictability of hydropower, make NPDs a highly attractive source for expanding the nation's renewable energy supply.

To better characterize this unique national resource, the DOE Water Power Program has undertaken a national-scale analysis of U.S. dams to determine the ability of NPDs to provide hydroelectric power (Hadjerioua et al. 2012). ORNL quantified the potential capacity available from powering U.S. NPDs. A thorough quality control and review process ensured that NPDs suitable for power production were accurately characterized. Figure 3-40 demonstrates the spatial and capacity potential distribution of the nation's NPDs with potential capacity greater than 5 MW. Electric generating capacities were calculated assuming that all water passing a facility would be converted to electrical energy and that hydraulic head at the facility would remain constant.

Adding power to U.S. NPDs has the potential to add up to 12.1 GW of new renewable capacity, a potential equivalent to increasing the size of the existing conventional hydropower fleet by 15%. A majority of this potential is concentrated in just 100 NPDs, which could contribute 8 GW of clean, reliable hydropower; the top 10 facilities alone could add up to 3 GW of new hydropower. Eighty-one of the 100 top NPDs are USACE facilities, many of which, including all of the top 10, are navigation locks on the Ohio, Mississippi, Alabama, and Arkansas Rivers. Dams owned by Reclamation hold the potential to add 260 MW and are also attractive options for adding clean power to existing dams.

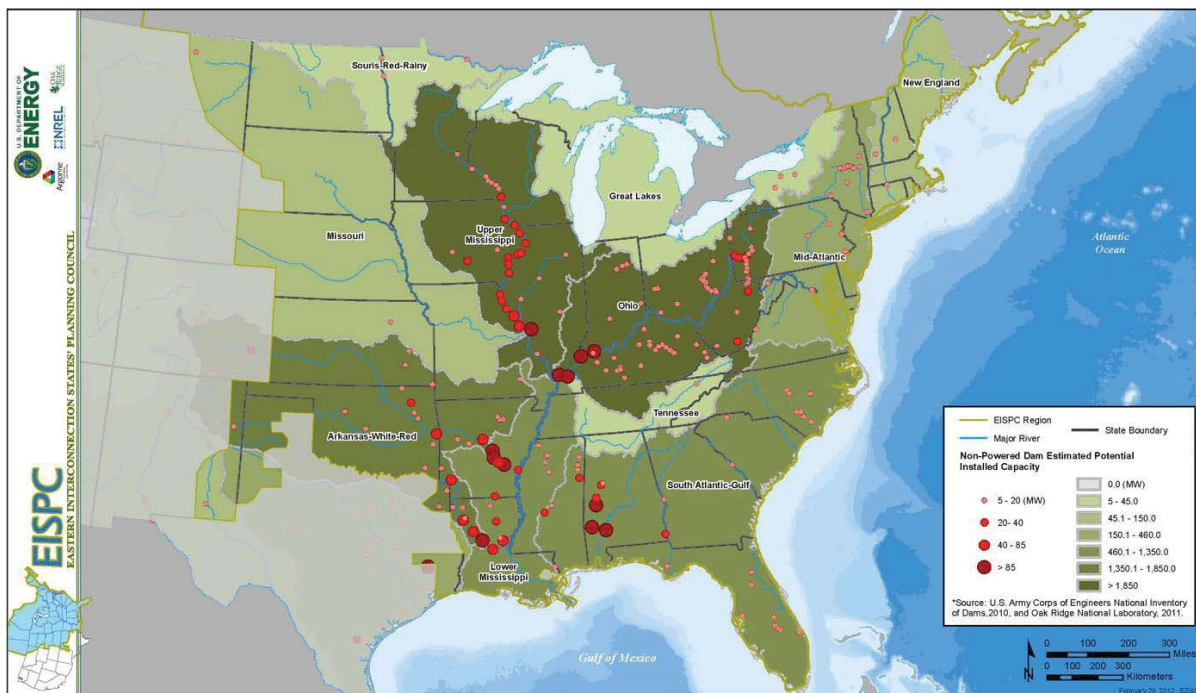


Figure 3-40 Hydropower Resources: Non-Powered Dam Resource Assessment by Hydrologic Region (Source: EZ Mapping Tool)

The national hydropower assessment is mainly targeted toward providing preliminary information for stakeholders who can further evaluate the potential to increase hydropower production at NPD sites. Developers could use the information provided in this assessment to focus on more detailed analysis of sites that demonstrate a reasonable potential for being developed. The availability and enhancement of national-scale datasets, such as the National Inventory of Dams (NID) and National Hydrography Dataset (NHD), provide a foundation for rigorous estimates of NPD potential for production for the entire country. Previous assessments, including Hall et al. (2004), DOI et al. (2007), and Reclamation (2011), have also been consulted in preparing the estimates reported herein.

3.8.4.3 River Hydrokinetic Energy

River hydrokinetic energy is the kinetic energy contained in non-tidal water currents. This energy is captured through turbines activated by the naturally flowing water in natural or constructed waterways. The turbines require a minimum current velocity referred to as “cut-in” speed to begin operation. Based on individual turbine design and performance, various water speeds correspond to optimal energy extraction.

With funding from DOE, EPRI conducted an assessment of the total available and technically recoverable in-stream hydrokinetic resources for the United States (excluding Hawaii). The assessment encompasses non-tidal rivers with a mean annual discharge exceeding 1,000 cfs. Table 3-20 summarizes the results from EPRI’s assessment (EPRI 2012).

Table 3-20 Theoretical and Technically Recoverable River Hydrokinetic Energy Estimates for the Continental United States

Hydrologic Region	Theoretical Power (Annual Energy, TWh/yr)	Technically Recoverable Power (Annual Energy, TWh/yr)
New England	14.4	0.2
Mid-Atlantic	33.5	1.0
South Atlantic Gulf	38.5	1.2
Great Lakes	6.2	0.01
Ohio	79.2	6.9
Tennessee	20.4	1.0
Souris Red-Rainy	1.8	0.03
Upper Mississippi	47.0	5.1
Lower Mississippi	208.8	57.4
Texas Gulf	8.9	0.05
Arkansas Red	45.1	1.3
Lower Missouri	79.8	5.6
Upper Missouri	74.3	2.8
Rio Grande	29.5	0.3
Lower Colorado	57.6	3.9
Upper Colorado	46.9	1.1
Great Basin	6.9	0.0
California	50.9	0.7
Pacific Northwest	296.7	11.3
Alaska	235	20.5
Total	1,381	119.9

3.8.4.4 Marine Tidal Hydrokinetic and Wave Energy

DOE released two assessments on January 18, 2012, revealing that waves and tidal coastal currents could contribute significantly to U.S. electricity production. The first was produced by EPRI (2011) and the second by Georgia Tech Research Corporation (2011). The West Coast, including Alaska and Hawaii, has especially high potential for wave energy development, while significant opportunities for wave energy also exist along the East Coast. In addition, parts of both coasts have strong tidal currents that could be utilized to produce energy. Combined with other analyses, these assessments show that water power, including conventional hydropower, could provide 15% of U.S. electricity by 2030.

The United States uses about 4,000 TWh of electricity per year. DOE estimates that the maximum theoretical electric generation that could be produced from waves and tidal currents is approximately 1,420 TWh per year, about one-third of the nation's total annual electricity use. Though not all of the resource potential identified in these assessments can be realistically developed, the results still represent major opportunities for new water power development by highlighting specific opportunities to expand on the 6% of the nation's electricity already generated from hydropower resources.

3.8.4.5 Other

In addition to the wave and tidal resource assessments, DOE plans to release additional resource assessments for ocean current, ocean thermal gradients, and new hydropower resources in 2012. To support the development of technologies that can tap into these vast resources, DOE's Water Power Program is undertaking a detailed technical and economic assessment of a wide range of water power technologies in order to more accurately predict the opportunities and costs of developing and deploying these innovative technologies. The program is sponsoring more than 40 demonstration projects that will advance the commercial readiness of these systems, providing first-of-a-kind, in-water performance data that will validate cost-of-energy predictions and identify pathways for large cost reductions.

3.8.5 Screening Factors

Two of the categories examined, increasing production at existing dams and conversion of existing NPDs to power, are only valid at specific sites with existing resources. Screening factors are not needed for them. For the purpose of this analysis, the marine tidal hydrokinetic screening factors are listed in Table 3-21. The other technologies evaluated are not mature enough to establish definitive screening factors. Rather, information layers are provided that give an overall sense of where possible resources may become available if technologies improve.

The specific default suitability criteria and ranges for each screening parameter are listed in Appendix A. The Protected Land, Habitat, and Imperiled Species screening parameters are discussed in Section 4. Informational layers may also be useful for additional analysis by overlaying them onto the suitability model results. The extensive list of EZ Mapping Tool informational layers is included in Appendix B.

Table 3-21 Hydropower Technology Screening Factors

Water Technology Type	Screening Factors (for established resources/technologies)
Marine tidal hydrokinetic energy	Tidal current speed (cm/s) Tidal power density Unexploded ordinance Navigable waterways Distance to port Proximity to electric transmission (all lines) Bathymetry Protected Land Habitat Imperiled Species

3.8.6 Data and Sources

Publicly available data to construct the screening factors for marine tidal hydrokinetic energy are available from a variety of sources listed in Table 3-22. The Protected Land, Habitat, and Imperiled Species screening layers and data sources are discussed in Section 4.

Added output from existing hydropower dams, new output from existing NPDs, in-stream hydrokinetic energy, and wave energy data are included as informational layers in the EZ Mapping Tool. Reports can be generated to summarize the inventory of these dams and their power potential, or the availability of in-stream hydrokinetic energy and wave energy data in an area of interest. Table 3-22 lists the sources of these data layers.

3.9 Wind

3.9.1 Introduction

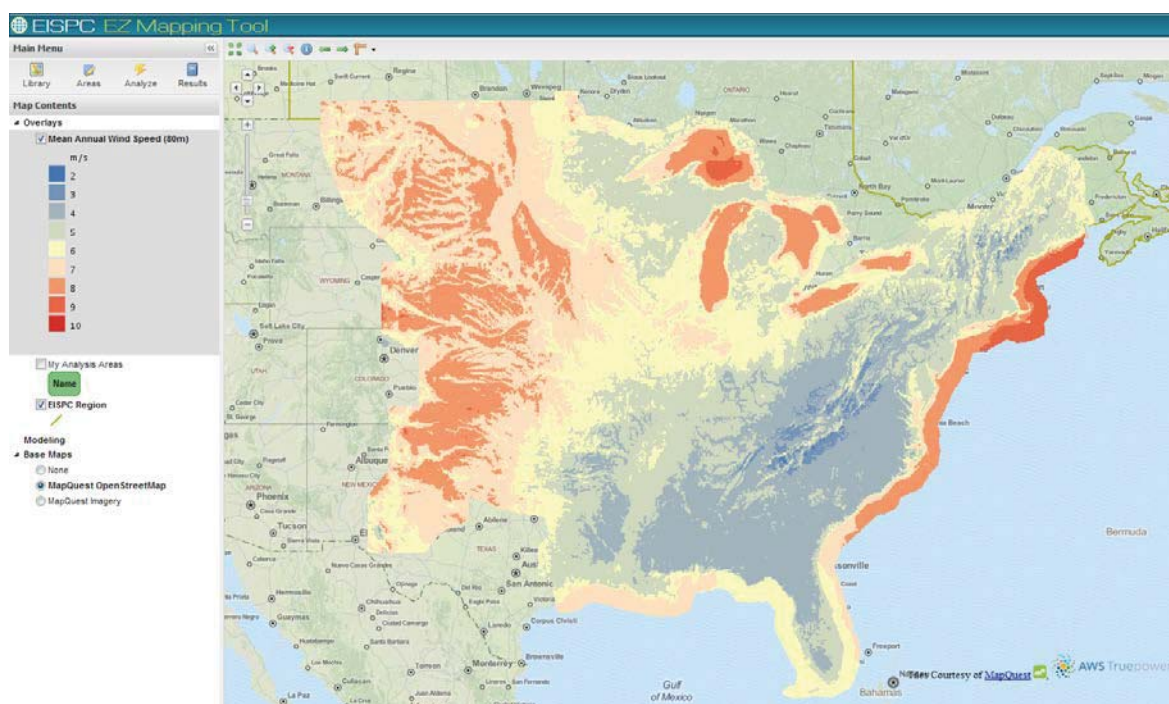
Wind deployment has increased significantly over the last decade and has been the fastest growing renewable technology market in the United States over that time. The EIA reported almost 40 GW of installed wind capacity in 2010 (EIA 2011); Wind Powering America and the American Wind Energy Association report that an additional 7 GW of wind was installed in 2011 (WPA 2012). Almost half of the total U.S. wind power capacity is installed in the Eastern Interconnection; more than half of the Eastern Interconnection's installed wind capacity is in the Midwest Independent Transmission System Operator, Inc. (MISO) or Southwest Power Pool (SPP) control areas. To date, all of the installed capacity in the United States is land based, but several offshore wind farms have been proposed.

Wind turbines use the kinetic energy in the wind to turn a large rotor and convert that rotational energy to electricity. Land-based wind resource data is available at 80-m and 100-m height above ground. These heights are the typical hub height of current wind turbine technology being installed in the United States and has been steady for the past several years (Wiser and Bolinger 2011). Figure 3-41 shows average wind potential at 80-m hub height. New installations are

Table 3-22 Marine Tidal Hydrokinetic Data and Sources^a

Resource/Factor	Data and Source
Tidal current speed (cm/s)	2012 Georgia Institute of Technology
Tidal power density	2012 Georgia Institute of Technology
Unexploded ordnance	2012 Department of Commerce (DOC), NOAA, National Ocean Service (NOS), Costal Services Center (CSC)
Navigable waterways	2012 Research and Innovative Technology Administration
Distance to port	2012 USACE
Electric transmission data	2012 Bentek Energy/Platts
Bathymetry	2013 NOAA

^a All metadata can be accessed via the EISPC EZ Mapping Tool.


Figure 3-41 Estimated Annual Average Land-Based and Offshore Wind Resource at 80-m Height Above Ground (Source: EZ Mapping Tool)

seeking higher hub heights to capture more wind energy. Offshore wind resource data is at 90-m hub heights.

Sections 3.9.2 through 3.9.7 outline the scope of the investigation and describe wind energy resources and available conversion technologies, screening factors used in the study, data and sources, and synergistic factors with other technologies.

3.9.2 Scope

This research effort considered conventional utility-scale land-based and offshore wind technologies. Distributed wind (turbines 100 kW or smaller in size) was considered out of scope

for this study, as was siting of less prevalent wind conversion technologies such as vertical-axis wind turbines. Potential offshore wind turbines are considered, but only those that would be anchored in shallow waters (30-m depths or less) as anchoring methods in deeper waters are not yet well developed.

3.9.3 Resource Description

Wind is produced due to the uneven heating of the Earth; the poles receive less solar energy than the equatorial regions, and land masses warm and cool more quickly than water bodies. The uneven heating creates temperature gradients in the atmosphere as air moves from cold (high-pressure) to warm (low-pressure) areas. In general, the stronger the pressure gradient, the harder the wind blows between the regions in order to equalize the pressure gradients (EPA 2011). Wind resource intensity varies spatially both horizontally along the ground and vertically into the atmosphere. Local terrain features can significantly impact wind resource intensity over short distances. For instance, a small elevated feature can be well exposed to wind resource and have high intensity, while a short distance down slope the land is sheltered and has low wind resource. There can also be local heating and cooling impacts on resource intensity over very short distances and time frames; that is, wind resource increases due to sea-breeze effects may dissipate within a few hundred meters of shore due to friction from surface vegetation. In general, wind resource increases with height above ground, but the rate of increase varies due to local terrain and meteorology. Offshore wind resources, moderated by the thermal cushioning of the surrounding water, generally display less spatial and temporal variability, though seasonal differences can still be significant.

The continental United States is characterized by a large-scale westerly flow (winds from the west) at higher levels of the atmosphere. The jet stream, located about 6 to 10 km above the surface, strongly influences weather systems across the country. Its influence is strongest in the northern states but can influence the entire continental United States. Regional wind climates in the United States are caused by the interplay of jet-stream-induced storm tracks, meteorological factors that occur closer to the surface, and regional and local terrain features. In the EZ Study area, land-based wind resources are present in the mountainous areas in the east; less intense but more consistent wind resources are in the central Great Plains. Resource is lowest in the southeast, but some suitable areas may be found along the coast or on elevated features. Offshore, considerable shallow areas suitable for development occur all along the eastern seaboard and Gulf Coast. Resource intensity is strongest in the northern portion, with lower offshore resource in the southern portion. However, offshore resource is noticeably stronger and more ubiquitous than land-based wind resource in the southern states.

Other parameters that can affect siting and performance of a wind farm include prevailing wind direction, frequency distributions of speed and direction, and wind shear (change of wind speed with height). Wind speeds are typically expressed in meters per second (m/s), and wind power density values are expressed as watts per square meter (W/m^2).

Public, high-resolution wind resource data were not available for the EZ Study area at the 80-m height above surface desired for this study. Therefore, a solicitation process was used to acquire a modeled wind resource dataset from a commercial source. AWS Truepower, LLC (AWST)

was the vendor selected, and it provided annual average wind speed and gross capacity factor estimates for the EZ Study area at 80- and 100-m heights above surface for land-based and offshore wind. The wind speed estimates are the result of AWST's MesoMap system (AWST 2012), a combination of mesoscale and microscale atmospheric models using a top-down approach for estimating wind near the surface. The microscale model then refines the wind estimates from the mesoscale model to capture the local influences of topography and surface roughness changes, and incorporates available surface observations when possible. The gross capacity factor estimates are the result of incorporating finer temporal resolution model estimates of wind speed with power curves from Class II IEC wind turbine power curves. Class II wind turbines are typical of wind turbines installed in the United States. However, Class III turbines, which utilize larger rotors at the same hub height to capture more energy at lower wind speeds, are increasingly being installed (Wiser and Bolinger 2011).

3.9.4 Conversion Technologies

For this study, the same conversion technology was used for both land-based and offshore wind energy extraction. The most common conversion technology is the horizontal axis wind turbine (Figure 3-42) which utilizes a tall tower upon which a spinning rotor is attached. There are variations on this design (i.e., two blades or three, size of the rotor blades, passive vs. active yaw systems), but these designs convert energy according to the same basic principles. The rotor at the top of the tower faces into or away from the wind, and the wind turns the rotor blades. Within



Figure 3-42 Maple Ridge Wind Farm in Lewis County, New York (Note: The wind farm contains a total of 195 1.65-MW wind turbines.) (Source: NREL 2013)

the turbine nacelle, the rotor is attached to a shaft which attaches to a generator, which generates electricity.

Offshore wind turbines utilize the same horizontal axis wind turbine structure but need to be anchored or supported to operate stably at a fixed location. The majority of offshore wind installations in the world have been sited in relatively shallow waters (30-m depths or less) where the turbines can be anchored directly into the seabed. Deployment of wind turbines in deeper waters through the use of floating platforms or other methods is still in the early stages of development (Musial and Ram 2010).

3.9.5 Screening Factors

Screening factors for land-based wind (Table 3-23) are well defined because of the number of wind installations over the last decade and are drawn in large part from national wind potential estimates generated by NREL (WPA 2011; Lopez et al. 2012). Offshore screening factors (Table 3-23) have been defined based on limits of the current technology, information from global offshore installations, and extrapolation of land-based screening factors. The specific default suitability criteria and ranges for each screening parameter are listed in Appendix A. The Protected Land, Habitat, and Imperiled Species screening parameters are discussed in Section 4. Informational layers may also be useful for additional analysis by overlaying them onto the suitability model results. The extensive list of EZ Mapping Tool informational layers is included in Appendix B.

Table 3-23 Wind Technology Screening Factors

Wind Technology	Screening Parameter
Land-based	Wind turbine gross capacity factor Population density Slope Land cover area Distance to major road Distance to airport runway Proximity to electric transmission (>345 kV) Protected Land Habitat Imperiled Species
Offshore	Wind turbine gross capacity factor Population density Bathymetry Distance to substation Unexploded Ordnance Distance to shore Navigable waterways Protected Land Habitat Imperiled Species

3.9.6 Data and Sources

Land-based and offshore wind resource data were obtained from AWT through a competitive solicitation. The data include average annual wind speeds at hub heights of 80 m and 100 m, based on a 200-m grid covering the entire Eastern Interconnection. Simulated temporal data provide estimates of hourly gross capacity factors for the same territory, but at a 20-km resolution.

Publicly available data used to construct the screening factor layers for the wind technologies are available from a variety of sources and are listed in Table 3-24. The Protected Land, Habitat, and Imperiled Species screening layers and data sources are discussed in Section 4.

3.10 Synergistic Considerations

The EZ Mapping Tool provides a means to find regions of higher energy potential from the different individual technologies described above. An important additional factor that the user must consider is the inter-relationships among the technologies. Close co-location of some technologies may provide synergies where one technology provides benefits for the other. In other situations, the technologies may be compatible, so that a region can support a greater density of electricity capacity than if only one were deployed. Lastly, the two may compete for the same resources or disrupt each other in other ways so that the combination of technologies has lower total capability than the sum of each by themselves.

A user of the EZ Mapping Tool should consider these synergy effects when analyzing the potential capacity for possible EZs. The discussion below and Table 3-25 provide some examples of possible synergistic impacts among different clean energy resources and the co-location compatibility of different technologies, as well as the incidence of competing

Table 3-24 Wind Technology Screening Factor Data and Sources^a

Factor (Parameter)	Data and Source
Population density	LandScan™, (http://www.ornl.gov/sci/landscan)
Slope	2012 NGA digital terrain elevation data/calculated and resized for 250-m cells
Land cover area	2011 USGS
Distance to major road	2012 National Transportation Atlas Database, www.bts.gov/publications/national_transportation_atlas_database/2012
Distance to airport runway	2012 FAA
Transmission data	2012 Bentek Energy/Platts
Bathymetry	2013 NOAA
Distance to substation	2012 Bentek Energy/Platts
Unexploded ordnance	2012 DOC, NOAA, NOC, CSC
Distance to shore	2012 Argonne
Navigable waterways	2012 Research and Innovative Technology Administration
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

Table 3-25 Synergies among Clean Energy Resources

	Water	Land	Operations
Biomass/coal-CCS	Compete for cooling		Dual fuel use through co-firing
Biomass/wind		Dual use (except forests)	
Coal-CCS/geothermal	Compete for cooling		
Coal-CCS/gas	Compete for cooling		
Coal-CCS/nuclear	Compete for cooling	Similar site resources	
Coal-CCS/solar			CSP augments feedwater heating
Coal-CCS/storage		Compete with CAES for underground space	
Coal-CCS/hydro	Dual use of reservoir		
Geothermal/nuclear	Compete for cooling		
Storage/nuclear	Dual use of reservoir		
Storage/solar			Firms electricity delivery
Storage/wind			Firms electricity delivery
Storage/hydro	Dual use of reservoir		



Positive synergy or compatibility



Negative synergy or competition

technologies. Energy planners can use the information on possible synergistic impacts to evaluate potential co-location of technologies where an overlap of two or more highly suitable clean energy resources has been identified.

The main categories for synergy or competition are in the use of water resources, land (above or below ground), and operational synergies based on the characteristics of the technologies. For example, limited water resources create competition among thermal technologies because they require water for cooling. In some cases, there can be synergy, such as the creation of a reservoir that provides both cooling water for thermal plants and a storage pool for hydroelectric or pumped storage hydroelectric power.

Land resources can provide synergy when a technology (such as wind) is compatible with other energy technologies such as farming of biomass resources. Wind turbines in a wind farm are spaced far apart and have a small, dedicated footprint per wind turbine, which allows for mixed use within a wind farm's boundaries. Synergy exists with biomass fuel development activities since they can readily be grown and harvested between turbine sites. This multiple use of the land increases the resource density and improves justification of infrastructure improvements for an EZ. Table 3-25 does note that tree-based (forest) biomass resources may conflict with wind due to the tree-height reducing some fraction of the wind resource. Solar and wind co-location is

also possible, but more problematic with likely shading effects from the turbine structures that would affect solar production. Similarly, utility-scale PV can be co-located with other types of power plants if sufficient land area is available. Siting would need to be carefully conducted to avoid shading from large structures.

Underground resources can also be a factor. The surface footprint of a geothermal power plant is only a fraction of the underground footprint. Similarly, CAES facilities are very small on the surface but utilize large underground space under high pressure. Carbon sequestration may also use deep underground storage of CO₂. These three technologies may conflict with each other if located in the same area.

Operational characteristics may create opportunities for synergy. Biomass resources can be co-fired with coal, thereby promoting a renewable resource while having a firm capacity available regardless of the variation in biomass fuel availability. In general, CSP energy production is compatible with fossil plants that utilize steam turbine generators, so long as they have sufficient land area available to support installation of the solar field. NREL and EPRI have conducted a study examining synergies between CSP and existing coal or natural gas power plants (Turchi et al. 2011). It is possible that hybrid geothermal and CSP plant designs might be jointly developed as both technologies advance.

Storage technologies provide a system-wide operational benefit by allowing the operators to smooth generation, make up for intermittent or lost production, or take advantage of system cost differences over differing time scales. Many of these system benefits do not require that the storage be co-located or close to generation technologies, but there can be synergies if they are. For example, variable generation, such as wind or solar, will often operate at only a fraction of their full power, but transmission capacity may be needed for their peak production. Co-located storage may allow the operators to better utilize this transmission capacity during times of low wind or solar output (Sullivan et al. 2008; Parsons et al. 2006). Aggregation of variable generation, relative cost of transmission capacity, and other factors will all play a role in determining the best location for storage. Baseload plants, such as nuclear, would see less gain from co-locating storage since they provide a relatively constant level of power.

As a distributed resource, rooftop PV has little direct synergy or conflict with any generation technology at transmission-level voltages. However, it does have a high potential for synergy with future “smart grid” technologies. Some of the potential synergy is economic. If smart grid facilitates time-of-use retail electricity rates, then customers would have a greater incentive to install rooftop PV systems. Rates for on-peak usage would be higher than for off-peak usage, which would make the value of on-peak load reduction greater.

A number of technologies may compete for similar land and water resources. Many of the technologies in the EZ Mapping Tool have similar screening criteria (e.g., population, protected lands, and flood zones), thus regions suitable for one may be suitable for others as well. This is most apparent for technologies of similar size and resource needs. For example, advanced coal plants, gas-fired combined cycle, and nuclear plants being thermally driven have somewhat similar land and water criteria. Sites suitable for nuclear plants (generally the most restrictive) would also be suitable for coal and natural gas facilities.

4 Environmental Considerations

4.1 Background

Including environmental screening layers in the EZ Mapping Tool allows environmental factors to be incorporated at the beginning of the planning process to reduce the risk of public opposition, regulatory intervention, and litigation later in the planning or development process. In the EZ Mapping Tool, environmental screening factors related to energy development were grouped into three model input layers: Protected Lands, Habitat, and Imperiled Species. These environmental screening layers were included in models for all nine clean energy resource types. Each environmental screening layer is a composite made up of several individual datasets (tables are provided in Appendices D and E).

An Environmental Focus Group (EFG) was created to determine the appropriate environmental spatial data to include in each composite environmental screening layer. The EFG included subject matter experts from federal and state agencies, environmental non-governmental organizations (NGOs), and industry stakeholders, including the following:

- American Transmission Company
- Argonne National Laboratory
- Association of Fish and Wildlife Agencies
- Bureau of Ocean Energy Management, Regulation and Enforcement
- The Conservation Fund
- Defenders of Wildlife
- Eastern Interconnection States' Planning Council
- Eastern Interstate Planning Council
- EPA Region 4
- Exelon Corporation
- Michigan Public Service Commission
- National Audubon Society
- The Nature Conservancy
- NatureServe

- New York Independent System Operator
- Oak Ridge National Laboratory
- Southern Regional Energy and Environmental Office
- Western Governors' Association
- The Wilderness Society
- Xcel Energy

4.2 Composite Environmental Screening Layer Development Methods

The majority of the datasets included in the habitat and protected lands screening layers were compiled by NatureServe and an NGO caucus of the Eastern Interconnection Planning Collaborative (EIPC) as an initial set of data layers to be considered during the assessment of zones suitable for clean energy development in the Eastern Interconnection. The EFG then identified several additional datasets to augment the initial list while attempting to prevent redundant data. When identifying additional datasets to include in the composite screening layers, the EFG focused on identifying high-quality regional environmental datasets and Green Infrastructure Data that identified core conservation areas and emphasized connectivity among them at a landscape scale, rather than focusing on species-specific habitat or datasets that cover small areas. The EZ Mapping Tool is not designed for project siting, thus more detailed information is necessary for that level of analysis. The resulting habitat and protected lands composite screening layers consist of a wide range of state, regional, and national datasets which collectively cover the Eastern Interconnection.

In order to create composite environmental screening layers, a four-tier sensitivity categorization utilizing red, yellow, orange, and background was applied to each individual dataset. These sensitivity categorization levels for clean energy resource development are defined below:

- Red (Exclude from development): Areas where development is already precluded by statute or regulation (federal, state, and local).
- Orange (Develop with extreme caution): Areas where development would likely pose a high risk to natural resources but development is not precluded, or where development would likely pose a high risk to important habitat or imperiled species (G1, G2, T1, T2, S1, ESA-E, ESA-T, ESA-C, ESA-P, State-E, and State-T).
- Yellow (Develop with caution): Areas where development would likely pose a moderate risk to protected lands (development has not already been precluded) or where development would likely pose a moderate risk to important habitat or imperiled species (G3, T3, ESA-SAT, ESA-SC, and S2).

- Background (Likely low conflict area): Areas where development would have the lowest impact on habitat, imperiled species, and protected lands based on the included data. Additional data may provide information to increase the sensitivity in these areas. Further research at the project level would provide a more comprehensive categorization of sensitivity in these areas.

Each sensitivity categorization level was assigned a different default suitability value for the default model runs ranging from 0 (unsuitable) to 100 (most suitable): red = 0, orange = 20, yellow = 40, and background = 95. In the EZ Mapping Tool, the default suitability values can be adjusted. The creators or data managers for each dataset were contacted and asked for feedback about the categorization of their data and their advice was incorporated. The EFG conducted webinars (approximately one a month) to discuss data needs as well as the categorization of the individual datasets. The composite screening layers were then created by combining the individual datasets, and the highest sensitivity level was retained in any overlapping regions. The imperiled species composite screening layer was created by and procured from NatureServe. NatureServe obtained data from state natural heritage programs and created a species-blind dataset categorized according to the four-tier sensitivity levels based on the Element Occurrences of imperiled plant and animal species and their federal and state listing status, as well as their NatureServe conservation status ranks: Global conservation status rank (G-rank), Subnational conservation status rank (S-rank), and Intraspecific taxon status rank (subspecies, varieties, and other designations below the level of the species) (T-rank). Species status ranks are defined as follows:

- G1 – Globally critically imperiled species
- G2 – Globally imperiled species
- G3 – Globally vulnerable species
- T1 – Critically imperiled subspecies
- T2 – Imperiled subspecies
- T3 – Vulnerable subspecies
- S1 – State critically imperiled species
- S2 – State imperiled species
- ESA-C – Candidate species for federal listing
- ESA-P – Proposed species for federal listing
- ESA-PDL – Proposed for delisting
- ESA-E – Federally endangered species

- ESA-T – Federally threatened species
- ESA-SAT – Federally threatened species due to similarity of appearance
- ESA-SC – Federal species of concern
- ESA-XN – Nonessential experimental population
- State-E – State endangered species
- State-T – State threatened species

4.3 Data Caveats

Areas not identified as sensitive to energy development in any of the three composite environmental screening layers are not determinedly low impact areas; they may represent areas not surveyed during the studies used to create the individual datasets contained in the composite layers. In addition, the availability of environmental data varied extensively within the Eastern Interconnection. Several regional datasets that cover the southeastern and northeastern United States were included in the habitat composite screening layer; however, no regional datasets were available for the Midwestern states. Environmental sensitivity development may appear to be greater in the eastern EISPC region than the western EISPC region due to a greater number of available data layers. Site-specific surveys must still be conducted at the project-level to ensure avoidance of highly sensitive environments.

5 Policy, Demand Response, and Smart Grid Considerations

The earlier sections of this report describe the possible technologies that may be in place within an EZ and the criteria used to establish highly suitable areas. There are other considerations, including policy, demand response (DR), and smart grid technologies, that play a role in determining areas for potential EZs, even though they do not directly identify technologies, groups of technologies, or areas of concentrated resources. Policy considerations assist in the determination of viable EZs within the Eastern Interconnection by providing either positive or negative incentives to certain regions. DR is a technology that has the potential to reduce electricity demands at key times so that less capacity is needed on the grid and can be a substitute for the resources described in Section 3 of this report. In addition, smart grid is an enabler for some types of DR, as well as for energy efficiency, emergency response, and improved reliability of the electricity grid.

5.1 Policy

Policy considerations are a crucial aspect for the advancement of clean energy. The incentives are less likely to be geographically based, except for the associated political boundaries. For most policies, the appropriate mapping representations are simply the political boundaries where the policies are in effect. For example, some states have RPSs that provide incentives for the development of certain clean energy technologies. Some of these RPS laws have additional incentives if the technology is located within the state. Other policies may include prohibitions on nuclear plant construction, local fuel supply preferences, or incentives for job development. At finer detail, smaller political subdivisions may have their own policy incentives or disincentives, down to zoning regulations. However, these levels of detail are beyond the present scope of the EZ Mapping Tool.

The EISPC contracted with CESA to create an inventory of the clean energy laws, regulations, incentives, and other policies in the different states and Canadian Provinces across the Eastern Interconnection that can be accessed from the EZ Mapping Tool. Rather than develop a static report, CESA collaborated with EZ Mapping Tool developers and helped create a database displayed within the EZ Mapping Tool website that also connects to other online databases through NREL's OpenEI.

To populate the inventory, CESA began with DSIRE, which is funded by DOE and has been implemented by the North Carolina Solar Center and the Interstate Renewable Energy Council (NCSU 2013). It is “the most comprehensive source of information on incentives and policies that support renewables and energy efficiency in the United States.” However, DSIRE does not cover some of the clean energy resource categories included in the EISPC EZ Mapping Tool, such as nuclear, natural gas, or geothermal. DSIRE also does not cover some types of policies (e.g., environmental regulations, state economic development incentives, climate action plans, and forestry policies) that can be relevant when making decisions about clean energy resource development. CESA therefore expanded its database to incorporate these technologies and policies.

CESA worked with NREL to create the database as a wiki in the OpenEI website <<http://en.openei.org/wiki/EZPolicies>> and populated it with available information. All states and provinces were invited to review the data and provide additional information. There are currently 2,360 policies in the database, including federal, state, and local policies. These are assigned to the different political entities as shown in Table 5-1. The database can be easily updated as new information is made available.

The EZ Mapping Tool incorporates the database with a tab that allows the user to search for policies and regulations by any combination of political entity, policy type, implementation sector, and affected technologies, as shown in Figure 5-1.

Table 5-1 Relevant Energy Policies in the EZ Mapping Tool Database as of April 19, 2013

All EZ Policies (2,360)	New Jersey (44)
United States Federal Policies (18)	New Mexico (53)
Canada Federal Policies (9)	New York (79)
	North Carolina (62)
State Policies	North Dakota (57)
Alabama (36)	Ohio (60)
Arkansas (31)	Oklahoma (45)
Connecticut (85)	Pennsylvania (72)
Delaware (38)	Rhode Island (48)
District of Columbia (22)	South Carolina (50)
Florida (74)	South Dakota (43)
Georgia (58)	Texas (91)
Illinois (58)	Tennessee (38)
Indiana (77)	Vermont (50)
Iowa (98)	Virginia (85)
Kansas (38)	West Virginia (49)
Kentucky (49)	Wisconsin (56)
Louisiana (43)	
Maine (61)	Canadian Province Policies
Maryland (119)	Manitoba (15)
Massachusetts (55)	Newfoundland and Labrador (10)
Michigan (47)	New Brunswick (12)
Minnesota (107)	Nova Scotia (13)
Mississippi (38)	Ontario (21)
Missouri (56)	Prince Edward Island (15)
Montana (95)	Quebec (14)
Nebraska (65)	Saskatchewan (15)
New Hampshire (33)	

EISPC EZ Mapping Tool

Provide policy updates or edits to eispctools@anl.gov.

Country/State/Province	Policy Type	Implementation Sector	Affected Technologies
US-National	Bond Program	Federal	Biomass/Biogas
Canada-National	Climate Policies	Local	Coal with CCS
Alabama	Corporate Tax Incentive	Non-Profit	Concentrating Solar Power
Arkansas	Enterprise Zone	State/Province	Energy Storage
Connecticut	Environmental Regulations	Utility	Fuel Cells
Delaware	Equipment Certification		Geothermal Electric
District of Columbia	Equity Investment		Hydroelectric
Florida	Fees		Natural Gas
Georgia	Generation Facility Data Modeling		Nuclear

Search

Figure 5-1 EZ Mapping Tool Search Parameters

Table 5-1 lists the political entities; the policy types that can be searched are listed in Table 5-2. The five implementation sectors are shown in Figure 5-1, while the affected technologies are listed in Table 5-3.

Search results include state-level summaries providing an overview of the state’s policy context and a summary description of each policy with a number of key characteristics; clicking on the name of the policy takes the user to more details on that policy provided within the OpenEI database.

5.2 Demand Response

FERC defines demand response as “the changes in electric usage by demand-side resources 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” (FERC 2009). DR tariffs and incentive programs are offered by utility companies, system operators, utility companies, electricity cooperatives, municipal power agencies, and other load-serving entities, and they incentivize consumers to reduce their electricity consumption over a specific period of time (Isser 2009; FERC 2009; PLMA 2002). DR programs are quite diverse in the means through which they offer energy-consumption-reduction incentives.

As part of its development of white papers and studies, the EISPC contracted with Navigant to conduct a survey and analysis of a broad range of demand-side resources for electrical energy end-uses within the Eastern Interconnection (Navigant 2013). These analyses considered six categories of resources:

- Study #1: End-use energy efficiency programs (EE),
- Study #2: Demand response programs (DR),
- Study #3: Distributed energy storage systems (ES),

Table 5-2 Searchable Policy Types in the EZ Mapping Tool Database as of April 19, 2013

Bond Program	Climate Policies
Corporate Tax Incentive	Enterprise Zone
Environmental Regulations	Equipment Certification
Equity Investment	Fees
Generating Facility Rate-Making	Generation Disclosure
Grant Program	Green Building Incentive
Green Power Purchasing	Industry Recruitment/Support
Interconnection	Leasing Program
Line Extension Analysis	Loan Program
Mandatory Utility Green Power Option	Net Metering
PACE Financing	Performance-Based Incentive
Personal Tax Incentives	Property Tax Incentive
Public Benefits Fund	Rebate Program
Renewables Portfolio Standards and Goals	Safety and Operational Guidelines
Sales Tax Incentive	Siting & Permitting
Solar/Wind Access Policy	Solar/Wind Contractor Licensing
Training/Technical Assistance	Utility Rate Discount
Workforce Development	

Table 5-3 Clean Energy Technologies in the EZ Mapping Tool Database as of April 19, 2013

Biomass/biogas	Coal with CCS	Concentrating solar power
Energy storage	Fuel cells	Geothermal electric
Hydroelectric	Natural gas	Nuclear
Solar photovoltaic	Tidal energy	Wave energy
Wind energy		

- Study #4: Distributed generation powered by fossil fuels (DG-F),
- Study #5: Distributed renewable resources (DG-R), and
- White Paper #1: Other programs and initiatives enabled by the smart grid (SG).

Study #2 focused on an analysis of DR programs across the Eastern Interconnection. The primary sources of data were the independent system operator/regional transmission organization (ISNO/RTO) forecasts in states that allow DR to participate in capacity markets and utility Integrated Resource Plans (IRPs) for all other states. Roughly three-fourths of the states in the Eastern Interconnection require utilities to file IRPs or other long-term plans. In addition, data were available through FERC and the EIA surveys and reporting forms. NERC also provided data through its Long-Term Reliability Assessment.

Navigant conducted a study of existing (2012), near-term (2013–2015), and long-term (2016–2030) forecasts of DR resources. Their results show a recent expansion of DR capacity with continued growth through the near-term. Long-term, it expects DR growth to roughly parallel overall growth in demand so that the percentage of capacity from DR will stay roughly constant.

Tables 5-4 and 5-5 show the base case results for Navigant’s analysis. The DR Resource Capacity is the total amount of DR that could be called upon, while the Peak Load Impact reflects that not all DR can or should be called upon at the same time. Some types of DR are only available at certain times, such as air-conditioning during hot days or water heating when heating is most in use such as winter mornings. Many may have limits on the amount of time they can be used, either as number of events per year and/or amount of time per event. Optimized utilization may mean that some resources are reserved for other peak periods to better equalize peaks.

Furthermore, some fraction of DR suppliers may not have their resource available when the capacity is called upon. Navigant summarizes all of these reasons by using what it refers to as the *realization rate* for DR. Navigant used the data from the FERC 2012 DR survey (FERC 2012) to find the ratio of potential peak reduction to actual peak reduction. Separate ratios were calculated for the different regions and for the different types of DR programs.

Figure 5-2 shows a breakdown of the project DR capacity by the different types of programs that Navigant modeled. Emergency/Reliability DR represents capacity that will respond to an emergency event (such as system or local constraints) in exchange for an incentive or rate discount. This includes interruptible load, load procured as a capacity resource, and emergency demand response programs. It is mainly provided by commercial and industrial customers. Another contributor is direct load control (DLC), where the program sponsor remotely shuts off or reduces the load of specific equipment at a customer’s site, such as air-conditioning or water heating. Time-based rates are expected to play an increasing role as more utilities provide this option.

Lastly, Navigant created four alternate scenarios to its base case, with varying policies in support of DR and level of economic growth. With more aggressive policies, the amount of DR

Table 5-4 Projected DR Resource Capacity by U.S. Census Region

U.S. Census Division	U.S. Census Region	Projected DR Resource Capacity (MW)						
		2012	2013	2014	2015	2020	2025	2030
Northeast	New England	1,253	1,435	1,460	1,462	899	957	1,025
	Middle Atlantic	6,767	8,416	9,539	9,706	10,230	10,800	11,427
Midwest	East North Central	6,694	7,352	9,981	10,298	10,848	11,439	12,080
	West North Central ^a	6,035	6,670	7,252	7,569	7,969	8,362	8,779
South	South Atlantic	11,657	13,033	15,638	16,032	17,002	18,078	19,232
	East South Central	4,785	4,993	5,420	5,494	5,881	6,286	6,730
	West South Central ^{a,b}	1,931	2,035	2,409	2,586	2,746	2,877	3,026
Total		39,123	43,933	51,698	53,148	55,574	58,799	62,298

^a Portions of both Montana and New Mexico fall within Eastern Interconnection territory. However, even though they are part of the Mountain Census Region, they are grouped into West North Central and West South Central, respectively, due to the proximity and small service area.

^b Excludes the Electric Reliability Council of Texas (ERCOT) portion of Texas.

Source: Navigant (2013).

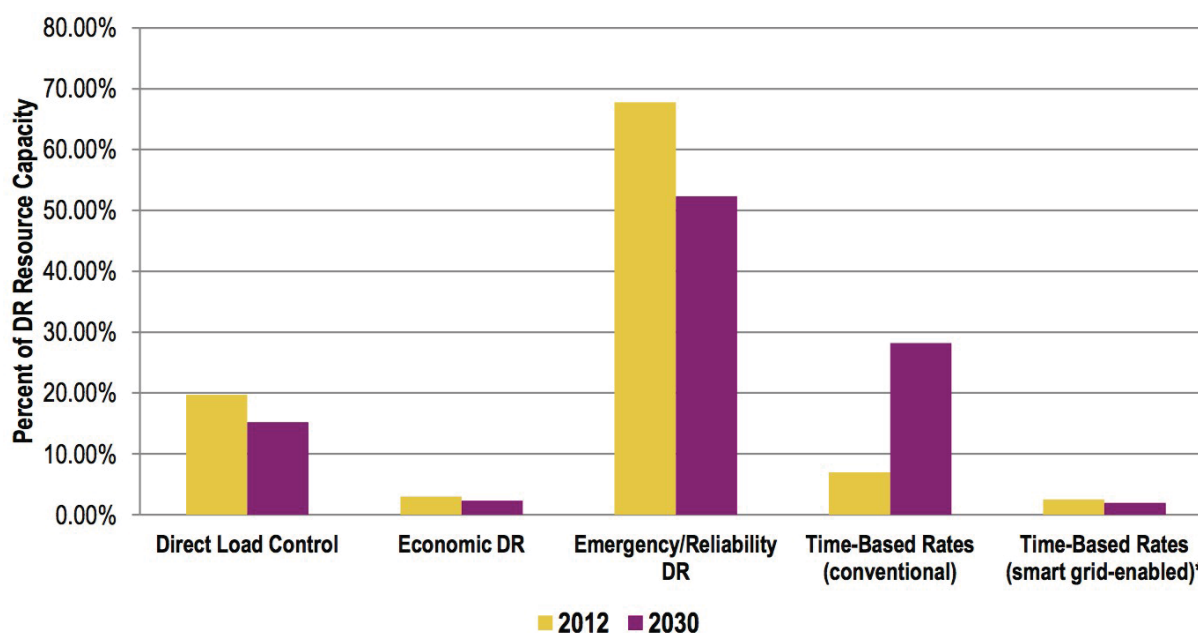
Table 5-5 Projected DR Peak Load Impact by U.S. Census Region

U.S. Census Division	U.S. Census Region	Projected DR Resource Peak Load Impact (MW)						
		2012	2013	2014	2015	2020	2025	2030
Northeast	New England	792	907	923	925	572	609	653
	Middle Atlantic	4,346	5,411	6,134	6,240	6,577	6,944	7,347
Midwest	East North Central	4,291	4,707	6,418	6,614	6,968	7,349	7,761
	West North Central ^a	3,759	4,151	4,509	4,704	4,953	5,198	5,457
South	South Atlantic	7,314	8,181	9,828	10,069	10,678	11,353	12,077
	East South Central	2,747	2,867	3,125	3,170	3,392	3,627	3,882
	West South Central ^{a,b}	1,194	1,260	1,492	1,604	1,703	1,784	1,877
Total		24,443	27,484	32,429	33,327	34,844	36,863	39,054

^a Portions of both Montana and New Mexico fall within Eastern Interconnection territory. However, even though they are part of the Mountain Census Region, they are grouped into West North Central and West South Central, respectively, due to the proximity and small service area.

^b Excludes the ERCOT portion of Texas.

Source: Navigant (2013).



* Includes time-based rate programs that require AMI meters with two-way communication capability.

Figure 5-2 Percentage of DR Resource Capacity by Sub-Resource Category (Source: Navigant 2013)

increased over the base case, and higher economic growth accelerated DR as grid capacity demand increased.

In addition to Navigant's study, DOE funded ORNL to conduct a separate study on the potential for DR in the Eastern Interconnection (Baek et al. 2012). This study focused on the potential for DR using a modified version of the National Assessment of Demand Response (NADR) simulator made available by FERC. The assessment covered each state within the Eastern

Interconnection through 2030. It involved four separate scenarios: Business As Usual (BAU) that kept current DR programs ongoing but with little expansion; Optimistic BAU that expanded the current programs to utilities that currently do not have them but did not change technologies or types of programs; Aggressive Deployment that increased the DR pricing programs available and utilized smart grid technologies; and Full Deployment where all potential DR participants joined in the programs.

Five types of DR programs were utilized, similar to the Navigant programs but with slight regroupings of sub-programs. The NADR model also allowed further breakdown of resources by customer type, disaggregating by residential, and small, medium, and large commercial and industrial customers. Figure 5-3 shows the amounts of DR projected in the different scenarios by the ORNL study. According to 2030 DR potential analysis by scenario, program type, and end-use sector, under the BAU and Optimistic BAU scenarios, the largest gains come through interruptible tariffs and other DR. A significant growth in pricing programs (with and without enabling technologies) is noticed under the Aggressive and Full Deployment scenarios. DLC has a significant impact on the residential and small commercial and industrial (C&I) sectors. The majority of DR comes from large C&I customers primarily through interruptible tariffs (rates) and capacity and load bidding. In the residential sector, the most untapped potential for DR comes from the pricing programs.

5.3 Smart Grid

According to DOE:

“Smart grid” generally refers to a class of technology people are using to bring utility electricity delivery systems into the 21st century, using computer-based remote control and automation. These systems are made possible by two-way communication technology and computer processing that has been used for decades in other industries. They are beginning to be used on electricity networks, from the power plants and wind farms all the way to the consumers of electricity in homes and businesses. They offer many benefits to utilities and consumers -- mostly seen in big improvements in energy efficiency on the electricity grid and in the energy users’ homes and offices (DOE 2013).

Figure 5-4 is a schematic of the energy and information flow in a smart grid. The key characteristic of a smart grid is the frequent (up to continuous) two-way communication between devices in the field and the utility’s network operations. Information on electricity usage, voltage, and even key equipment status can be sent from customers to the operators, while data such as varying prices and critical power problems can be transmitted to customers. This extra information can help both customers and operators to better manage the electricity grid.

Customers can respond to high prices or critical power needs by reducing demand during those periods. Operators can remotely modify the line voltage or operating characteristics of equipment as well.

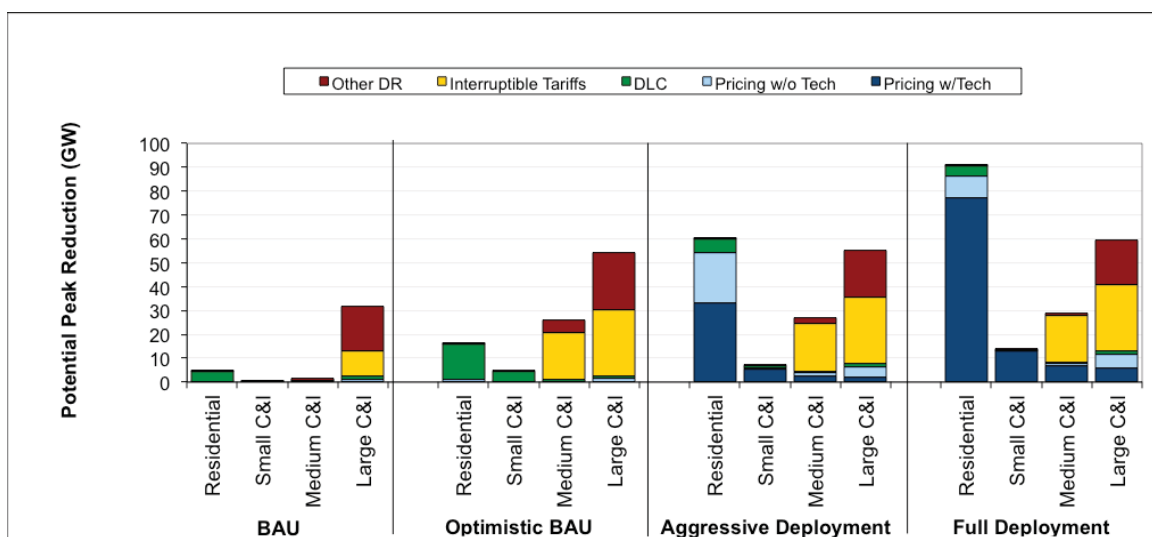


Figure 5-3 Potential Peak Reduction from DR in the Eastern Interconnection, 2030
(Source: Baek et al. 2012)

The smart grid by itself does not reduce demand. Rather, it is an *enabler* of demand response by providing additional, up-to-date information to consumers and system operators so they can make informed decisions on how to best use or make power. Automating the decision making (such as through smart appliances and thermostats) helps increase utilization of the information to make the savings more persistent and consistent.

The two main DR programs that the Navigant study (Navigant 2013) identified as most directly dependent on the existence of a Smart grid are:

- Automated Metering Infrastructure (AMI) and Time-Based Rate (TBR) programs that are enabled by AMI and,
- Conservation Voltage Reduction (CVR) programs.

An AMI requires not only smart meters installed at customers premises but also a communication system and large computing and data storage hardware systems, due to the large increase in data flow to and from consumers. TBRs may either change on an ongoing basis or only during critical times, depending on the design of the program.

CVR is a strategy used by utility operators to lower the voltage on a feeder during peak times while maintaining minimum voltage levels along its length. The smart grid provides information on the voltage all along the line so the utility operator can drop voltages closer to the minimum level without causing equipment damage from under-voltage. The utility needs to deploy dispatchable load-tap transformers in order to take advantage of this information.

Tables 5-6 and 5-7 show the projected resource capacity and peak load impact from the two smart grid-related DR resources combined for each of the major census regions. Since CVR is

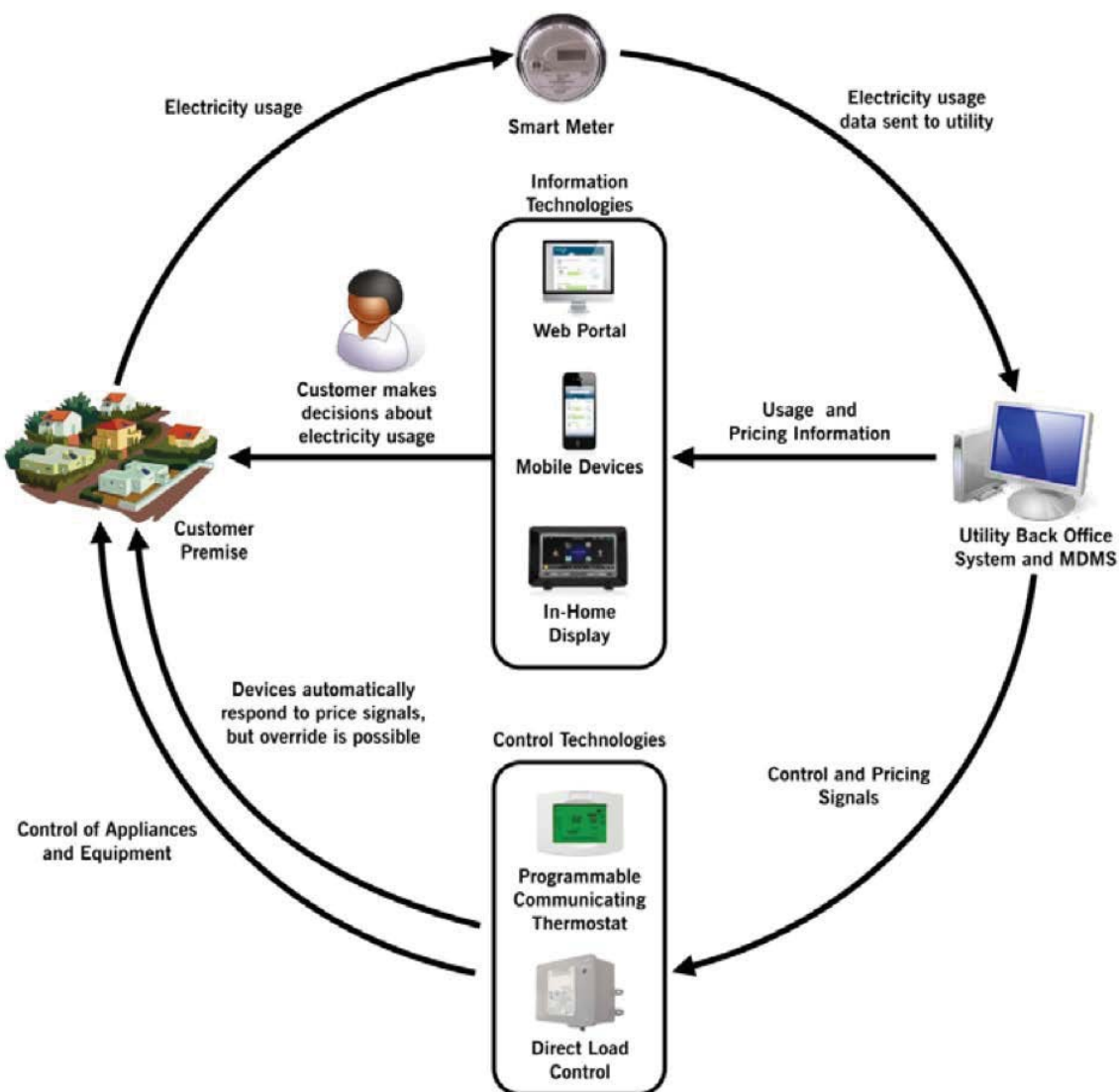


Figure 5-4 Overview of Consumer Devices and Systems for Managing Electricity Consumption and Costs (Source: DOE 2012)

controlled by the utilities, it is only dispatched during peak time, and the realization rate is 1.0. Its contribution to peak load is the same as its capacity.

The Navigant report (Navigant 2013) gives a further disaggregation into each category, as well as the energy impact from each. It also shows the expected impact under the scenarios with higher or lower economic growth and DR policies.

Lastly, it is worthwhile to show the results from Navigant’s combined analysis of different demand-side resources analyzed, some of which are not included in the EZ Mapping Tool. Table 5-8 shows the potential resource capacity under the base case for each category, and Figure 5-5 presents the information in graphical form. Table 5-9 presents the Peak Load Impact from each category, along with Navigant’s estimate of peak demands. Note that the full range of programs combined represents roughly 20% of peak demand by 2030.

Table 5-6 Smart Grid (TBR + CVR) Capacity by U.S. Census Region

U.S. Census Division	U.S. Census Region	Projected Smart Grid Capacity (MW)						
		2012	2013	2014	2015	2020	2025	2030
Northeast	New England	33	36	37	241	479	824	1,034
	Middle Atlantic	157	211	272	305	1,117	1,879	2,503
Midwest	East North Central	335	552	624	757	1,485	2,270	2,838
	West North Central ^a	105	124	138	169	509	896	1,361
South	South Atlantic	1,398	1,477	1,614	1,966	3,678	5,046	5,879
	East South Central	18	19	32	49	576	1,146	1,620
	West South Central ^{a,b}	370	433	526	575	815	1,107	1,372
Total		2,417	2,851	3,243	4,061	8,659	13,168	16,607

^a Portions of both Montana and New Mexico fall within Eastern Interconnection territory. However, even though they are part of the Mountain Census Region, they are grouped into West North Central and West South Central, respectively, due to the proximity and small service area.

^b Excludes the ERCOT portion of Texas.

Source: Navigant (2013).

Table 5-7 Smart Grid (TBR + CVR) Peak Load Impact by U.S. Census Region

U.S. Census Division	U.S. Census Region	Projected Smart Grid Peak Load Reduction (MW)						
		2012	2013	2014	2015	2020	2025	2030
Northeast	New England	15	16	17	219	361	611	768
	Middle Atlantic	72	98	125	149	538	952	1,275
Midwest	East North Central	192	378	413	479	837	1,311	1,622
	West North Central ^a	53	62	69	90	292	576	852
South	South Atlantic	774	810	890	1,187	1,980	2,970	3,470
	East South Central	8	9	20	36	294	670	929
	West South Central ^{a,b}	166	217	262	286	411	637	798
Total		1,282	1,589	1,796	2,446	4,711	7,727	9,714

^a Portions of both Montana and New Mexico fall within Eastern Interconnection territory. However, even though they are part of the Mountain Census Region, they are grouped into West North Central and West South Central, respectively, due to the proximity and small service area.

^b Excludes the ERCOT portion of Texas.

Source: Navigant (2013).

Table 5-8 Total Demand-Side Resource Capacity by Resource Category

		Projected Total Demand-Side Resource Capacity (MW)						
		2012	2013	2014	2015	2020	2025	2030
Energy Efficiency		3,016	5,650	8,567	11,542	25,956	40,106	53,369
Demand Response	<i>Conventional Programs</i>	36,739	41,270	48,613	49,535	47,469	48,007	48,790
	<i>Smart Grid-Enabled^a</i>	2,384	2,662	3,086	3,613	8,105	10,793	13,508
Energy Storage		88	93	125	149	1,118	2,180	3,479
DG-Fossil		17,811	17,725	17,718	17,671	18,107	18,832	19,909
DG-Renewables		6,126	7,150	8,333	9,744	19,974	33,603	50,091
Smart Grid (CVR)		353	557	612	1,124	1,481	3,276	4,075
Total		66,517	75,109	87,053	93,378	122,209	156,796	193,221

^a Includes time-based rate programs that require AMI meters with two-way communication capability.
Source: Navigant (2013).

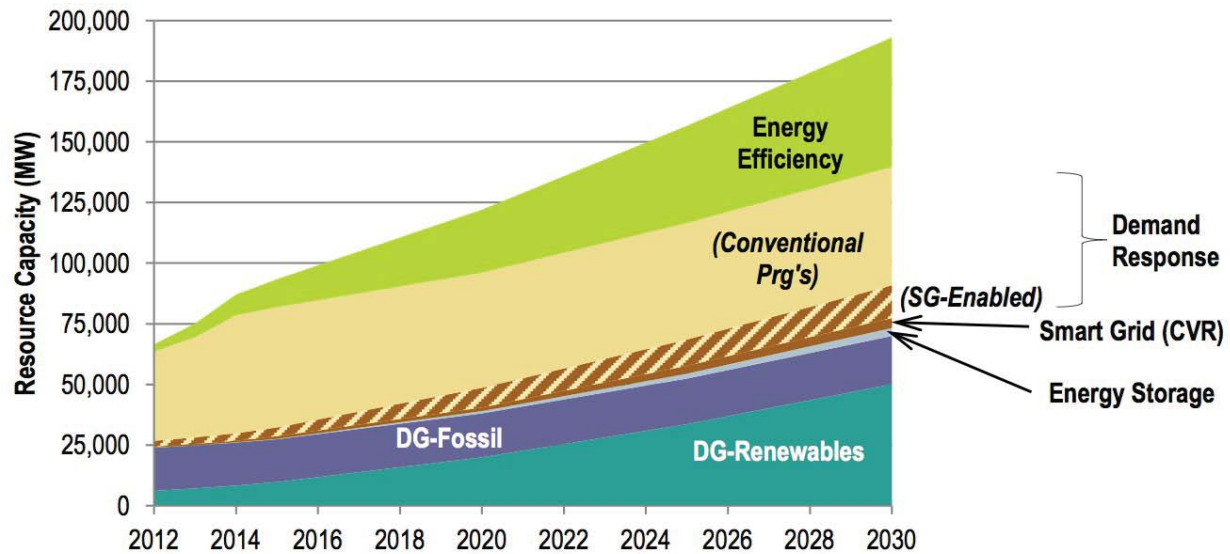


Figure 5-5 Total Demand-Side Resource Capacity by Resource Category (Source: Navigant 2013)

Table 5-9 Total Demand-Side Resource Peak Load Impact by Resource Category

		Projected Total Demand-Side Resource Capacity (MW)						
		2012	2013	2014	2015	2020	2025	2030
Energy Efficiency		3,016	5,650	8,567	11,542	25,956	40,106	53,369
Demand Response	<i>Conventional Programs</i>	23,370	26,286	31,041	31,701	31,197	32,007	32,976
	<i>Smart Grid-Enabled^a</i>	1,073	1,198	1,389	1,626	3,647	4,857	6,079
Energy Storage		64	68	76	79	629	1,253	2,040
DG-Fossil		16,030	15,953	15,946	15,904	16,296	16,949	17,918
DG-Renewables		4,198	4,713	5,289	5,972	10,745	17,007	24,516
Smart Grid (CVR)		353	557	612	1,124	1,481	3,276	4,075
Total		48,103	54,424	62,918	67,948	89,950	115,454	140,972
<i>Total Annual Peak Load</i>		<i>577,087</i>	<i>585,752</i>	<i>596,594</i>	<i>604,471</i>	<i>640,249</i>	<i>677,684</i>	<i>718,217</i>
% of Peak Load Supported by Demand-Side Resources		8.30	9.30	10.50	11.20	14.00	17.00	19.60
^a Includes time-based rate programs that require AMI meters with two-way communication capability. Source: Navigant (2013).								

6 EISPC EZ Mapping Tool Overview and Tutorial

This section provides an overview of the EZ Mapping Tool and describes the following: navigating the homepage, registering for and launching the tool, explaining the default layout, adding and removing mapping layers, using the map tools, creating analysis areas, creating corridors, copying and revising analysis areas and corridors, running models and reports, and exiting the system. This information and supplemental help videos are available to users on the website.

6.1 Navigating the Homepage

The URL for the EISPC EZ Mapping Tool is <http://eispctools.anl.gov>. That URL will bring you to the homepage.

EISPC EZ Mapping Tool

[About the Study](#) | [Energy Resources](#) | [Data](#) | [Policies & Regs](#) | [Maps](#) | [Documents](#) | [Links](#) | [Launch Tool](#)

EISPC EZ Mapping Tool

A map-based tool for identifying areas within the eastern United States that may be suitable for clean power generation.

[Launch Tool](#)

About the Tool

The EISPC Energy Zones Mapping Tool is a free online mapping tool to identify potential clean energy resource areas within the Eastern Transmission Interconnection.

This web site provides information [about the study](#), background on the [energy resources](#), and details on the [data](#) layers used in the tool. There are also links to [policies and regulations](#), printable [maps](#), [documents](#), and related [links](#).

Features

- Nine energy resources: [Biomass](#), [Clean Coal](#), [Geothermal](#), [Natural Gas](#), [Nuclear](#), [Solar](#), [Storage](#), [Water](#), and [Wind](#)
- Flexible analysis of siting factors such as slope and land protections
- Analysis of potential collocation of energy technologies
- Informed analysis to reduce new transmission construction

Getting Started

Click the [Launch Tool](#) button above to start the tool, on the image below to view an introductory [video](#), or use the Help menu at the top of the page for more detailed directions.



We are interested in your feedback. Please email your comments to eispctools@anl.gov.

News

August 30, 2013
[Webcast Training Seminar: Thursday, September 12, 10:00 a.m. - 12:00 p.m. Central](#)
 A free two-hour EISPC Energy Zone Mapping Tool training seminar will be presented on...

August 26, 2013
[Recorded Training Session Now Accessible Online](#)
 Lectures from a classroom training session for the tool were recorded on August 26,

Partners and Sponsors


The study is led by the Eastern Interconnection States' Planning Council (EISPC). The research support and technical assistance to EISPC is provided by Argonne National Laboratory, National Renewable Energy Laboratory, and Oak Ridge National Laboratory. Funding is provided by the U.S. Department of Energy. [More >](#)








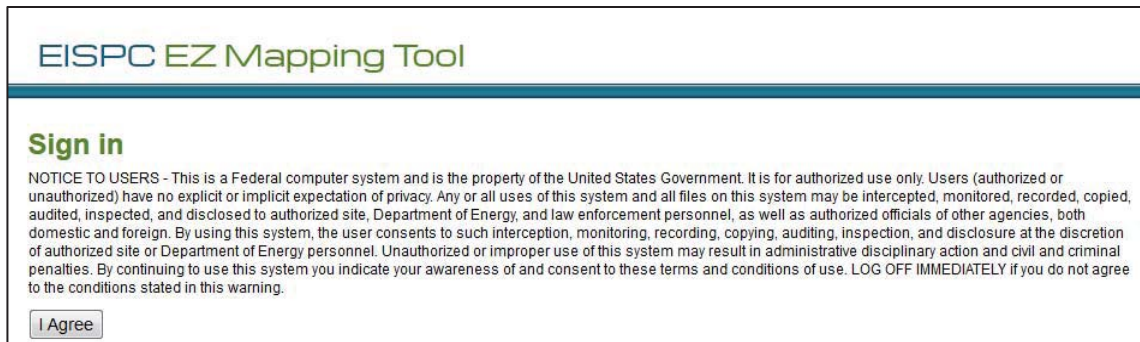
The EISPC EZ Mapping Tool homepage includes eight links at the top of the screen: ***Home***, ***About the Study***, ***Energy Resources***, ***Data***, ***Policies & Regs***, ***Maps***, ***Documents***, and ***Links***

- The home icon () will return you back to the main homepage.
- ***About the Study*** describes the purpose as well as the participants of the EISPC EZ Study.
- ***Energy Resources*** lists the resource categories and the technologies within each resource. You can click on a resource category and read a summary describing the basics about that resource. There are also references listed at the bottom of the page if you are interested in reading more about a particular energy resource.
- ***Data*** provides a list of all of the datasets available in the *Map Layer catalog*. To access metadata for a given dataset, click on the plus (+) next to the layer thumbnail and then click the *Metadata File* link. A PDF of the metadata will open in a new window. The metadata provide additional information about a dataset such as a summary of the dataset, the credits for who created the dataset, and information about the attributes contained within the dataset.
- ***Policies & Regs*** provides a searchable database of clean energy policy and incentive information. To search the database, choose at least one field from the *Country/State/Province*, *Policy Type*, *Implementation Sector*, or *Affected Technologies* scroll menus and then click the *Search* icon. A list of all of the policies and incentives matching your search will be generated.
- ***Maps*** provides a list of static maps available for viewing and printing. PDF maps have been created for technology resource data that are available in the EISPC catalog.
- ***Documents*** contains links for important documents such as white papers.
- ***Links*** contains a list of other helpful resources such as other available mapping tools and more information about EIPC and EISPC.

6.2 Registering for and Launching the EZ Mapping Tool

- (1) In order to use the EISPC EZ Mapping Tool, you must create a login, which uses your email address and a password. Your activities within the mapping tool will be saved to your account so that your work can continue from one session to the next. From the

Home Page, clicking on ***Login*** or the Launch Tool icon () will bring you to a banner containing the Department of Energy terms and conditions notice. After you have read and agreed to the terms and conditions, click on the *I Agree* button.

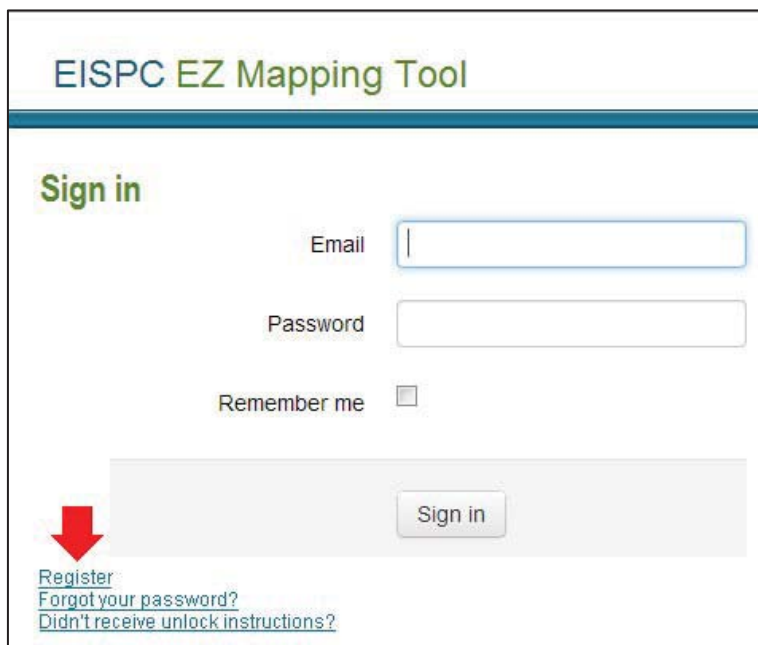


EISPC EZ Mapping Tool

Sign in

NOTICE TO USERS - This is a Federal computer system and is the property of the United States Government. It is for authorized use only. Users (authorized or unauthorized) have no explicit or implicit expectation of privacy. Any or all uses of this system and all files on this system may be intercepted, monitored, recorded, copied, audited, inspected, and disclosed to authorized site, Department of Energy, and law enforcement personnel, as well as authorized officials of other agencies, both domestic and foreign. By using this system, the user consents to such interception, monitoring, recording, copying, auditing, inspection, and disclosure at the discretion of authorized site or Department of Energy personnel. Unauthorized or improper use of this system may result in administrative disciplinary action and civil and criminal penalties. By continuing to use this system you indicate your awareness of and consent to these terms and conditions of use. LOG OFF IMMEDIATELY if you do not agree to the conditions stated in this warning.

- (2) Clicking the *I Agree* button will lead you to the Sign in page. To register for the tool, click on the Register link in the bottom left-hand corner of the screen.




EISPC EZ Mapping Tool

Sign in

Email

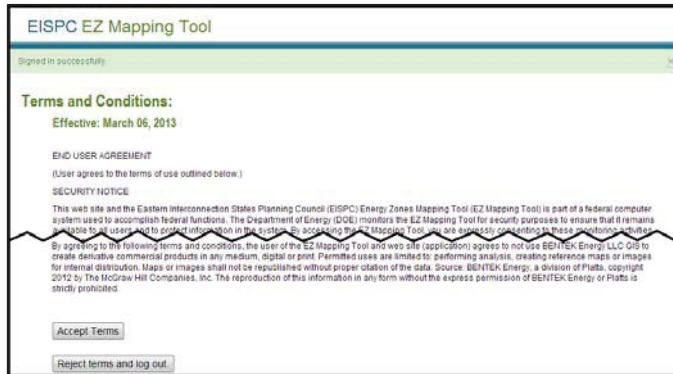
Password

Remember me ☐

 [Register](#)
[Forgot your password?](#)
[Didn't receive unlock instructions?](#)

- (3) On the Registration page, fill out the information pertaining to your name, organization, and state. Your e-mail address and password will be used as your login information. There are two options at the bottom of the page. By leaving the box next to the User Community page option unchecked, you agree to have your first name, last name, organization, and state listed on the User Community page. If your organization is not already in the Organization list, choose “Other (Enter below)” from the bottom of the drop-down list, and enter your organization in the Other organization box. By leaving the box checked next to the e-mail notification option, you agree that you would like to be e-mailed occasionally when significant changes are made to the site. After you have completed the registration information, click on **Register** at the bottom of the page. You will receive an e-mail confirmation message. Use the link in that message to confirm your e-mail address, and you will receive a second e-mail when your registration is complete.

- (4) When your registration is complete, return to the sign in page, enter your e-mail and password, and click **Sign in**. This will lead you to the “Terms and Conditions” page of the EZ mapping tool.



- (5) Either accept the terms by clicking **Accept Terms** or reject the terms by clicking **Reject terms and log out**. Clicking on **Accept Terms** will either launch the EZ Mapping Tool (if you originally clicked the Launch Tool icon) or will take you back to the home page (if you originally clicked **Login**) where you can now click the Launch Tool icon (



- (6) When the tool launches, a splash screen appears with links to training videos and a version of this document. The check box in the lower left corner controls whether the splash screen will be displayed in later sessions, and it can be displayed at any time by clicking Help at the top right of the page.



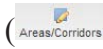
6.3 Understanding the Default Layout

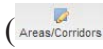
Launching the tool will open a new tab or browser window with the default layout of the mapping tool.

- The panel on the left side of the screen contains the *Main Menu* and *Map Contents*.
- The *Main Menu* contains the Library, Areas/Corridors, Analyze, and Results icons.



- The Library icon () is used to add new map layers or model layers to the map Contents dialog (see [Adding Map Layers](#) and [Adding Model Layers](#)).




- The Areas/Corridors icon () is used to create analysis areas (see [Creating an Analysis Area](#)) and corridors (see [Creating a Corridor](#)).

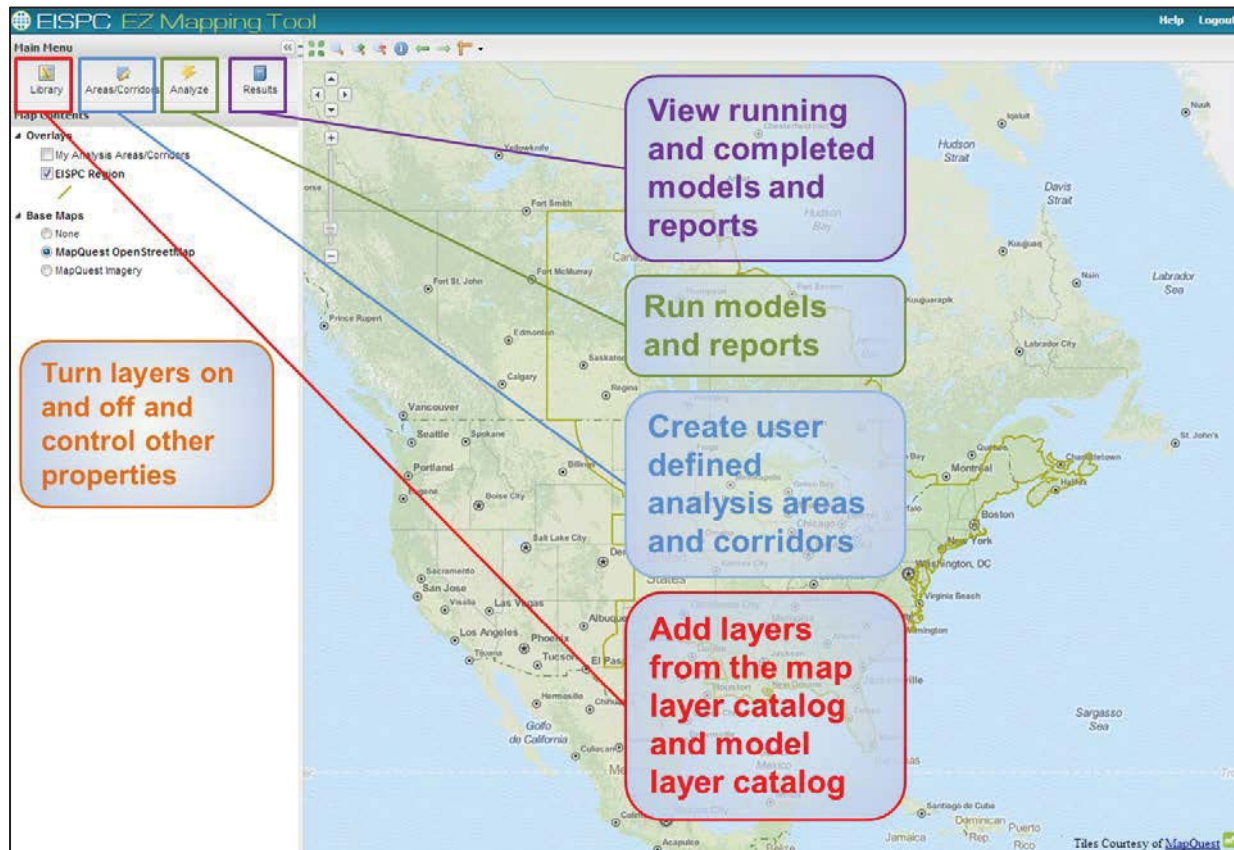


- The Analyze icon () is used to run models or reports (see [Running a Model](#) or [Running a Report](#)).



- The Results icon () is used to view model and report results (see [Running a Model](#) or [Running a Report](#)).

- The *Map contents* panel controls the layers displayed on the map.




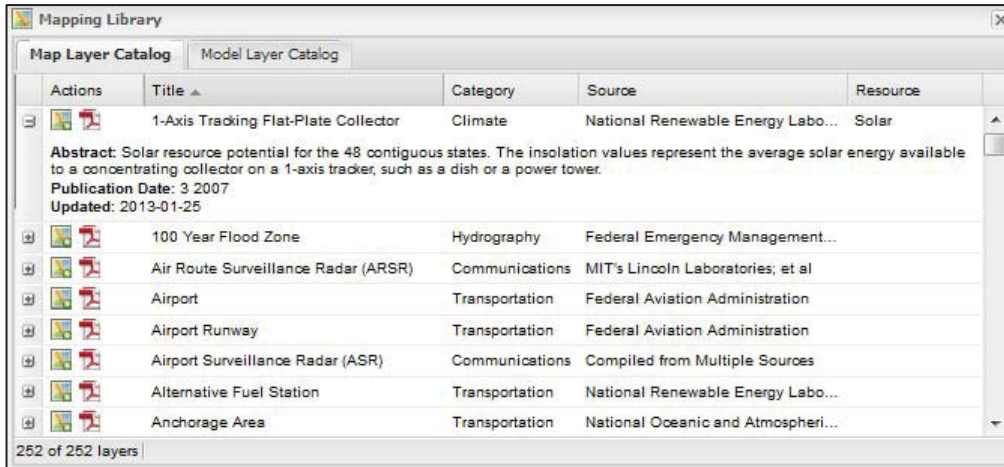
6.4 Layers

The default map shows a few base map options and the EISPC region, but more than 250 mapping layers are available in the tool.

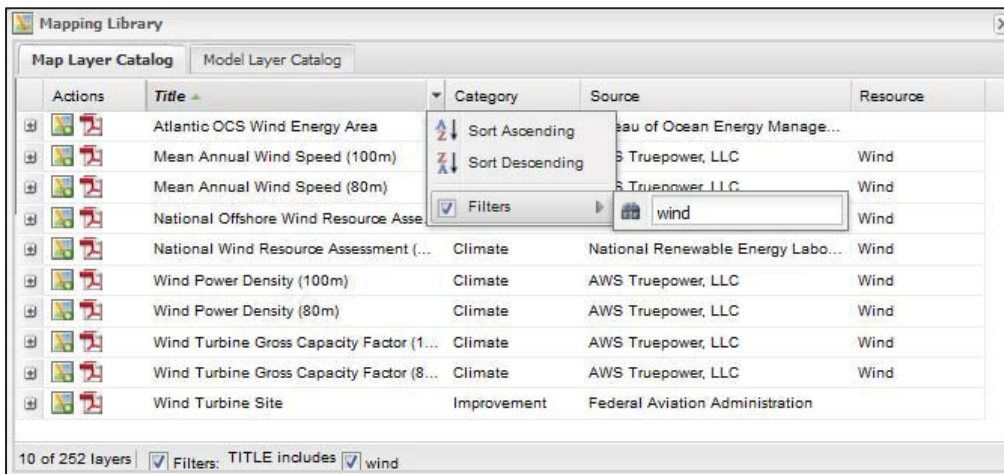
All other layers are added by using the icons in the *Main Menu* panel.



6.4.1 Adding Map Layers

- (1) Click the Library icon () in the upper left corner of the *Main Menu*.
- (2) A dialog opens, displaying all of the layers contained in the *Map Layer Catalog*. Click on the plus (+) next to a layer name to display the abstract, publication date, and last date the layer was updated.



- Place the cursor over a heading (*Title*, *Category*, *Source*, or *Resource*) and a down arrow appears to the right of the heading name. Click the down arrow to sort or filter the list. The *Category* and *Resource* columns list all possible options to sort by. Click the filters that you wish to use. The *Title* and *Source* columns allow you to choose a filter term. Place the cursor over *Filters* and type a word in the box that appears. You can remove the filters by unchecking the boxes at the bottom of the dialog.



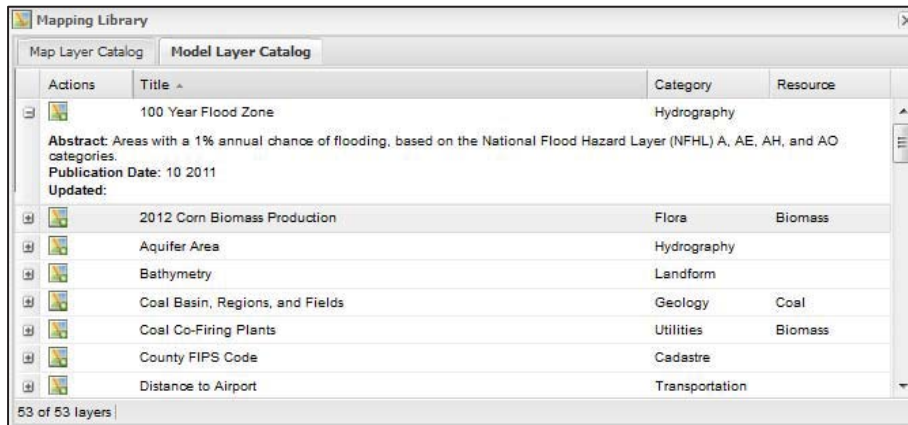
- Click the Map icon () to add the layer to the map. It will also be listed in the *Overlays* section of the *Map Contents* dialog.
- If you would like to see the metadata for a particular layer, click on the PDF icon () next to the layer name. A PDF will open containing the metadata for that layer.

6.4.2 Adding Model Layers

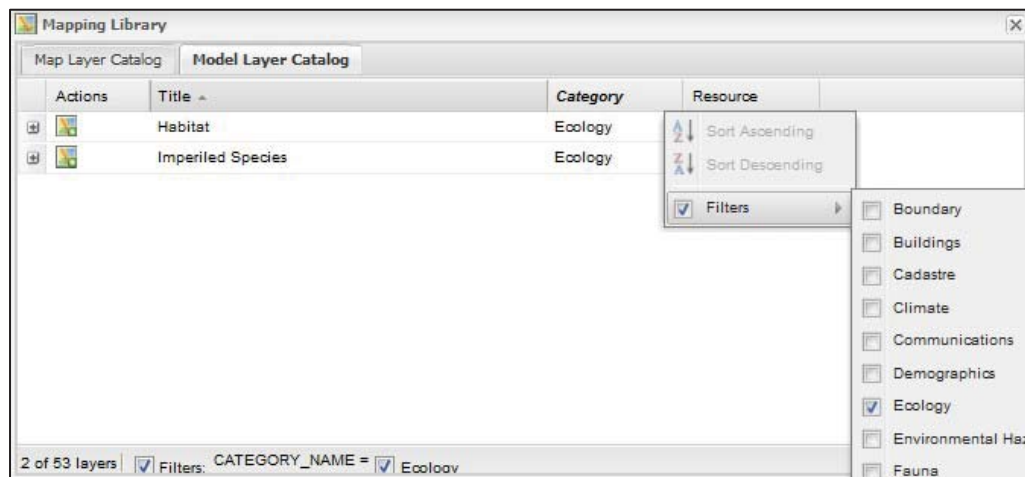
- (1) If you are interested in viewing the screening layers for a particular model, click the

Library icon () in the upper left corner of the *Main Menu*.

- (2) In the Mapping Library dialog, click the *Model Layer Catalog* tab. Click on the plus (+) next to a layer name to display the abstract, publication date, and last date the layer was updated.



- (3) Place the cursor over a heading (*Title*, *Category*, or *Resource*) and a down arrow appears to the right of the heading name. Click the down arrow to sort or filter the list. The *Category* and *Resource* columns list all possible options to sort by. Click the filters that you wish to use. The *Title* column allows you to choose a filter term. Place the cursor over *Filters* and type a word in the box that appears. You can remove the filters by unchecking the boxes at the bottom of the dialog.



- (4) Click the Map icon () to add the layer to the map.

(5) The selected layer is added to the *Map Contents* panel.






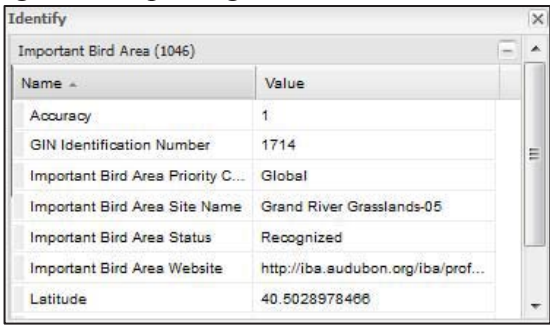

6.4.3 Removing Layers



- To remove a layer from the map but keep it in the *Map Contents* panel, uncheck its box.
- To remove a layer from the map and the *Map Contents* panel, right-click the layer name and then click Remove layer (red circle with white minus sign). This does not permanently remove the layer from the application, but only from your *Map Contents* panel. To add the layer again at a later time, repeat the steps under [Layers](#).

6.5 Using the Map Tools





The map tools are located at the top of the map and allow you to navigate the map.




	<i>Zoom to Max Extent</i>	Click to display the map at its maximum extent (i.e., zoom out as far as possible).
	<i>Zoom by Dragging</i>	When active, click or click-and-drag on the map to zoom to the selected area. Click the icon again to stop zooming.
	<i>Zoom In</i>	Click to zoom in one level on the map.
	<i>Zoom Out</i>	Click to zoom out one level on the map.
	<i>Identify</i>	<p>When active, click a feature on the map to retrieve more information about that specific feature. If there is more than one layer or feature at the click point, the information for each one will be listed in the results. Click the <i>Identify</i> tool icon again to stop using it.</p> 
	<i>Zoom to Previous Extent</i>	Return to the previous zoom level/view.

	<i>Zoom to Next Extent</i>	Go to the next zoom level/view (after going to Previous Extent).
	<i>Measure</i>	Click the black down arrow, choose Length or Area, then click the map to draw a polygon to measure. Click once to draw each point on the line (Length) or polygon (Area). To complete the polygon, double click. Click the Measure tool again to stop measuring.

6.5.1 Map Navigation

	<i>Pan Controls</i>	Use the pan controls to pan the map up and down, left and right.
	<i>Zoom In</i>	Click to zoom in one level.
	<i>Zoom Out</i>	Click to zoom out one level.
	<i>Zoom Slider</i>	Click and drag the slider to zoom in (up) and out (down).

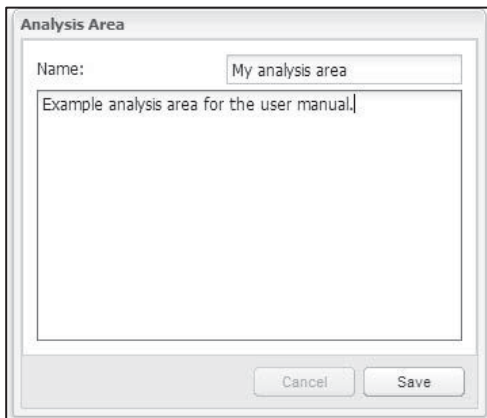
6.6 Creating an Analysis Area






- (1) Click the Areas/Corridors icon () in the *Main Menu* panel. The *Analysis Areas and Corridors* dialog opens.



- (2) Click the New Analysis Area icon () *New Analysis Area*).


- (3) Add an analysis area to the map by clicking the mouse once for each point and double-clicking to complete the analysis area. Then the *Analysis Area* dialog will open to assign a name and notes for the analysis area.




- (4) Click **Save**. The analysis area will be listed in the *Analysis Areas and Corridors* dialog. To display the analysis area on the map, click the box next to *My Analysis Areas/Corridors* in the *Overlays* section of the *Map Contents* panel. A shaded region will then appear on your map. The analysis area can now be chosen in the *Choose Region* drop down when you run a report (See [Running a Report](#) for instructions).
- (5) There are several actions to choose in the *Actions* column of the *Analysis Areas and Corridors* dialog.
- The Show/Hide Area icon () controls whether individual analysis areas or corridors are shown on the map.
 - The Magnifying Glass icon () zooms the map to the analysis area or corridor.
 - The Run Report icon () runs a report on that analysis area or corridor (see [Running a Report](#)).
 - The Edit icon () allows the name and notes for analysis areas and corridors to be edited and also allows the user to copy and revise the analysis areas and corridors on the map.
 - The Delete icon () permanently deletes the analysis area or corridor.

6.7 Creating a Corridor

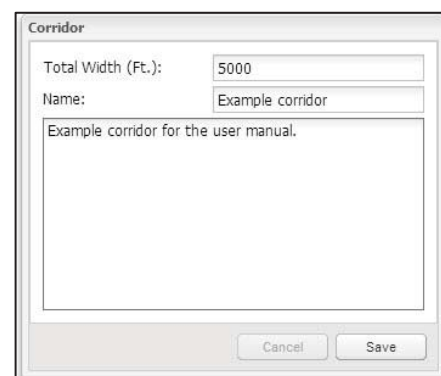







- (1) Click the Areas/Corridors icon () in the *Main Menu* panel. The *Analysis Areas and Corridors* dialog opens.



- (2) Click the New Corridor icon ().
- (3) Add a corridor centerline to the map by clicking the mouse once for each point and double-clicking the last point to complete the centerline. Then the *Corridor* dialog will open to assign a name and notes for the corridor.

- (4) Click **Save**. The corridor will be listed in the *Analysis Areas and Corridors* dialog. To display the corridor on the map, click the box next to *My Analysis Areas/Corridors* in the *Overlays* section of the *Map Contents* panel. The corridor will then appear on the map with the width shown as a shaded area around the centerline. The corridor can now be chosen in the *Choose Region* drop down when you run a corridor report (See [Running a Report](#) for instructions).





- (5) There are several actions to choose in the *Actions* column of the *Analysis Areas and Corridors* dialog.
 - The Show/Hide Area icon () controls whether individual analysis areas or corridors are shows on the map.
 - The Magnifying Glass icon () zooms the map to the analysis area or corridor.
 - The Run Report icon () runs a report on that analysis area or corridor (see [Running a Report](#)).
 - The Edit icon () allows the name and notes for analysis areas and corridors to be edited, and also allows the user to copy and revise the analysis areas and corridors on the map.
 - The Delete icon () permanently deletes the analysis area or corridor.

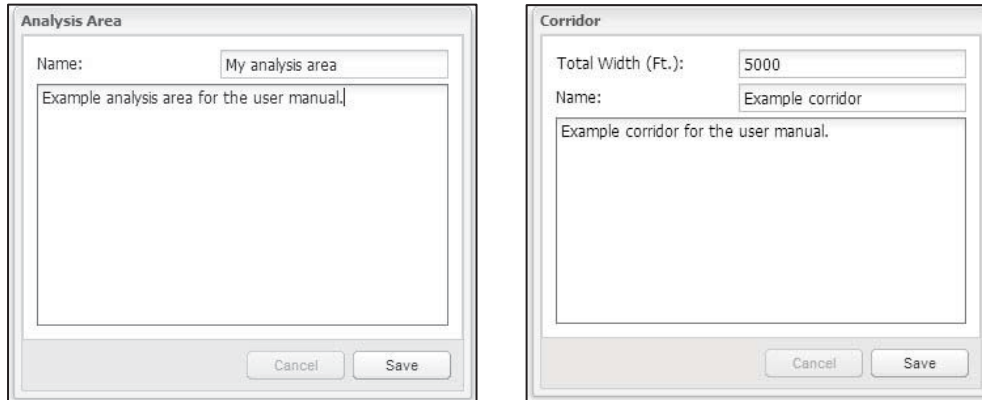
6.8 Copying and Revising Analysis Areas and Corridors

In some cases, it is useful to copy and revise an analysis area or corridor to investigate alternate extents. For example, if a potential issue is found along a corridor route, an adjustment to the centerline or width might avoid the issue.

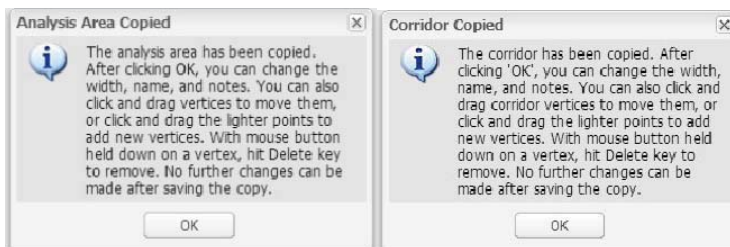


- (1) Click the Areas/Corridors icon () in the *Main Menu* panel. The *Analysis Areas and Corridors* dialog opens.

- (2) Click the Edit icon () for the analysis area or corridor to be copied and revised.
- (3) Depending on whether an analysis area or corridor is chosen, the *Analysis Area* or *Corridor* dialog will open, with **Copy** button added.

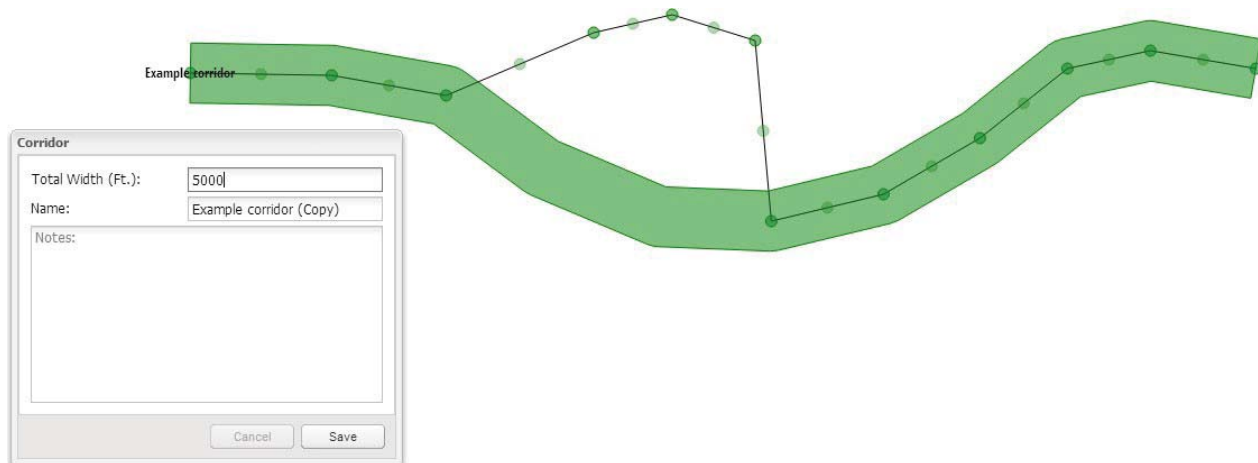


- (4) Clicking **Copy** displays one of the instructional dialogs shown below. Click **OK**.

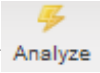


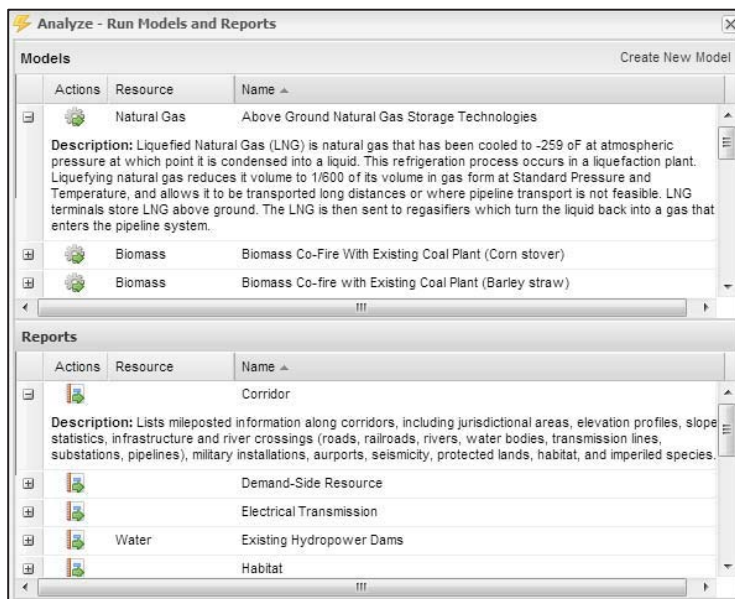
- (5) Until you click **Save** in the main dialog, you can change the name and notes, change the width for corridors, and edit the analysis area boundary or corridor centerline on the map. On the map, edit handles are shown at each point making up the analysis area or corridor centerline. Click and drag these handles to move them. Midway between each point are lighter handles. Clicking and dragging these handles adds a new point to the shape. To delete a point, hold down the mouse button over a handle and hit the Delete key. Click **Save** when you are finished making changes.


The image below shows an example of a corridor being revised.

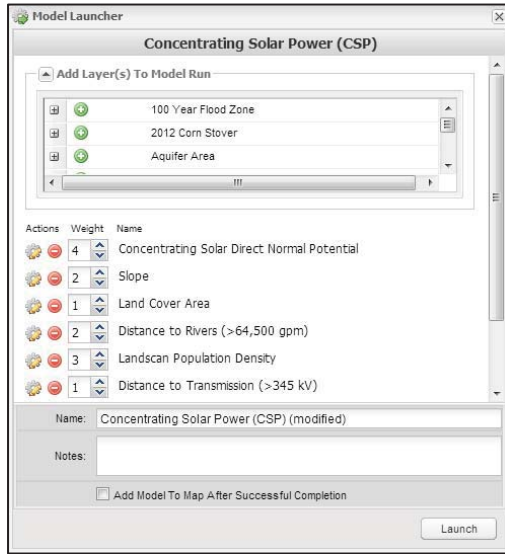





6.9 Running a Model

- (1) Click the Analyze icon () in the *Main Menu* panel to open the *Analyze – Run Models and Reports* dialog. All of the available models are listed in the *Models* section of the dialog. Click on the plus (+) next to a model name to display a description of that model.



- (2) Click on the Run Model icon () to the left of the model name to open the *Model Launcher*.



- (3) The default screening layers and weights are displayed in the *Model Launcher* dialog. These settings are based on the recommendations of subject matter experts familiar with the technology being modeled, but should be reviewed and revised by individual users to meet their analysis goals and assumptions. Clicking the down arrow next to *Add Layer(s) To Model Run* displays a list of additional screening layers that can be added to your model run by clicking the Add Layer icon () next to the layer name. If desired, adjust the relative weights given to each screening layer by increasing or decreasing the numbers to the left of the layer names from 1 to 10, with 1 meaning that the layer should be given the smallest possible influence on the model and 10 meaning that the layer should be given the highest possible influence on the model. You can also remove a screening layer from the model run by clicking the Remove Layer icon ().
- (4) To inspect or adjust the suitability values within a screening layer, click on the Edit Suitability Settings icon () to the left of the layer name. The *Suitability Adjustment* dialog opens. To adjust suitability values for one of the ranges in a screening layer, type a value or use the arrows. Suitability values range from 0 (unsuitable) to 100 (most suitable). Click **Save** if you have made changes you want to keep, or **Cancel**, to return to the *Model Launcher* dialog.


Suitability Adjustment: Distance to Transmission (>345 kV)

Description: Distance in miles to nearest overhead or underground electric transmission line with at least 345kV capacity, based on Bentek Energy/Platts data.

Suitability	Range in Distance (miles)
100	No data
100	0 - 5
75	6 - 10
50	11 - 15
25	16 - 20
5	21 - 50
1	51 - 100000

Cancel Save

- (5) If you would like to view a screening layer listed in the *Model Launcher* dialog on the map, you can add it using the *Model Layer Catalog* (see [Adding Model Layers](#)).
- (6) Change the default name of the model and add any notes about the model run by typing in the boxes at the bottom of the *Model Launcher* dialog.
- (7) When you have finished customizing your model run, click **Launch**. You can view the

status of your model run by clicking on the Results icon (). The *Analysis Results* dialog will open. The status will be displayed as an hourglass while the model is running and a check mark when the model is complete.







The *Analysis Results* dialog also lists default versions of each model as System runs. You can add these model results to the map and view them without having to run the model.

Analysis Results

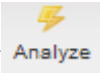
Actions	Type	Owner	Status	Name	Extent	Created
	Model	Me	✓	Concentrating Solar Pow...	ESPC Region	7/17/2013 1:20 PM
	Report	Me	✓	Corridor Report	ND Wilton (Copy)	7/17/2013 1:34 PM
	Model	System	✓	Geopressed (default)	ESPC Region	7/18/2013 8:01 AM
	Model	System	✓	Compressed Air Energy S...	ESPC Region	7/18/2013 8:01 AM
	Model	System	✓	Offshore wind turbine (S...	ESPC Region	7/18/2013 8:01 AM
	Model	System	✓	Land-based wind turbine	ESPC Region	7/18/2013 8:01 AM
	Model	System	✓	New Integrated Gasificati...	ESPC Region	7/18/2013 8:01 AM
	Model	System	✓	Marine Tidal hydrokinetic ...	ESPC Region	7/18/2013 8:01 AM
	Model	System	✓	Concentrating Solar Pow...	ESPC Region	7/18/2013 8:02 AM
	Model	System	✓	High-Temperature Gas-co...	ESPC Region	7/18/2013 8:01 AM
	Model	System	✓	New Coal Fluidized Bed (...)	ESPC Region	7/18/2013 8:02 AM
	Model	System	✓	Biomass Co-Fire With Exi...	ESPC Region	7/18/2013 8:02 AM
	Model	System	✓	New Biomass-fired Plant	ESPC Region	7/18/2013 8:02 AM

Refresh

(8) There are several actions to choose from in the *Actions* column of the *Analysis Results* window.

- The Add Results icon () allows you to add model results to the *Map Contents* panel and the map.
- The Run Report icon () allows you to run a Model Results Report on that model.
- The Report Results icon () allows you to display the generated report.
- The Modify Model icon () opens up the *Model Launcher* dialog with the model settings saved. The settings can be revised and run as a new model.
- The Edit icon () allows you to edit the name and notes for a personal model run.
- The Delete icon () allows you to permanently delete personal model runs.




6.10 Running a Report


- (1) Click the Analyze icon () in the *Main Menu* panel. The *Analyze – Run Models and Reports* dialog opens. All of the available reports are listed in the *Reports* section of the dialog. Click on the plus (+) next to a report name to display a description of that report.

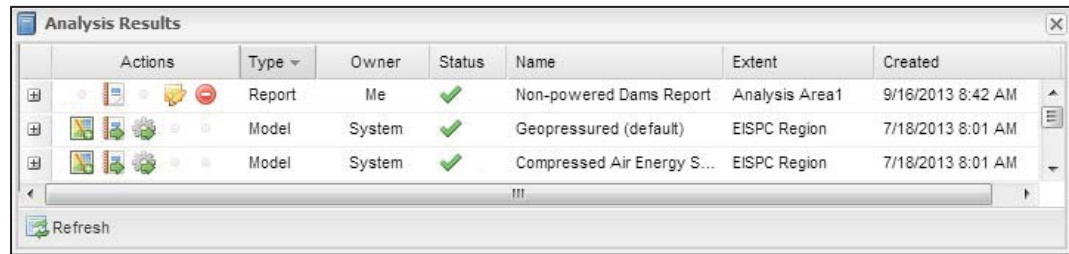


- (2) Select a report by clicking on the Run Report icon () to the left of the report name. The *Report Run Launcher* dialog opens.

Note: The Corridor report can only be run for corridors.

- (3) In the *Region* section of the *Report Run Launcher* dialog, use the *Type* drop-down menu to choose whether to run a report on an analysis area, corridor, state, or county. Then use the subsequent drop-down menu to select the specific choice within that group that you would like to run your report on.
- (4) Contents of the *Parameters* section vary, depending on the report. For the report shown, two buffer distances can be specified around the analysis area.
- (5) You can change the default name of the report and add any notes about the report by typing in the boxes at the bottom of the *Report Run Launcher* dialog.
- (6) When you have finished customizing your report run, click **Launch Report**. You can view the status of your report run by clicking on the Results icon (). The *Analysis Results* dialog will open. The status will be displayed as an hourglass while the report is running, and a check mark when the report is complete.
- (7) There are several actions to choose from in the *Actions* column of the *Analysis Results* dialog.
 - The Display Report icon () allows you to view your report in a new browser tab.
 - The Edit icon () allows you to edit the name and notes for your report.

The Delete icon () allows you to permanently delete your report.



6.11 Exiting the Mapping Tool

To exit the mapping tool, simply close the browser window or tab, or click **Logout** in the upper right-hand corner of the screen. Your layers in your *Map Contents* panel as well as your model runs and reports are saved as you work and can be accessed the next time you log in to the EISPC EZ Mapping Tool.

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7 Case Studies and Interpreting Results

This section discusses several case examples that demonstrate the numerous ways the EZ Mapping Tool can be used. Section 7.1 includes an example of running models for both CSP and new clean coal technologies, and it explains how to find a synergy between them. Section 7.2 investigates using the environmental data in the tool to quickly determine whether a possible EZ has protected land or habitat nearby. Practical use of geothermal geopressed technology is discussed in Section 7.3, and Section 7.4 describes a corridor report use case example.

7.1 Concentrating Solar Power Co-sited with New Pulverized Coal Synergy Case

A hypothetical, synergistic example of using the EZ Mapping Tool can be seen when investigating the possibility of co-locating two technologies, such as CSP and a clean coal technology. The plant uses the CSP portion to preheat or create steam, which is then used in the coal plant to generate electricity.

The EZ Mapping Tool can be used to help identify regions where this technology may be feasible to implement. In this example, a new PC plant with CCS technology is considered coupled with a CSP plant located on site. The PC model uses a layer that represents the proximity to geologic formations that are considered suitable to store CO₂. This unique coupling of technologies creates a low-carbon-emission power plant.

To begin, a model representing the PC technology is run. The user has a choice between accepting the default configuration of the model, which has been determined by technology experts for this energy resource, or modifying the weighting and suitability scheme in the tool. In this example, the default configuration will suffice. Regionally, the results of the suitability display show that the highest valued areas are near Indiana, eastern Kansas, eastern Arkansas, and eastern Ohio, primarily due to the saline aquifer layer that allows for the CO₂ to be stored.

Running the CSP model indicates that the southwestern part of the Eastern Interconnection is most highly suited. The solar insolation values are the highest there, which is the driving force of the CSP model. Other factors aid in screening out areas where other resources, such as water, are not available in sufficient quantities, or physical characteristics, such as geographical slope, do not allow for the development of this technology.

The results of the two models can be run through a function of the tool that allows for areas of best overlap to be shown together (Figure 7-1). This allows two or more technologies to be co-located together. Weights can be assigned to the suitability inputs that can prioritize a given technology. In this example, the CSP model is given a two-to-one preference over the coal technology. The area with greatest synergy is seen in eastern Kansas.

In the synergy presented here, areas outside of the preferred region are incompatible, or listed as marginally suitable due to the physical constraints of the technology requirements. Both CSP and clean coal technologies require a supply of water for their operation. In this case, the PC coal technology is assumed to require 12,500 gallons per minute (gpm) of water and the CSP

Concentrating Solar Power j New Pulverized CoalSynergy

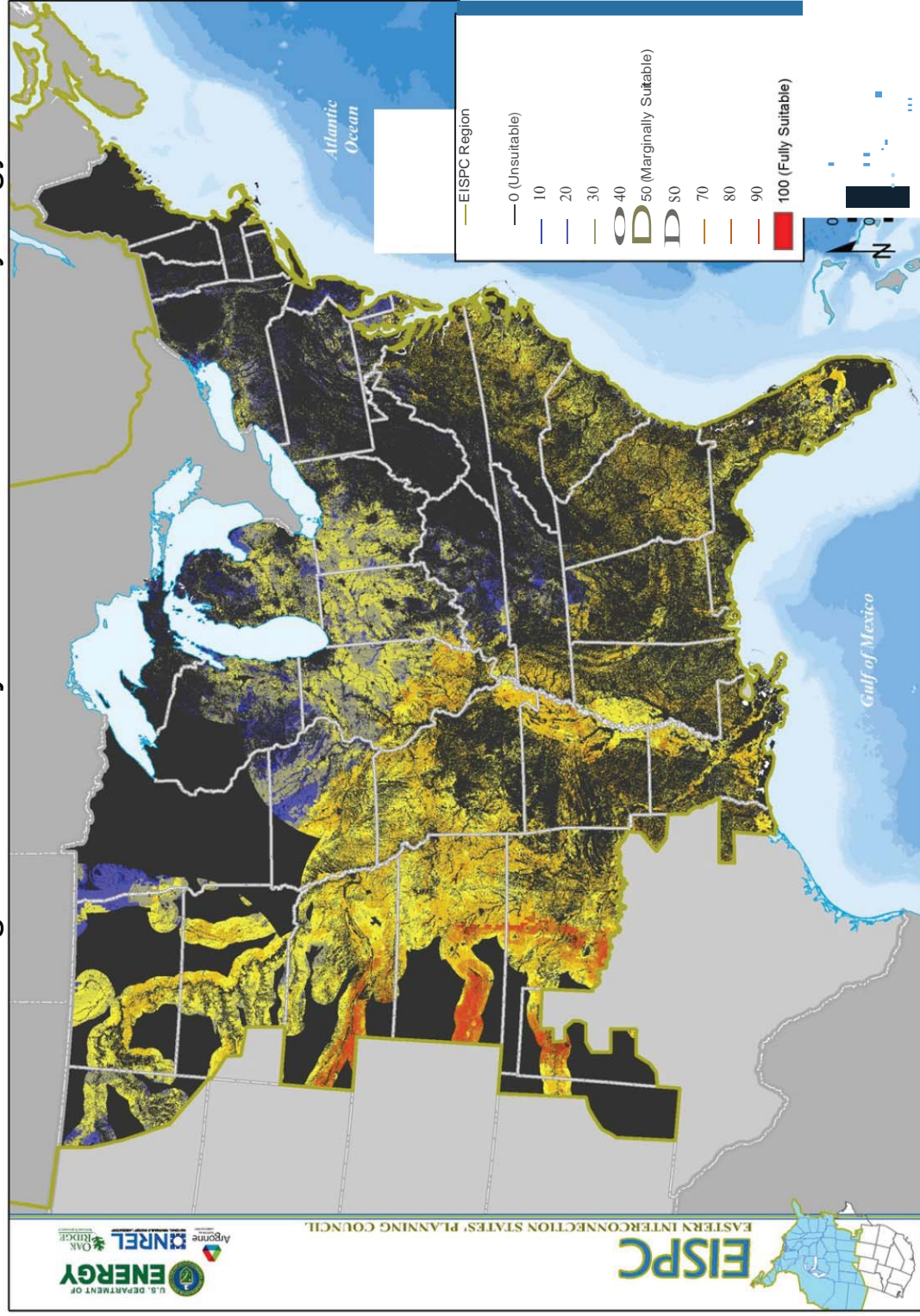


Figure 7-1 Example Synergy between Concentrating Solar Power and Clean Coal Power Technologies

technology would require 6,400 gpm. These are sourced from 125,000- and 64,000-gpm rivers respectively, assuming a 10% output withdraw. Because the coal plant requires a larger amount of water and the CSP plant would be utilizing this same water and not requiring additional water, the water layer was removed from the CSP model.

Further analysis of the synergistic areas could be investigated by using the various reporting options available in the EZ Mapping Tool. Some reports that may be of interest in this application are the transmission, protected lands, habitat, and imperiled species reports. The policies and regulations database search on the website is also valuable for further analysis.

7.2 Environmental Investigation Case

Using several built-in functions of the EZ Mapping Tool, a user can incorporate environmental factors into the process of identifying a suitable EZ. The environmental components of the EZ Mapping Tool include a large library of environmental layers, three composite environmental screening layers that the user can incorporate into any suitability model, and three environmental reporting tools.

There are two ways to view environmental data layers in the EZ Mapping Tool: the original data as they arrived from the various sources, or a composite overlay that combines the original datasets and ranks them based on their sensitivity to energy development. When viewing the original layers on the map, additional attribute information can be viewed about specific areas by using the “Identify” tool. This is not accessible with the composite graphic; only the sensitivity categorization is shown in the composites. Section 4.2 details the process of making these composite layers.

Running a resource model will make use of the three environmental composite layers by default. The weights that are assigned to these three layers were suggested by technology experts and provide a reasonable reflection of their importance in respect to the other layers in the model. In this example, an 80-m land-based wind model is run with a low importance assigned to the environmental layers. It is then contrasted with a suitability run (Figure 7-2) using a high environmental importance. Table 7-1 shows the different model run parameters for each composite environmental layer.

When searching for an EZ, it is important to run a model multiple times to favor different aspects of the model in order to see how each layer influences the outcome. For example, Figure 7-2 shows that some environmentally protected areas are harder to see with the default weight. The yellow linear feature that is visible in the highly weighted (right) version is most clearly defined as the environmental weights are increased; while it is evident the yellow parameter of the airport in the low-weighted model run disappears as the environmental layers are weighted more.

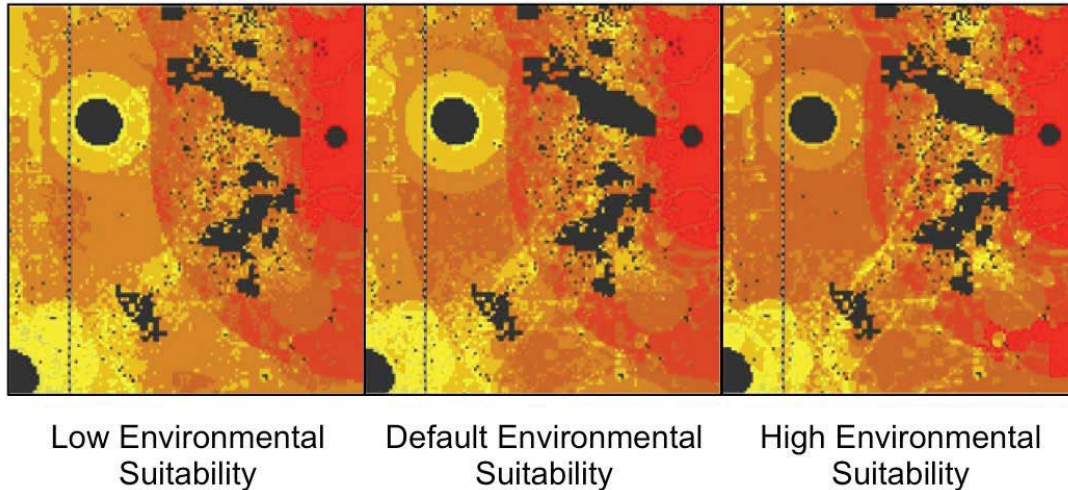


Figure 7-2 Suitability Map Showing Different Suitability Weights for the Three Environmental Layers (Red indicates highly suitable areas, orange is minimally suitable, and yellow areas are not suitable.)

Table 7-1 Adjusted Weights for Environmental Layers

Low Environmental Importance Layer	Weight	Default Environmental Importance Layer	Weight	High Environmental Importance Layer	Weight
Protected Lands	2	Protected Lands	3	Protected Lands	5
Habitat	1	Habitat	2	Habitat	4
Imperiled Species	2	Imperiled Species	3	Imperiled Species	5

After viewing the model results and understanding the significance of the environmental layers, the user may want to run the habitat, protected lands, or imperiled species reports on an area to learn more about why the area is environmentally sensitive. Each of these reports summarizes the occurrence of imperiled species or lists the datasets of the protected areas, or habitat, that was found in the analysis area. These provide a quick summary, which saves the user time by eliminating the need to manually go through and check each layer for conflicting areas. If an area needs to be investigated further, the original layers can be overlaid on the map. These layers will provide additional attribute details about the protected land or habitat area.

7.3 Geothermal Geopressured Case

The geothermal geopressured resource technology is one of the unique cases in the EZ Mapping Tool where the resource is concentrated in a specific region. The nature of geopressured energy relies on heat and fluid availability in the Earth's crust to generate hot water, or steam, which is then used to turn a turbine. In the Eastern Interconnection, the only area favorable for this unique geologic situation is along the Texas and Louisiana Gulf Coast.

The default configuration for this model shows areas suitable for utility-scale land-based geothermal plants. However, a significant portion of the resource is available offshore. The geopressedured model allows the user to choose between showing land-based or offshore areas using a “Land-based/Offshore” layer. The visibility of these areas can be adjusted to either show the region assigned a suitability above zero, or it will mask out a region assigned a suitability of zero. In this situation, the suitability of the layer is being used as a 100%/0% toggle, and so the layer weight is assigned a 1. The layer’s overall impact is not significant because it is a Boolean yes/no layer, and, as such, it is given the lowest possible model layer weight of one. Figure 7-3 illustrates land-based (left) or offshore (right) areas of the geopressedured model.

7.4 Corridor Report Use Case

Investigating a region in the western part of Nebraska provides an interesting hypothetical example of how to use the corridor reporting tool. Figure 7-4 shows suitability model results for land-based wind turbines with a 100-m hub height for Nebraska, with and without the proximity to transmission lines being included in the model (top and bottom, respectively). When proximity to transmission is removed from the model, new areas in northwest Nebraska (circled) are shown as suitable. This indicates that a primary limiting factor for wind turbine development in that area is electrical transmission. Extending transmission lines to that area may be appropriate.

A utility company in Omaha might want to investigate buying power from a hypothetical wind farm in northwest Nebraska. Figure 7-5 shows existing electrical transmission lines of 345 kV or greater in Nebraska, and the analysis area of interest. Few high-voltage transmission lines exist in that part of the state.

To investigate the characteristics of a potential corridor from Energy Zone 1 to Omaha, a corridor was added (Figure 7-6). A width of 1,000 ft was used for the corridor.

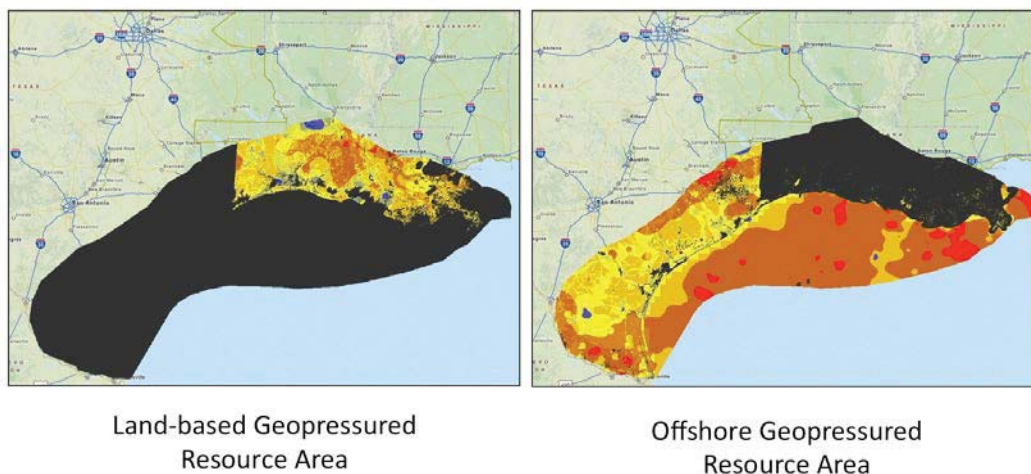


Figure 7-3 Suitability Map Showing Land-Based (left) and Offshore Geopressedured Resource Areas (Note: Red indicates highly suitable areas, orange is minimally suitable, and yellow areas are not suitable.)

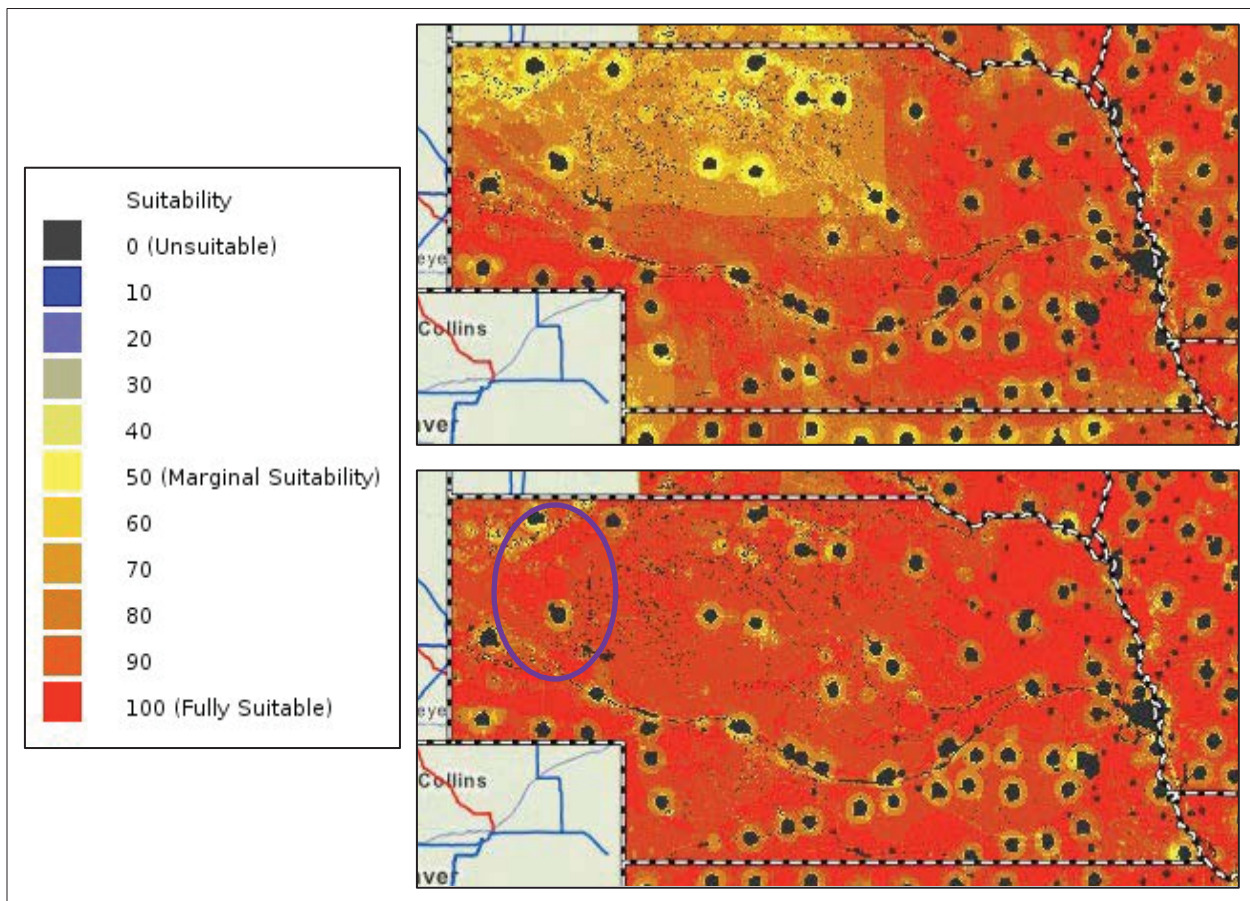


Figure 7-4 Comparison of Default Wind Turbine Model Results (top), and with the Proximity to Electrical Transmission Siting Factor Removed (bottom)

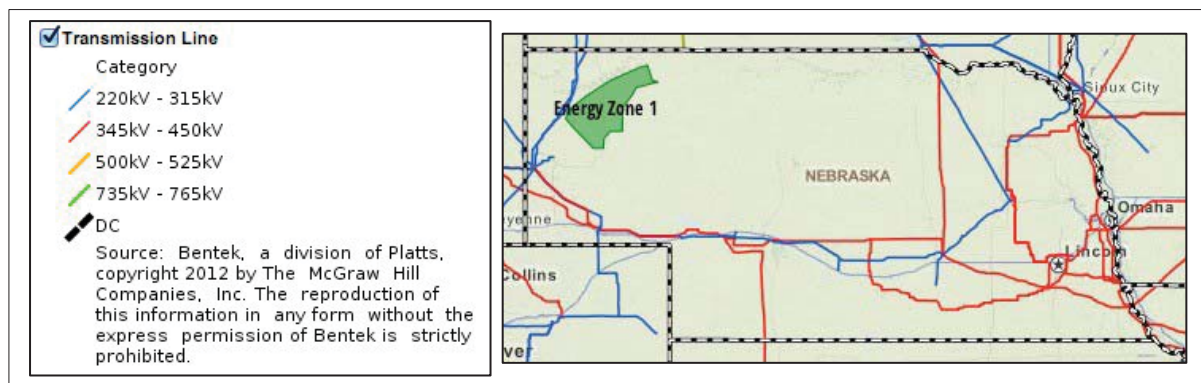


Figure 7-5 Existing Electrical Transmission Lines in Nebraska and a Hypothetical Energy Zone



Figure 7-6 Map Displaying a Hypothetical Transmission Corridor (green line) from Energy Zone 1 to Omaha, Nebraska

A corridor report generated from the corridor in Figure 7-6 provides a quick summary of potential issues that may be encountered within its extent. It shows that the corridor is 354 mi long and crosses 16 counties. The elevation difference is 923 ft from the highest (west) to lowest (east) point. Features crossing the corridor include roads, railroads, rivers, water bodies, existing electrical transmission lines, substations, pipelines, airports, military areas, and earthquake peak ground acceleration factors are listed. Environmental factors, including protected lands, habitat, and imperiled species are summarized at the end of the report. The report indicates numerous places where the analyzed corridor crosses areas marked as “develop with extreme caution” for protected lands. This layer can be added to the map and investigated for opportunities to revise the corridor route to reduce the potential impacts in this category. In the interface, a corridor can be duplicated and the route revised to avoid an issue identified by the initial corridor report. Figure 7-7 shows an example of revising a corridor to avoid an identified issue.

Running the report on the revised corridor route will show the effect of routing around this particular issue, and whether new issues occur in the changed area. The corridor report is also intended for screening level assessment of oil and natural gas pipeline corridors.

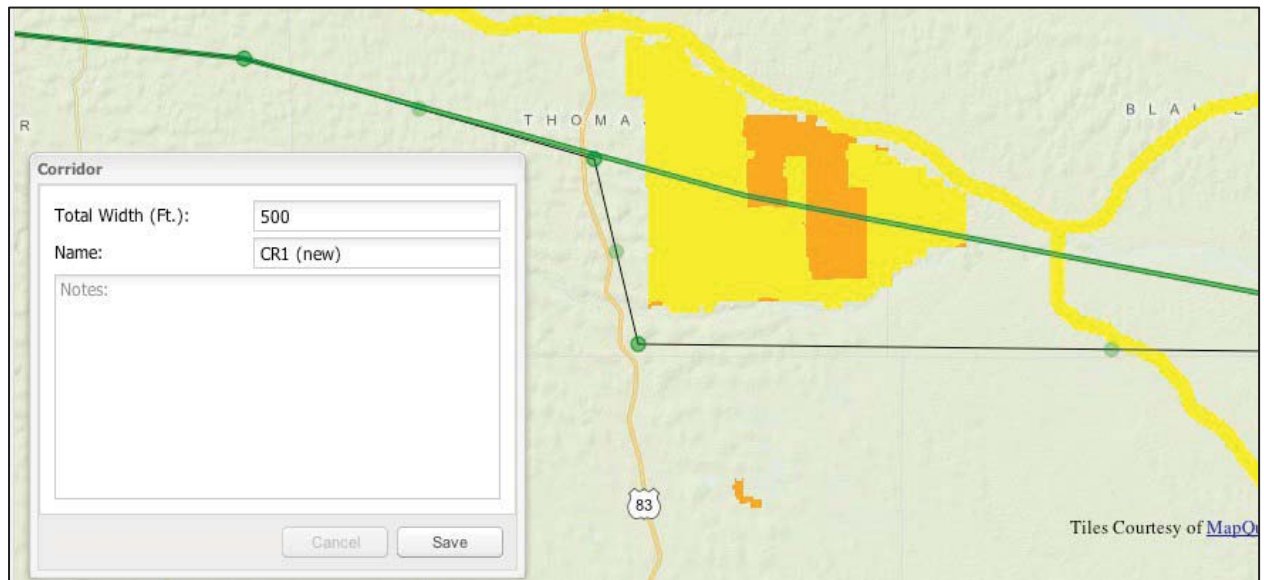


Figure 7-7 Map Showing a Revised Corridor Path (black) to Avoid Crossing a Sensitive Wildlife Area (yellow and orange).

8 Recommendations for Future Work

The following recommendations for future work cover two broad areas: (1) enhancements to the EZ Mapping Tool itself, and (2) planning applications where the tool’s capabilities could provide additional insight and transparency. Both these areas provide opportunities to link the work of EISPC with companion work conducted by the EIPC.

A key element of any future work using the EZ Mapping Tool is to continue the planning work of EISPC itself. The purpose guiding the development of the tool is to aid “the development of coordinated State electricity policies, programs, laws, and regulations,” as stated in the American Recovery and Reinvestment Act. The National Association of Regulatory Utility Commissioners (NARUC) is the awardee for Recovery Act funding focusing on policy coordination in the Eastern Interconnection, working through EISPC. Keeping the EZ Mapping Tool consistent with its original purpose and expanding its use and applications by EISPC members and other stakeholders will greatly depend on the continued engagement of NARUC and EISPC.

8.1 Enhancements

Specific tool enhancements could include the following:

- Regular updates of resource data, the policy inventory, and the addition of new data layers identified by EISPC and other users as available and relevant.
- More detailed screening analysis of potential energy corridors, including developing models that use screening factors to create a suitability surface map and optimization techniques to compute the best path connecting two locations specified by the user. The optimization routine would avoid sensitive ecological areas and other protected lands and attempt to minimize the overall path distance and other factors such as close proximity to densely populated areas and large river crossings.
- Development of a model for identifying areas suitable for smaller natural gas combined-cycle plants (250–500 MW) in populated areas at industrial or brownfield locations, including existing power plants that might be repowered.
- Development of models for estimating electricity generation potential of certain clean energy technologies within an analysis area.
- Development of models to analyze an optimal mix of generating resources and the number of power plants that can be located within a selected analysis area.
- Addition of wind resource layers showing the temporal characteristics of wind power in a given location (i.e., seasonal profiles and diurnal profiles).

- Enhancement of models to account for zone contiguity (i.e., eliminate areas computed as otherwise suitable but too small and too isolated from other suitable areas to accommodate a project).
- Ability to upload new GIS layers for individual users, groups of users, or all users.
- Enhancements to facilitate virtual collaboration, such as sharing models and analysis areas among different users.
- Integration of policy data as a map layer to allow users to include relevant policy information in reports.

More complex enhancements could include layers showing current load, load growth, the potential for distributed resources in addition to rooftop solar, current and future water consumption needs for electricity generation, potential load changes due to energy efficiency, and potential load changes resulting from increased use of electric vehicles.

8.2 Planning Applications

EIPC's final report suggests a number of planning applications using the mapping tool. For example, EIPC projected that about 728 TWh of new generation would come from wind power under its scenario that assumes nationally implemented federal carbon constraints, increased energy efficiency, and increased demand response. The EZ Mapping Tool could complement this projection by identifying where 728 TWh could be generated with the least amount of capital investment and the least environmental impact. In addition, the tool could be used to perform a screening analysis of potential pathways for new transmission lines. Case studies could be conducted for all three EIPC scenarios for wind, other renewables, combined-cycle gas generators, and peakers.

Other potential planning applications could include:

- Mapping the location of flexible generating resources, such as pumped hydro and compressed-air energy storage, in relation to variable renewable resources (wind and solar).
- Identifying environmental and land use impacts that could limit capacity expansion at sites with existing natural gas plants.
- Mapping and characterizing offshore wind resources in the Great Lakes region, their likely injection points, and their hourly coincidence with load.
- Identifying areas in the Great Plains region where wind potential has the highest capacity factors, the least environmental impact, and exists in the greatest geographic concentration.

- Identifying biomass zones in the Southeast and New England.
- Constructing renewable energy supply curves by state or other user-selected region, taking into account resource energy potential, environmental and other land use constraints, capacity factor gradients, and other factors likely to affect cost.
- Measuring and mapping the reduction in wind potential when assuming stringent rather than moderate habitat avoidance criteria.
- Validating modeled results against existing project locations.

These examples of EZ Mapping Tool applications can support a broader goal: to facilitate strategic planning throughout the Eastern Interconnection. Many of the issues and risks confronting long-term electric delivery in the Eastern Interconnection extend beyond traditional short-term operational planning. They require examining risk and uncertainty over a 20-year time frame or longer, and many of the solutions are regional and inter-regional rather than local. The tool can help states collaboratively examine common risks and opportunities, providing utilities with an impetus to engage in their own long-term strategic planning.

In some applications, the EZ Mapping Tool could supplement other analytical tools such as production cost models and capacity expansion models. Examples include consolidated planning (i.e., combining smaller transmission projects into one higher-voltage project to take advantage of economies of scale), energy corridor analysis, the temporal mismatch between the development of new generation and new transmission, and other issues.

Expanding the tool to include the Western Interconnection, Texas Interconnection, and the Canadian portions of the Eastern Interconnection would be a logical next step and desirable extension of this work. While technically feasible, expanding the tool's geographic coverage would require scoping decisions that are beyond the original purpose of Recovery Act funding used for this project. Such issues are more appropriately explored by NARUC and its peer organizations, in collaboration with DOE.

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Appendix A: Screening Factors

The specific default suitability criteria and ranges for each screening parameter for the models contained in the EZ Mapping Tool are listed below. The suitability scale ranges from zero to 100 with zero being unsuitable and 100 being most-suitable. The weights listed for each screening parameter range from 1 to 10, with 1 representing the lowest importance and 10 representing the highest importance.

Biomass Co-Firing with Coal

2012 Corn Stover Production			
Weight: 8		(Dry tons per sq. mile)	
Minimum	Maximum	Suitability	
0	100	0	
101	250	1	
251	500	20	
501	1000	40	
1001	1500	50	
1501	2000	75	
2001	2500	100	
2501	3000	100	
3001	3500	100	
3501	100000	100	

Distance to Coal Plants with Biomass Cofiring			
Weight: 3		(Miles)	
Minimum	Maximum	Suitability	
0	5	100	
6	10	90	
11	20	80	
21	30	70	
31	40	60	
41	50	50	
51	60	1	
61	100000	0	


Slope			
Weight: 2		(Percent)	
Minimum	Maximum	Suitability	
0	2	100	
3	4	100	
5	6	100	
7	8	90	
9	10	80	
11	12	50	
13	14	25	
15	16	1	
17	18	0	
19	20	0	
21	30	0	
31	10000	0	

Surface Water Flow (>2,000 GPM)			
Weight: 3		(Miles)	
Minimum	Maximum	Suitability	
0	1	100	
2	2	85	
3	5	70	
6	10	50	
11	20	20	
21	50	1	
51	100000	0	


Landscan Population Density			
Weight: 2		(People per sq. km)	
Minimum	Maximum	Suitability	
0	100	100	
101	150	75	
151	200	50	
201	300	25	
301	400	0	
401	500	0	
501	100000	0	


Distance to Railroad			
Weight: 5		(Miles)	
Minimum	Maximum	Suitability	
0	25	100	
26	50	100	
51	75	100	
76	100	75	
101	125	50	
126	100000	0	


Distance to Major Roads			
Weight: 1		(Miles)	
Minimum	Maximum	Suitability	
0	5	100	
6	10	80	
11	15	50	
16	20	1	
21	30	1	
31	100000	1	


100 Year Flood Zone		
Weight: 1		
Category		Suitability
A		0
AE		0
AH		0
AO		0

Protected Land		
Weight: 3		
Category		Suitability
Likely low conflict area		95
Develop with caution		40
Develop with extreme caution		20
Exclude from development		0

Distance to Port			
Weight: 1 (Miles)			
Minimum		Maximum	Suitability
0		1	100
2		3	75
4		5	50
6		10	5
11		20	5
21		100000	1

Habitat		
Weight: 3		
Category		Suitability
Likely low conflict area		95
Develop with caution		40
Develop with extreme caution		20

Distance to Transmission (>220 kV)			
Weight: 3 (Miles)			
Minimum		Maximum	Suitability
0		1	100
2		2	85
3		5	70
6		10	50
11		20	20
21		50	1
51		100000	0

Imperiled Species		
Weight: 3		
Category		Suitability
Low conflict area		95
Develop with caution		40
Develop with extreme caution		20

Biomass

2012 Wheat Straw Production			
Weight: 8		(Dry tons per sq. mile)	
Minimum	Maximum	Suitability	
0	50	0	
0	100	0	
101	200	10	
201	300	30	
301	400	50	
401	500	60	
501	600	70	
601	700	80	
701	800	90	
801	900	100	
901	1000	100	
1001	100000	100	

Slope			
Weight: 2		(Percent)	
Minimum	Maximum	Suitability	
0	2	100	
3	4	100	
5	6	100	
7	8	90	
9	10	80	
11	12	50	
13	14	25	
15	16	1	
17	18	0	
19	20	0	
21	30	0	
31	10000	0	

Surface Water Flow (>2000 GPM)			
Weight: 3		(Miles)	
Minimum	Maximum	Suitability	
0	1	100	
2	2	85	
3	5	70	
6	10	50	
11	20	20	
21	50	1	
51	100000	0	

Landscan Population Density			
Weight: 2		(People per sq. km)	
Minimum	Maximum	Suitability	
0	100	100	
101	150	75	
151	200	50	
201	300	25	
301	400	0	
401	500	0	
501	100000	0	

Distance to Railroad			
Weight: 5		(Miles)	
Minimum	Maximum	Suitability	
0	25	100	
26	50	100	
51	75	100	
76	100	75	
101	125	50	
126	100000	0	

100 Year Flood Zone		
Weight: 1		
Category		Suitability
A		0
AE		0
AH		0
AO		0

Distance to Port		
Weight: 1 (Miles)		
Minimum	Maximum	Suitability
0	1	100
2	3	75
4	5	50
6	10	5
11	20	5
21	100000	1

Distance to Transmission (>220 kV)		
Weight: 3 (Miles)		
Minimum	Maximum	Suitability
0	1	100
2	2	85
3	5	70
6	10	50
11	20	20
21	50	1
51	100000	0

Distance to Major Roads		
Weight: 1 (Miles)		
Minimum	Maximum	Suitability
0	5	100
6	10	80
11	15	50
16	20	1
21	30	1
31	100000	1

Habitat		
Weight: 3		
Category		Suitability
Likely low conflict area		95
Develop with caution		40
Develop with extreme caution		20

Imperiled Species		
Weight: 3		
Category		Suitability
Low conflict area		95
Develop with caution		40
Develop with extreme caution		20

Protected Land		
Weight: 3		
Category		Suitability
Likely low conflict area		95
Develop with caution		40
Develop with extreme caution		20
Exclude from development		0

Coal Fluidized Bed

Coal Basin Regions and Fields		
Weight: 5		
Category		Suitability
Inter-resource Area		50
Coal Resource		100

Distance to Saline Formation for CO2 Storage			
Weight: 5		(Miles)	
Minimum	Maximum		Suitability
0	25		100
26	50		90
51	75		80
76	100		70
101	125		60
126	150		50
151	175		40
176	200		30
201	225		20
226	250		10
251	100000		0

Slope			
Weight: 1		(Percent)	
Minimum	Maximum		Suitability
0	2		100
3	4		100
5	6		100
7	8		100
9	10		100
11	12		100
13	14		85
15	16		75
17	18		65
19	20		50
21	30		10
31	10000		0

Land Cover Area		
Weight: 2		
Category		Suitability
Unclassified		50
Open Water		0
Perennial Snow/Ice		0
Open Space		50
Developed Low Intensity		50
Developed Medium Intensity		10
Developed High Intensity		1
Barren Land		100
Deciduous Forest		70
Evergreen Forest		70
Mixed Forest		70
Shrub/Scrub		100
Herbaceous		100
Hay/Pasture		100
Cultivated Crops		100
Woody Wetlands		0
Emergent Herbaceous Wetlands		0

Distance to Rivers (>30000 GPM)			
Weight: 3		(Miles)	
Minimum	Maximum		Suitability
0	10		100
11	20		50
21	30		20
31	40		1
41	100000		0

Landscape Population Density			
Weight: 3		(People per sq. km)	
Minimum	Maximum		Suitability
0	100		100
101	150		75
151	200		50
201	300		25
301	400		0
401	500		0
501	100000		0

Distance to Railroad			
Weight: 1		(Miles)	
Minimum	Maximum	Suitability	
0	2	100	
3	4	75	
5	7	45	
8	10	10	
11	20	1	
21	100000	1	

Distance to Transmission (>345kV)			
Weight: 1		(Miles)	
Minimum	Maximum	Suitability	
0	5	100	
6	10	75	
11	15	50	
16	20	25	
21	50	5	
51	100000	1	

100 Year Flood Zone			
Weight: 1			
Category		Suitability	
A		0	
AE		0	
AH		0	
AO		0	

Protected Land			
Weight: 4			
Category		Suitability	
Likely low conflict area		95	
Develop with caution		40	
Develop with extreme caution		20	
Exclude from development		0	

Distance to Port			
Weight: 1		(Miles)	
Minimum	Maximum	Suitability	
0	1	100	
2	3	100	
4	5	50	
6	10	1	
11	20	1	
21	100000	1	

Habitat			
Weight: 4			
Category		Suitability	
Likely low conflict area		95	
Develop with caution		40	
Develop with extreme caution		20	

Imperiled Species			
Weight: 4			
Category		Suitability	
Low conflict area		95	
Develop with caution		40	
Develop with extreme caution		20	

Coal Integrated Gasification Combined Cycle

Coal Basin Regions and Fields		
Weight: 5		
Category		Suitability
Inter-resource Area		50
Coal Resource		100

Distance to Saline Formation for CO2 Storage			
Weight: 5 (Miles)			
Minimum	Maximum		Suitability
0	25		100
26	50		90
51	75		80
76	100		70
101	125		60
126	150		50
151	175		40
176	200		30
201	225		20
226	250		10
251	100000		0

Slope			
Weight: 1 (Percent)			
Minimum	Maximum		Suitability
0	2		100
3	4		100
5	6		100
7	8		100
9	10		100
11	12		100
13	14		85
15	16		75
17	18		65
19	20		50
21	30		10
31	10000		0

Land Cover Area		
Weight: 2		
Category		Suitability
Unclassified		50
Open Water		0
Perennial Snow/Ice		0
Developed Open Space		50
Developed Low Intensity		50
Developed Medium Intensity		10
Developed High Intensity		1
Barren Land		100
Deciduous Forest		70
Evergreen Forest		70
Mixed Forest		70
Shrub/Scrub		100
Herbaceous		100
Hay/Pasture		100
Cultivated Crops		100
Woody Wetlands		0
Emergent Herbaceous Wetlands		0

Distance to Rivers (>45,000 GPM)			
Weight: 3 (Miles)			
Minimum	Maximum		Suitability
0	10		100
11	20		50
21	30		20
31	40		1
41	100000		0

Landscape Population Density			
Weight: 3 (People per sq. km)			
Minimum	Maximum		Suitability
0	100		100
101	150		75
151	200		50
201	300		25
301	400		0
401	500		0
501	100000		0

100 Year Flood Zone	
Weight: 1	
Category	Suitability
A	0
AE	0
AH	0
AO	0

Distance to Railroad		
Weight: 1 (Miles)		
Minimum	Maximum	Suitability
0	2	100
3	4	75
5	7	45
8	10	10
11	20	1
21	100000	1

Distance to Port		
Weight: 1 (Miles)		
Minimum	Maximum	Suitability
0	1	100
2	3	100
4	5	50
6	10	1
11	20	1
21	100000	1

Distance to Transmission (>345kV)		
Weight: 1 (Miles)		
Minimum	Maximum	Suitability
0	5	100
6	10	75
11	15	50
16	20	25
21	50	5
51	100000	1

Protected Land	
Weight: 4	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20
Exclude from development	0

Habitat	
Weight: 4	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Imperiled Species	
Weight: 4	
Category	Suitability
Low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Pulverized Coal

Coal Basin Regions and Fields		
Weight: 5		
Category		Suitability
Inter-resource Area		50
Coal Resource		100

Slope			
Weight: 1 (Percent)			
Minimum	Maximum		Suitability
0	2		100
3	4		100
5	6		100
7	8		100
9	10		100
11	12		100
13	14		85
15	16		75
17	18		65
19	20		50
21	30		10
31	10000		0

Distance to Saline Formation for CO2 Storage			
Weight: 5 (Miles)			
Minimum	Maximum		Suitability
0	25		100
26	50		90
51	75		80
76	100		70
101	125		60
126	150		50
151	175		40
176	200		30
201	225		20
226	250		10
251	100000		0

Land Cover Area		
Weight: 2		
Category		Suitability
Unclassified		50
Open Water		0
Perennial Snow/Ice		0
Developed Open Space		50
Developed Low Intensity		50
Developed Medium Intensity		10
Developed High Intensity		1
Barren Land		100
Deciduous Forest		70
Evergreen Forest		70
Mixed Forest		70
Shrub/Scrub		100
Herbaceous		100
Hay/Pasture		100
Cultivated Crops		100
Woody Wetlands		0
Emergent Herbaceous Wetlands		0

Surface Water Flow (>125,000 GPM)			
Weight: 3 (Miles)			
Minimum	Maximum		Suitability
0	10		100
11	20		50
21	30		20
31	40		1
41	100000		0

Landsan Population Density			
Weight: 3 (People per sq. km)			
Minimum	Maximum		Suitability
0	100		100
101	150		75
151	200		50
201	300		25
301	400		0
401	500		0
501	100000		0

Distance to Railroad			
Weight: 1		(Miles)	
Minimum	Maximum	Suitability	
0	2	100	
3	4	75	
5	7	45	
8	10	10	
11	20	1	
21	100000	1	

100 Year Flood Zone	
Weight: 1	
Category	Suitability
A	0
AE	0
AH	0
AO	0

Distance to Port			
Weight: 1		(Miles)	
Minimum	Maximum	Suitability	
0	1	100	
2	3	100	
4	5	50	
6	10	1	
11	20	1	
21	100000	1	

Distance to Transmission (>345kV)			
Weight: 1		(Miles)	
Minimum	Maximum	Suitability	
0	5	100	
6	10	75	
11	15	50	
16	20	25	
21	50	5	
51	100000	1	

Protected Land	
Weight: 4	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20
Exclude from development	0

Habitat	
Weight: 4	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Imperiled Species	
Weight: 4	
Category	Suitability
Low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Enhanced Geothermal Systems

Enhanced Geothermal System Potential		
Weight: 8		
Category		Suitability
Most favorable		100
highly favorable		80
Moderately favorable		50
Less favorable		10
Least favorable		1
Unknown		0

Slope		
Weight: 2		
Minimum	Maximum	Suitability
0	30	100
31	10000	0



Land Cover Area		
Weight: 1		
Category		Suitability
Unclassified		100
Open Water		0
Perennial Snow/Ice		0
Developed Open Space		100
Developed Low Intensity		100
Developed Medium Intensity		0
Developed High Intensity		0
Barren Land		100
Deciduous Forest		100
Evergreen Forest		100
Mixed Forest		100
Shrub/Scrub		100
Herbaceous		100
Hay/Pasture		100
Cultivated Crops		100
Woody Wetlands		0
Emergent Herbaceous Wetlands		0



Landscape Population Density		
Weight: 2 (People per sq. km)		
Minimum	Maximum	Suitability
0	100	100
101	150	75
151	200	50
201	300	25
301	400	0
401	500	0
501	100000	0

Distance to Transmission (>220kV)		
Weight: 1 (Miles)		
Minimum	Maximum	Suitability
0	5	100
6	10	75
11	15	50
16	20	25
21	50	10
51	100000	1

Distance to Rivers (>130,000 GPM)		
Weight: 2 (Miles)		
Minimum	Maximum	Suitability
0	10	100
11	20	75
21	30	50
31	40	25
41	50	1
51	100000	0

Protected Lands		
Weight: 2		
Category		Suitability
Likely low conflict area		95
Develop with caution		40
Develop with extreme caution		20
Exclude from development		0

Habitat	
Weight: 2	
Category 	 Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Imperiled Species	
Weight: 2	
Category 	 Suitability
Low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Geopressured Geothermal

GeoPressure Energy Potential - Plan 2			
Weight: 10		(kWe/km ²)	
Minimum	Maximum	Suitability	
0	250	1	
251	500	15	
501	750	45	
751	1000	50	
1001	1500	80	
1501	1800	100	
1801	2000	100	

Onshore/Offshore	
Weight: 1	
Category	Suitability
Onshore	100
Offshore	0

Land Cover Area	
Weight: 1	
Category	Suitability
Unclassified	100
Open Water	0
Perennial Snow/Ice	0
Developed Open Space	100
Developed Low Intensity	100
Developed Medium Intensity	0
Developed High Intensity	0
Barren Land	100
Deciduous Forest	100
Evergreen Forest	100
Mixed Forest	100
Shrub/Scrub	100
Herbaceous	100
Hay/Pasture	100
Cultivated Crops	100
Woody Wetlands	100
Emergent Herbaceous Wetlands	100

Slope			
Weight: 1		(Percent)	
Minimum	Maximum	Suitability	
0	30	100	
31	10000	0	

Protected Lands	
Weight: 5	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20
Exclude from development	0

Habitat	
Weight: 5	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Imperiled Species	
Weight: 5	
Category	Suitability
Low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Nuclear High-Temperature Gas-cooled Reactor

Slope			
Weight: 1		(Percent)	
Minimum	Maximum	Suitability	
0	2	100	
3	4	100	
5	6	100	
7	8	100	
9	10	100	
11	12	100	
13	14	85	
15	16	75	
17	18	65	
19	20	50	
21	30	10	
31	10000	0	

Seismic Hazard	
Weight: 7	
Category	Suitability
No Damage: 0-3.9 %g	100
Light Damage: 9.2-18 %g	50
Moderate Damage: 18-34 %g	25
Mod./Heavy Damage: 34-65 %g	10

Quaternary Fault Exclusion	
Weight: 1	
Category	Suitability
Background	100
Fault Exclusion Area	0

Distance to Airport			
Weight: 1		(Miles)	
Minimum	Maximum	Suitability	
0	5	0	
6	10	0	
11	15	50	
16	20	100	
21	100000	100	

Land Cover Area	
Weight: 2	
Category	Suitability
Unclassified	50
Open Water	0
Perennial Snow/Ice	0
Developed Open Space	50
Developed Low Intensity	40
Developed Medium Intensity	5
Developed High Intensity	1
Barren Land	100
Deciduous Forest	70
Evergreen Forest	70
Mixed Forest	70
Shrub/Scrub	100
Herbaceous	100
Hay/Pasture	100
Cultivated Crops	100
Woody Wetlands	0
Emergent Herbaceous Wetlands	0

Landsan Population Density			
Weight: 3			
Minimum	Maximum	Suitability	
0	100	100	
101	150	75	
151	200	50	
201	300	25	
301	400	0	
401	500	0	
501	100000	0	

100 Year Flood Zone	
Weight: 1	
Category	Suitability
A	0
AE	0
AH	0
AO	0

Distance to Military Installation		
Weight: 1		(Miles)
Minimum	Maximum	Suitability
0	1	0
2	3	25
4	5	50
6	1000000	100

Protected Land	
Weight: 4	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20
Exclude from development	0

Habitat	
Weight: 4	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Imperiled Species	
Weight: 4	
Category	Suitability
Low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Nuclear Light-Water Reactor

Slope			
Weight: 1		(Percent)	
Minimum	Maximum	Suitability	
0	2	100	
3	4	100	
5	6	100	
7	8	100	
9	10	100	
11	12	100	
13	14	85	
15	16	75	
17	18	65	
19	20	50	
21	30	10	
31	10000	0	

Seismic Hazard			
Weight: 7			
Category		Suitability	
No Damage: 0-3.9 %g		100	
Light Damage: 9.2-18 %g		50	
Moderate Damage: 18-34 %g		25	
Mod./Heavy Damage: 34-65 %g		10	

Quaternary Fault Exclusion			
Weight: 1			
Category		Suitability	
-1	-1	100	
1	1	0	

100 Year Flood Zone			
Weight: 1			
Category		Suitability	
A		0	
AE		0	
AH		0	
AO		0	

Land Cover Area			
Weight: 2			
Category		Suitability	
Unclassified		50	
Open Water		0	
Perennial Snow/Ice		0	
Developed Open Space		50	
Developed Low Intensity		20	
Developed Medium Intensity		1	
Developed High Intensity		0	
Barren Land		100	
Deciduous Forest		70	
Evergreen Forest		70	
Mixed Forest		70	
Shrub/Scrub		100	
Herbaceous		100	
Hay/Pasture		100	
Cultivated Crops		100	
Woody Wetlands		0	
Emergent Herbaceous Wetlands		0	

Distance to Rivers (>200,000 GPM)			
weight: 3		(Miles)	
Minimum	Maximum	Suitability	
0	10	100	
11	20	50	
21	30	20	
31	40	1	
41	100000	0	

Landscape Population Density			
Weight: 3		(People per sq. km)	
Minimum	Maximum	Suitability	
0	100	100	
101	150	75	
151	200	50	
201	300	25	
301	400	0	
401	500	0	
501	100000	0	

Distance to Airport		
Weight: 1 (Miles)		
Minimum	Maximum	Suitability
0	5	0
6	10	0
11	15	50
16	20	100
21	100000	100

Distance to Military Installation		
Weight: 1 (Miles)		
Minimum	Maximum	Suitability
0	1	0
2	3	25
4	5	50
6	1000000	100

Protected Land	
Weight: 4	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20
Exclude from development	0

Habitat	
Weight: 4	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Imperiled Species	
Weight: 4	
Category	Suitability
Low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Nuclear Small Modular Reactor

Slope			
Weight: 1		(Percent)	
Minimum	Maximum	Suitability	
0	2	100	
3	4	100	
5	6	100	
7	8	100	
9	10	100	
11	12	100	
13	14	85	
15	16	75	
17	18	65	
19	20	50	
21	30	10	
31	10000	0	

Seismic Hazard	
Weight: 7	
Category	Suitability
No Damage: 0-3.9 %g	100
Light Damage: 9.2-18 %g	50
Moderate Damage: 18-34 %g	25
Mod./Heavy Damage: 34-65 %g	5

Quaternary Fault Exclusion	
Weight: 1	
Category	Suitability
Background	100
Fault Exclusion Area	0

100 Year Flood Zone	
Weight: 1	
Category	Suitability
A	0
AE	0
AH	0
AO	0

Land Cover Area	
Weight: 2	
Category	Suitability
Unclassified	50
Open Water	0
Perennial Snow/Ice	0
Developed Open Space	50
Developed Low Intensity	50
Developed Medium Intensity	10
Developed High Intensity	1
Barren Land	100
Deciduous Forest	70
Evergreen Forest	70
Mixed Forest	70
Shrub/Scrub	100
Herbaceous	100
Hay/Pasture	100
Cultivated Crops	100
Woody Wetlands	0
Emergent Herbaceous Wetlands	0

Distance to Rivers (>50,000 GPM)			
Weight: 3		(Miles)	
Minimum	Maximum	Suitability	
0	10	100	
11	20	50	
21	30	20	
31	40	1	
41	100000	0	

Landscape Population Density			
Weight: 3		(People per sq. km)	
Minimum	Maximum	Suitability	
0	100	100	
101	150	75	
151	200	50	
201	300	25	
301	400	0	
401	500	0	
501	100000	0	

Distance to Airport		
Weight: 1		
Minimum	Maximum	(Miles) Suitability
0	5	0
6	10	0
11	15	50
16	20	100
21	100000	100

Distance to Military Installation		
Weight: 1		
Minimum	Maximum	(Miles) Suitability
0	1	0
2	3	25
4	5	50
6	1000000	100

Protected Land	
Weight: 4	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20
Exclude from development	0

Habitat	
Weight: 4	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Imperiled Species	
Weight: 4	
Category	Suitability
Low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Natural Gas Combined-Cycle Gas Turbine

Distance to Natural Gas Pipeline (>=12 inch)			
Weight: 5 (Miles)			
Minimum	Maximum	Suitability	
	0	5	100
	6	10	90
	11	15	80
	16	20	70
	21	25	50
	26	30	40
	31	35	30
	36	40	20
	41	45	10
	46	50	1
	51	500	0

Slope			
Weight: 5 (Percent)			
Minimum	Maximum	Suitability	
	0	2	100
	3	4	75
	5	6	50
	7	8	40
	9	10	30
	11	12	20
	13	14	10
	15	16	1
	17	18	0
	19	20	0
	21	30	0
	31	10000	0

Distance to Railroad			
Weight: 3 (Miles)			
Minimum	Maximum	Suitability	
	0	2	100
	3	4	75
	5	7	45
	8	10	10
	11	20	1
	21	100000	1

Land Cover Area	
Weight: 5	
Category	Suitability
Unclassified	50
Open Water	0
Perennial Snow/Ice	0
Developed Open Space	30
Developed Low Intensity	30
Developed Medium Intensity	65
Developed High Intensity	10
Barren Land	100
Deciduous Forest	60
Evergreen Forest	60
Mixed Forest	60
Shrub/Scrub	100
Herbaceous	100
Hay/Pasture	100
Cultivated Crops	100
Woody Wetlands	0
Emergent Herbaceous Wetlands	0

Surface Water Flow (>100,000 GPM)			
Weight: 5 (Miles)			
Minimum	Maximum	Suitability	
	0	10	100
	11	20	70
	21	30	25
	31	40	1
	41	100000	0

Landscape Population Density			
Weight: 1 (People per sq. km)			
Minimum	Maximum	Suitability	
	0	100	100
	101	150	100
	151	200	100
	201	300	100
	301	400	100
	401	500	0
	501	100000	0

100 Year Flood Zone		
Weight: 1		
Category		Suitability
A		0
AE		0
AH		0
AO		0

Protected Land		
Weight: 4		
Category		Suitability
Likely low conflict area		95
Develop with caution		40
Develop with extreme caution		20
Exclude from development		0

Distance to Port			
Weight: 2 (Miles)			
Minimum	Maximum		Suitability
0	2		100
3	4		75
5	7		45
8	10		10
11	20		1
21	100000		1

Habitat		
Weight: 4		
Category		Suitability
Likely low conflict area		95
Develop with caution		40
Develop with extreme caution		20

Distance to Transmission (>=100 kV)			
Weight: 5 (Miles)			
Minimum	Maximum		Suitability
0	5		100
6	10		80
11	15		65
16	20		50
21	50		5
51	100000		1

Imperiled Species		
Weight: 4		
Category		Suitability
Low conflict area		95
Develop with caution		40
Develop with extreme caution		20

Photovoltaic Solar

Tilted Photovoltaic Potential			
Weight: 4		(Wh/m ² /Day)	
Minimum	Maximum	Suitability	
0	3000	1	
3001	4000	5	
4001	4500	15	
4501	5000	20	
5001	5250	55	
5251	5500	85	
5501	6000	90	
6001	7000	92	
7001	8000	95	
8001	9000	100	
9001	10000	100	

Slope			
Weight: 2		(Percent)	
Minimum	Maximum	Suitability	
0	1	100	
2	2	90	
3	3	90	
4	4	30	
5	5	10	
6	10	1	
11	10000	0	

Distance to Transmission (>345 kV)			
Weight: 1		(Miles)	
Minimum	Maximum	Suitability	
0	5	100	
6	10	90	
11	15	80	
16	20	70	
21	50	45	
51	100000	5	

Land Cover Area	
Weight: 1	
Category	Suitability
Unclassified	100
Open Water	0
Perennial Snow/Ice	0
Developed Open Space	0
Developed Low Intensity	50
Developed Medium Intensity	15
Developed High Intensity	10
Barren Land	100
Deciduous Forest	20
Evergreen Forest	10
Mixed Forest	10
Shrub/Scrub	25
Herbaceous	10
Hay/Pasture	80
Cultivated Crops	70
Woody Wetlands	5
Emergent Herbaceous Wetlands	5

Landscan Population Density			
Weight: 2		(People per sq. km)	
Minimum	Maximum	Suitability	
0	100	100	
101	150	75	
151	200	50	
201	300	25	
301	400	0	
401	500	0	
501	100000	0	

Protected Lands	
Weight: 2	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20
Exclude from development	0

Habitat Weight: 2	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Imperiled Species Weight: 2	
Category	Suitability
Low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Concentrating Solar Power

Concentrating Solar Direct Normal Potential Weight: 4 (Wh/m ² /Day)			
Minimum	Maximum	Suitability	
0	3000	0	
3001	4000	1	
4001	5000	15	
5001	5500	50	
5501	6000	75	
6001	6500	85	
6501	7000	100	
7001	7500	100	
7501	8000	100	
8001	9000	100	

Slope Weight: 2 (Percent)			
Minimum	Maximum	Suitability	
0	1	100	
2	2	90	
3	3	80	
4	4	50	
5	5	10	
6	10	0	
11	10000	0	



Distance to Transmission (>345 kV) Weight: 1 (Miles)			
Minimum	Maximum	Suitability	
0	5	100	
6	10	75	
11	15	50	
16	20	25	
21	50	5	
51	100000	1	



Land Cover Area Weight: 1	
Category	Suitability
Unclassified	100
Open Water	0
Perennial Snow/Ice	0
Developed Open Space	0
Developed Low Intensity	50
Developed Medium Intensity	15
Developed High Intensity	0
Barren Land	100
Deciduous Forest	0
Evergreen Forest	0
Mixed Forest	0
Shrub/Scrub	50
Herbaceous	100
Hay/Pasture	80
Cultivated Crops	75
Woody Wetlands	0
Emergent Herbaceous Wetlands	0

Distance to Rivers (>64,500 gpm) Weight: 2 (Miles)			
Minimum	Maximum	Suitability	
0	10	100	
11	20	75	
21	30	50	
31	100000	0	

Landscan Population Density Weight: 3 (People per sq. km)			
Minimum	Maximum	Suitability	
0	100	100	
101	150	75	
151	200	50	
201	300	25	
301	400	0	
401	500	0	
501	100000	0	

Protected Lands		
Weight: 2		
Category		 Suitability
Likely low conflict area		95
Develop with caution		40
Develop with extreme caution		20
Exclude from development		0

Imperiled Species		
Weight: 2		
Category		 Suitability
Low conflict area	10	95
Develop with cau	100	40
Develop with ext	1000	20

Habitat		
Weight: 2		
Category		 Suitability
Likely low conflict area		95
Develop with caution		40
Develop with extreme caution		20

Compressed Air Energy Storage

Aquifer Area		
Weight:3		
Category		Suitability
Unknown Lithology		75
Carbonate-rock aquifers		100
Igneous and metamorphic-rock aq		10
Sandstone and carbonate-rock aq		100
Sandstone aquifers		100
Semiconsolidated sand aquifers		10
Unconsolidated sand and gravel a		10

Distance to Domal Salt Formation			
Weight: 4 (Miles)			
Minimum	Maximum		Suitability
0	1		100
2	20		1
21	30		1
31	40		1
41	100000		1

Distance to Bedded Salt Formation			
Weight: 3 (Miles)			
Minimum	Maximum		Suitability
0	1		100
2	20		1
21	30		1
31	40		1
41	100000		1

Population Density			
Weight: 2 (People per sq. km)			
Minimum	Maximum		Suitability
0	100		100
101	150		75
151	200		50
201	300		25
301	400		0
401	500		0
501	100000		0

Slope			
Weight: 2 (Miles)			
Minimum	Maximum		Suitability
0	2		100
3	4		90
5	6		80
7	8		70
9	10		60
11	12		50
13	14		0
15	16		0
17	18		0
19	20		0
21	30		0
31	10000		0

Land Cover Area	
Weight: 2	
Category	Suitability
Unclassified	50
Open Water	0
Perennial Snow/Ice	0
Developed Open Space	50
Developed Low Intensity	50
Developed Medium Intensity	0
Developed High Intensity	0
Barren Land	100
Deciduous Forest	80
Evergreen Forest	80
Mixed Forest	70
Shrub/Scrub	100
Herbaceous	100
Hay/Pasture	100
Cultivated Crops	100
Woody Wetlands	0
Emergent Herbaceous Wetlands	0

100 Year Flood Zone		
Weight: 1		
Category		Suitability
A		0
AE		0
AH		0
AO		0

Distance to Transmission (All lines)			
Weight: 1 (Miles)			
Minimum		Maximum	Suitability
0		5	100
6		10	80
11		15	70
16		20	60
21		24	50
25		100000	0

Distance to Natural Gas Pipelines			
Weight: 3 (Miles)			
Minimum		Maximum	Suitability
0		1	100
2		3	75
4		5	50
6		10	10
11		20	1
21		100000	0

Landslide		
Weight: 1 (Incidence and Susceptibility)		
Category		Suitability
Low		100
Moderate		0
High		0
Suspected moderate		100
Suspected high		100
Combo-high		0
No-data		100

Protected Land		
Weight: 2		
Category		Suitability
Likely low conflict area		95
Develop with caution		40
Develop with extreme caution		20
Exclude from development		0

Habitat		
Weight: 2		
Category		Suitability
Likely low conflict area		95
Develop with caution		40
Develop with extreme caution		20

Imperiled Species		
Weight: 2		
Category		Suitability
Low conflict area		95
Develop with caution		40
Develop with extreme caution		20

Marine Tidal Hydrokinetic

Tidal Current Speed			
Weight: 5		(cm/sec)	
Minimum	Maximum	Suitability	
0	20	1	
21	40	1	
41	60	50	
61	80	70	
81	100	80	
101	120	90	
121	140	100	
141	160	100	
161	180	100	
181	200	100	

Distance to Transmission (all lines)			
Weight: 3		(Miles)	
Minimum	Maximum	Suitability	
0	0	100	
1	1	100	
2	2	90	
3	3	80	
4	4	70	
5	5	50	
6	10	15	
11	15	10	
16	20	1	
21	100000	0	

Tidal Power Density			
Weight: 5		(W/m²)	
Minimum	Maximum	Suitability	
0	100	1	
101	200	1	
201	300	50	
301	400	70	
401	500	80	
501	600	90	
601	700	100	
701	800	100	
801	900	100	
901	1000	100	
1001	100000	100	



Bathymetry			
Weight: 4		(Meters)	
Minimum	Maximum	Suitability	
-10000	-31	100	
-30	-16	100	
-15	-6	100	
-5	0	0	
1	5000	0	



Unexploded Ordnance			
Weight: 1			
Category	Suitability		
Area between features	100		
Unexploded ordnance area	1		

Distance to Port			
Weight: 1		(Miles)	
Minimum	Maximum	Suitability	
0	0	100	
1	1	100	
2	10	100	
11	20	75	
21	30	50	
31	10000	25	

Navigable Waterways			
Weight: 2			
Category	Suitability		
Background	100		
Waterway	1		

Protected Lands	
Weight: 3	
Category 	 Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20
Exclude from development	0

Imperiled Species	
Weight: 3	
Category 	 Suitability
Low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Habitat	
Weight: 3	
Category 	 Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Offshore Wind Turbine

Wind Turbine Gross Capacity Factor (80m)			
Weight: 5		(Percent)	
Minimum	Maximum	Suitability	
0	5	0	
6	10	0	
11	15	0	
16	20	0	
21	25	0	
26	30	1	
31	35	30	
36	40	50	
41	45	70	
46	50	80	
51	55	90	
56	60	100	
61	65	100	
66	70	100	
71	75	100	
76	80	100	
81	85	100	

Landscape Population Density			
Weight: 1			
Category		Suitability	
Background			100
500 People/sq. mile with two mile buffer			0



Bathymetry			
Weight: 2		(Meters)	
Minimum	Maximum	Suitability	
-5000	-91	0	
-90	-61	0	
-60	-31	20	
-30	0	100	
1	5000	0	



Distance to Substation			
Weight: 1		(Miles)	
Minimum	Maximum	Suitability	
0	5	100	
6	10	100	
11	15	100	
16	20	85	
21	50	75	
51	75	50	
76	100	25	
101	100000	25	



Unexploded Ordnance			
Weight: 1			
Category		Suitability	
Area between features			100
Unexploded ordnance area			1

Distance to Shore			
Weight: 1			
Minimum	Maximum	Suitability	
0	1	80	
2	3	87	
4	5	93	
6	7	95	
8	9	100	
10	15	90	
16	20	70	
21	25	50	
26	30	20	
31	40	10	
41	50	1	
51	1000	0	

Navigable Waterways			
Weight: 2			
Category		Suitability	
Background			100
Waterway			1

Protected Lands	
Weight: 3	
Category 	 Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20
Exclude from development	0

Habitat	
Weight: 2	
Category 	 Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Imperiled Species	
Weight: 2	
Category 	 Suitability
Low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Land-Based Wind Turbine

Wind Turbine Gross Capacity Factor (80m)			
Weight: 5		(Percent)	
Minimum	Maximum	Suitability	
0	5	0	
6	10	0	
11	15	0	
16	20	1	
21	25	10	
26	30	30	
31	35	50	
36	40	60	
41	45	70	
46	50	80	
51	55	90	
56	60	100	
61	65	100	
66	70	100	
71	75	100	
76	80	100	
81	85	100	

Land Cover Area	
Weight: 2	
Category	Suitability
Unclassified	100
Open Water	0
Perennial Snow/Ice	0
Developed Open Space	100
Developed Low Intensity	50
Developed Medium Intensity	0
Developed High Intensity	0
Barren Land	100
Deciduous Forest	50
Evergreen Forest	50
Mixed Forest	50
Shrub/Scrub	100
Herbaceous	100
Hay/Pasture	100
Cultivated Crops	100
Woody Wetlands	0
Emergent Herbaceous Wetlands	0

Slope			
Weight: 2		(Percent)	
Minimum	Maximum	Suitability	
0	3	100	
4	5	70	
6	8	60	
9	12	50	
13	20	10	
21	50	0	
51	10000	0	

Distance to Transmission (>345 kV)		
Weight: 3		(Miles)
Minimum	Maximum	Suitability
0	5	100
6	10	85
11	15	75
16	20	60
21	50	40
51	75	10
76	100000	5

Population Density (with 2 mile buffer)	
Weight: 1	
Category	Suitability
Background	100
500 People/sq. mile with two mile buffer	0

Distance to Major Road		
Weight: 1		(Miles)
Minimum	Maximum	Suitability
0	5	100
6	10	85
11	15	75
16	20	60
21	50	40
51	75	10
76	100000	5

Distance to Airport Runway			
Weight: 2		(Miles)	
Minimum	Maximum	Suitability	
0	1	0	
2	5	1	
6	10	5	
11	15	50	
16	20	100	
21	100000	100	

Protected Lands	
Weight: 3	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20
Exclude from development	0

Imperiled Species	
Weight: 3	
Category	Suitability
Low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Habitat	
Weight: 2	
Category	Suitability
Likely low conflict area	95
Develop with caution	40
Develop with extreme caution	20

Appendix B: EZ Mapping Tool Informational Layers

Layer Title	Category	Source	Layer Type	Publication Year
100-Year Flood Zone	Hydrography	Federal Emergency Management Agency	Screening	2011
113th Congressional District		U.S. Census Bureau	Information	2013
1-Axis Tracking Flat-Plate Collector	Climate	National Renewable Energy Laboratory (NREL), et al.	Resource	2007
Air Route Surveillance Radar (ARSR)	Communications	Massachusetts Institute of Technology's (MIT's) Lincoln Laboratories, et al.	Information	2012
Airport	Transportation	Federal Aviation Administration (FAA)	Information	2012
Airport Runway	Transportation	FAA	Information	2012
Airport Surveillance Radar (ASR)	Communications	Compiled from multiple sources	Resource	2012
Alternative Fuel Station	Transportation	NREL	Information	2012
Anchorage Area	Transportation	National Oceanic and Atmospheric Administration (NOAA)	Screening	2010
Appalachian Foothills Focus Area (OH)	Ecology	OH Department of Natural Resources - Division of Wildlife	Screening	
Aquatic Conservation Focus Area (MT)	Ecology	MT Department of Fish, Wildlife, and Parks	Screening	2006
Aquatic Priority Area (TN)	Ecology	TN Wildlife Resources Agency	Screening	2005
Aquatic Priority Conservation Area (AL)	Ecology	AL Department of Conservation and Natural Resources	Screening	2008
Aquifer Area	Hydrography	U.S. Geological Survey (USGS)	Screening	2003
Artificial Reef		NOAA	Screening	2012
Atlantic Outer Continental Shelf (OCS) Wind Energy Area	Climate	Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE)	Information	2012
Bathymetry Digital Elevation Model (DEM) with Great Lakes	Landform	NOAA	Information	
Bedded Salt Formation	Geology	Oak Ridge National Laboratory (ORNL)	Resource	2005
Biodiversity (Indiana)	Ecology	IN Department of Natural Resources	Screening	
Biodiversity and Wildlife Habitat Assessment (NC)	Ecology	NC Office of Conservation, Planning, and Community Affairs	Screening	2010
Biological Hotspot (VT)	Ecology	University of VT - Spatial Analysis Lab	Screening	2000
Biologically Unique Landscape (NE)	Land Status	NE Game and Parks Commission	Screening	2011
Candidate Landfill Methane Project	Environmental Hazards	U.S. Environmental Protection Agency (EPA)	Resource	2012
Census Tract	Demographics	U.S. Census Bureau	Screening	2010
County Natural Heritage Inventory (CNHI): Core Habitat (PA)	Ecology	PA Natural Heritage Program - Western PA Conservancy	Screening	2010
CNHI: Landscape Conservation Area (PA)	Land Status	PA Natural Heritage Program - Western PA Conservancy	Screening	2010
CNHI: Supporting Landscapes (PA)	Ecology	PA Natural Heritage Program - Western PA Conservancy	Screening	2010
Coal Basin, Region and Field	Geology	U.S. Energy Information Administration (EIA)	Information	2007
Coal Bed Carbon Dioxide Storage Suitability	Geology	NREL	Information	2011
Coal Mine/Facility	Geology	USGS	Resource	

Layer Title	Category	Source	Layer Type	Publication Year
Coal Plants Suitable for Co-Firing Biomass	Utilities	EPA	Resource	2011
Coal Power Plant	Utilities	NREL	Resource	2007
Coalbed Methane Field	Geology	EIA	Information	2007
Coastal Barrier Resources System	Improvement	U.S. Fish and Wildlife Service (USFWS)	Information	2010
Cold-Water Coral Habitat	Ecology	USGS	Screening	2010
College/University	Buildings	Argonne National Laboratory (Argonne)	Screening	
Commercial Nuclear Power Plant	Utilities	UN Environment Programme/GRID	Information	1999
Concentrating Solar Direct Normal Potential	Climate	NREL, et al.	Resource	2005
Conservation Focus Area (NH)	Land Status	The Nature Conservancy	Screening	2006
Conservation Opportunity Area (MO)	Ecology	MO Department of Conservation	Screening	
Conservation Opportunity Area (PA)	Land Status	PA Natural Heritage Program	Screening	
Conserved Land (ME)	Land Status	ME Department of Conservation Bureau of Parks and Land, et al.	Screening	2010
Conserved Land (NH)	Land Status	Complex Systems Research Center - University of NH	Screening	1995
Conventional Crops 2012	Flora	Bioenergy Knowledge Discovery Framework	Resource	2011
Conventional Crops 2022	Flora	Bioenergy Knowledge Discovery Framework	Resource	2011
County Boundary	Boundary	U.S. Census Bureau, et al.	Information	2012
Critical Habitat Area		USFWS	Screening	2010
Cross Ranch State Nature Preserve (ND)	Cadastre	ND Parks and Recreation Department	Screening	
Crude Oil Pipeline	Utilities	Platts/Bentek Energy	Information	2011
Current State House Legislative District		U.S. Census Bureau	Information	2013
Current State Senate Legislative District		U.S. Census Bureau	Information	2013
Dam/Lock	Hydrography	U.S. Army Corps of Engineers (USACE)	Information	2006
Domal Salt Formation	Geology	ORNL	Resource	
Earthquake Intensity	Geology	USGS	Screening	2010
Eastern Brook Trout Status	Fauna	U.S. Forest Service (USFS)	Screening	2006
Ecological Conservation Site (TN)	Land Status	TN Department of Environment and Conservation - Division of Natural Areas - Natural Heritage Inventory Program	Screening	2010
Ecological Cores/Restoration Priorities	Ecology	The Wilderness Society	Screening	
Ecoregional Portfolio	Ecology	The Nature Conservancy	Screening	2011
EISPC Region	Boundary	Argonne	Information	2010
Electrical Power Plant Capacity	Utilities	EPA	Screening	2011
Energy Potential Non-Powered Dam	Improvement	ORNL	Resource	2012
Enhanced Geothermal System (EGS) Potential	Geology	NREL	Resource	2009

Layer Title	Category	Source	Layer Type	Publication Year
Enhanced Geothermal System (EGS) Technology Potential	Geology	NREL	Resource	
Environmental Hazard Site	Environmental Hazards	EPA	Screening	2012
Environmental Sensitive Area (NJ)	Land Status	NJ Department of Environmental Protection (NJDEP) - Planning and Sustainable Communities	Screening	2008
EPA Class I Area	Visual	EPA	Screening	2007
EPA Renewable Energy Sites	Environmental Hazard	EPA, et al.	Screening	2009
Essential Fish Habitat	Ecology	NOAA	Screening	2009
Existing Hydropower Dam (At least 50 MW)	Utilities	Platts/Bentek Energy	Information	2011
Ferry Route	Transportation	USGS	Screening	2012
USFWS Boundary	Cadastre	USFWS	Screening	2012
Florida Conservation Land (FL)	Land Status	FL Natural Areas Inventory - FL State University	Screening	2010
Florida Forever Board of Trustees Project Area (FL)	Land Status	FL Natural Areas Inventory - FL State University	Screening	2010
Focal Areas of Conservation Significance	Ecology	The Nature Conservancy	Screening	2012
Focus Area (ND)	Land Status	ND Parks and Recreation Department	Screening	2007
Focus Area of Ecological Significance (ME)	Ecology	ME Department of Conservation	Screening	2011
Forest Focal Areas - Atlantic Flyway	Ecology	National Audubon Society	Screening	2012
Formerly Used Defense Site	Environmental Hazards	USACE	Information	2010
USFWS Specially Designated Area	Land Status	USFWS	Screening	2012
Gauging Station	Improvement	USGS	Information	2001
Geologic Fault	Geology	USGS	Screening	2003
Geologic Survey Map	Geology	USGS	Information	2005
Geopressure Energy Potential - Plan 2	Geology	NREL	Resource	1978
Geopressure Energy Potential - Plan 3	Geology	NREL	Resource	1978
Grand River/Mosquito Focus Area (OH)	Ecology	OH Department of Natural Resources - Division of Wildlife	Screening	
Great Lake Opportunity Area (WI)	Ecology	WI Department of Natural Resources - Bureau of Endangered Resources	Screening	2008
Green Infrastructure Network Characterization	Ecology	The Conservation Fund	Screening	2010
Greenway Corridor (RI)	Cadastre	RI Department of Administration - Statewide Planning	Screening	1995
Gunlogson State Nature Preserve (ND)	Cadastre	ND Parks and Recreation Department	Screening	
H.R. Morgan State Nature Preserve (ND)	Cadastre	ND Parks and Recreation Department	Screening	
Habitat	Ecology	Argonne, et al.	Screening	2013
Habitat Block/Wildlife Corridor (VT)	Ecology	VT Agency of Natural Resources	Screening	2011
Habitats of Particular Concern	Ecology	NOAA	Screening	2010
Head of the Mountain State Nature Preserve (ND)	Cadastre	ND Parks and Recreation Department	Screening	

Layer Title	Category	Source	Layer Type	Publication Year
High Irreplaceability Area	Ecology	Two Countries, One Forest	Screening	2007
Highest Ranked Wildlife Habitat (NH)	Ecology	NH Fish and Game Department - Wildlife Division	Screening	2010
Hospital	Buildings	USGS	Screening	2012
Human Footprint (Northern Appalachian/Acadian Ecoregion)	Ecology	Wildlife Conservation Society Canada	Screening	2007
HydroKinetic Project Issued Preliminary Permit	Hydrography	Federal Energy Regulatory Commission (FERC)	Resource	2012
HydroKinetic Project Pending Preliminary Permit	Hydrography	FERC	Resource	2012
Imperiled Species	Ecology	NatureServe	Screening	2013
Important Bird Area	Land Status	National Audubon Society	Screening	2012
Indian Reservation	Cadastral	U.S. Census Bureau, et al.	Information	2012
Karst Area	Geology	USGS	Information	2005
Key Area for Conservation Action (NM)	Land Status	NM Department of Game and Fish	Screening	
Killbuck Focus Area (OH)	Ecology	OH Department of Natural Resources - Division of Wildlife	Screening	
Killdeer Focus Area (OH)	Ecology	OH Department of Natural Resources - Division of Wildlife	Screening	
Lake Erie Marsh Focus Area (OH)	Ecology	OH Department of Natural Resources - Division of Wildlife	Screening	
Landscape Permeability Flow Model	Ecology	Colorado State University	Screening	2012
Landscape v3.1 - Atlantic Coastal Region (NJ)	Ecology	NJDEP - Division of Fish & Wildlife	Screening	2012
Landscape v3.1 - Delaware Bay Region (NJ)	Ecology	NJDEP - Division of Fish & Wildlife	Screening	2012
Landscape v3.1 - Freshwater Mussel Habitat (NJ)	Ecology	NJDEP - Division of Fish & Wildlife	Screening	2012
Landscape v3.1 - Marine Region (NJ)	Ecology	NJDEP - Division of Fish & Wildlife	Screening	2012
Landscape v3.1 - Piedmont Plains Region (NJ)	Ecology	NJDEP - Division of Fish & Wildlife	Screening	2012
Landscape v3.1 - Pinelands Region (NJ)	Ecology	NJDEP - Division of Fish & Wildlife	Screening	2012
Landscape v3.1 - Skylands Region (NJ)	Ecology	NJDEP - Division of Fish & Wildlife	Screening	2012
Landscape v3.1 - Vernal Habitat (NJ)	Ecology	NJ DEP - Division of Fish & Wildlife	Screening	2012
Landslide Incidence and Susceptibility	Environmental Hazards	USGS	Screening	2001
Lasuan Focus Area (OH)	Ecology	OH Department of Natural Resources - Division of Wildlife	Screening	
Major Road	Transportation	Federal Highway Administration, et al.	Information	2012
Marine Port	Transportation	USACE	Information	2012
Marine Protected Areas Database	Land Status	USGS	Screening	2011
Marine Sanctuary	Land Status	NOAA	Screening	2004
Marine Wreck/Obstruction	Transportation	NOAA	Screening	2002
Mean Annual Wind Speed (100 m)	Climate	AWS Truepower, LLC (AWST)	Resource	2012
Mean Annual Wind Speed (80 m)	Climate	AWST	Resource	2012

Layer Title	Category	Source	Layer Type	Publication Year
Military Installation	Cadastre	Office of the Deputy Under Secretary of Defense for Installations and Environment	Screening	2011
Military Training Route Centerline	Military Operations	National Geospatial-Intelligence Agency (NGA)	Information	2010
Military Training Route Corridor	Military Operations	NGA	Information	2010
Mineral Resource	Land Status	USGS	Resource	2005
Mountain Treasures Area	Land Status	The Wilderness Society	Screening	
National Ambient Air Quality Standard Area - Lead	Environmental Hazards	EPA	Information	2007
National Ambient Air Quality Standard Area - Ozone - 1-hour	Environmental Hazards	EPA	Information	2007
National Ambient Air Quality Standard Area - Ozone - 8-hour	Environmental Hazards	EPA	Information	2006
National Ambient Air Quality Standard Area - Carbon Monoxide	Environmental Hazards	EPA	Screening	2007
National Ambient Air Quality Standard Area - PM10	Environmental Hazards	EPA	Screening	2007
National Ambient Air Quality Standard Area - PM2.5	Environmental Hazards	EPA	Information	2006
National Ambient Air Quality Standard Area - Sulfur Dioxide	Environmental Hazards	EPA	Screening	2007
National Conservation Easement Database	Cadastre	The Conservation Registry	Screening	2012
National Interest Electric Transmission Corridor	Land Status	Argonne, et al.	Information	2010
National Land Cover Database	Flora	USGS	Screening	2006
National Monument	Land Status	Argonne, et al.	Screening	2009
National Offshore Wind Resource Assessment (90 m)	Climate	NREL, et al.	Resource	2009
National Park Service Boundary	Cadastre	U.S. National Park Service	Screening	2010
National Trail	Improvement	Argonne, et al.	Screening	2011
National Wind Resource Assessment (50 m)	Climate	NREL, et al.	Resource	2003
Natural Area (DE)	Ecology	DE Department of Natural Resources and Environmental Control - Division of Parks and Recreation	Screening	2006
Natural Diversity Database (CT)	Ecology	CT Department of Environmental Protection	Screening	2010
Natural Gas Pipeline	Utilities	Platts/Bentek Energy	Information	2011
Natural Heritage Area (NC)	Ecology	NC Department of Environment and Natural Resources	Screening	2012
Natural Heritage Area (RI)	Ecology	RI Department of Environmental Management - The Nature Conservancy Natural Heritage Program	Screening	1990
Natural Heritage Inventory Managed Area (OK)	Land Status	University of OK - Natural Heritage Inventory	Screening	2010

Layer Title	Category	Source	Layer Type	Publication Year
Natural Heritage Priority Site (NJ)	Land Status	NJDEP - Office of Natural Lands Management	Screening	2007
Natural Land Network (VA)	Land Status	VA Department of Conservation & Recreation - Natural Heritage Program	Screening	2007
Natural Landscape Assessment: Ecological Core (VA)	Ecology	VA Department of Conservation & Recreation - Natural Heritage Program	Screening	2007
Natural Landscape Block (VA)	Ecology	VA Department of Conservation & Recreation - Natural Heritage Program	Screening	2007
Natural Services Network (NH)	Land Status	NH Department of Transportation	Screening	2007
Natural Vegetation (IA)	Flora	IA Department of Natural Resources - Wildlife Bureau	Screening	
Navigable Waterway Network	Transportation	Research and Innovative Technology Administration, et al.	Information	2012
Navigational Aid	Transportation	NOAA	Screening	2010
Next-Generation Weather Radar (NEXRAD)	Communications	NOAA, et al.	Information	2012
NHESP BioMap2 Core Habitat	Ecology	MA Division of Fisheries and Wildlife, et al.	Screening	2010
NHESP BioMap2 Critical Natural Landscape	Ecology	MA Division of Fisheries and Wildlife, et al.	Screening	2010
North American Carbon Dioxide Source	Environmental Hazards	NREL	Information	
North American Oil & Gas Field	Geology	NREL	Information	
North American Saline Basin	Geology	NREL	Screening	
Operational Anaerobic Digester	Environmental Hazards	EPA	Resource	2012
Operational Landfill Methane Project	Environmental Hazards	EPA	Resource	2012
Paint Creek Focus Area (OH)	Ecology	OH Department of Natural Resources - Division of Wildlife	Screening	
Petrochemical Facility	Utilities	ORNL	Screening	2011
Photovoltaic Potential	Climate	NREL, et al.	Resource	2007
Population Density (LandScan)	Demographics	ORNL	Screening	2009
Potential Bicknell Thrush Habitat	Ecology	Vermont Center for Ecotudies	Information	2009
Potential Conservation Opportunity Area (GA)	Flora	GA Department of Natural Resources	Screening	
Potential Retrofitted Pulverized Coal Plant	Utilities	Platts/Bentek Energy	Information	2011
Power Plant - Existing	Utilities	Platts/Bentek Energy	Information	2011
Power Plant - Not Operational/Unknown	Utilities	Platts/Bentek Energy	Information	2011
Power Plant - Planned	Utilities	Platts/Bentek Energy	Information	2011
Prison	Buildings	Argonne	Screening	2004
Protected Areas Database	Land Status	USGS, et al.	Screening	2011
Protected Lands	Land Status	Argonne, et al.	Screening	2013
Pumped Storage Issued Preliminary Permit	Hydrography	FERC	Resource	2011
Pumped Storage Pending Preliminary Permit	Hydrography	FERC	Resource	2011
Pumped Storage Site	Hydrography	Argonne	Resource	2011

Layer Title	Category	Source	Layer Type	Publication Year
Quaternary Fault	Geology	USGS	Screening	2004
Railroad	Transportation	Federal Railroad Administration	Information	2012
Rare Species (MA)	Ecology	MA Division of Fisheries and Wildlife; et al.	Screening	2008
Rare Species Concentration Area (MN)	Ecology	MN Department of Natural Resources - Division of Ecological Resources	Screening	2008
Rare, Threatened, and Endangered Species and Significant Community (VT)	Ecology	VT Fish and Wildlife Department - Nongame and Natural Heritage Program	Screening	2006
Refined Product Pipeline	Utilities	Platts/Bentek Energy	Information	2011
River Opportunity Area (WI)	Ecology	WI Department of Natural Resources - Bureau of Endangered Resources	Screening	2008
Saline Formation Suitability	Geology	NREL, et al.	Resource	
Scenic Byway	Visual	U.S. Department of Transportation	Screening	2010
School	Buildings	USGS	Screening	2012
Seafloor Geology	Geology	USGS	Information	2005
Secondary Agriculture Residue 2012	Flora	Bioenergy Knowledge Discovery Framework	Resource	2011
Section 368 Centerline	Land Status	Argonne, et al.	Information	2008
Section 368 Centerline (Developable Area)	Land Status	Argonne, et al.	Information	2008
Section 368 Zone	Land Status	Argonne, et al.	Information	2008
Section 368 Zone (Developable Area)	Land Status	Argonne, et al.	Information	2008
Seismic Hazard	Geology	USGS	Screening	2012
Sensitive Species Project Review Area (MD)	Ecology	MD Department of Natural Resources - Wildlife and Heritage Service	Screening	2010
Sentinel Butte State Nature Preserve (ND)	Cadastre	ND Parks and Recreation Department	Screening	
Shale Gas Basin	Geology	EIA	Information	2008
Shipping Fairways, Lanes, and Zones	Transportation	NOAA	Screening	2013
Shutdown Anaerobic Digester	Environmental Hazards	EPA	Resource	2012
Slope	Landform	USGS, et al.	Information	2011
Southeastern Ecological Framework Model	Ecology	University of Florida - GeoPlan Center	Screening	2001
Special Use Airspace	Military Operations	NGA	Screening	2010
Stacked Plays	Geology	EIA	Information	2008
State Boundary	Boundary	U.S. Census Bureau, et al.	Information	2012
State Claimed Water Body (LA)	Land Status	LA Division of Administration - State Land Office	Screening	2011
State Owned/Leased Land (LA)	Land Status	LA Division of Administration - State Land Office	Screening	2011
Stream/River	Hydrography	USGS	Information	2010
Submarine Cable	Utilities	NOAA	Screening	2011
Substation	Utilities	Platts/Bentek Energy	Information	2011
Subterranean Priority Area (TN)	Ecology	TN Wildlife Resources Agency	Screening	2005
Surface Water Flow - NHDPlus Version 2	Hydrography	Horizon Systems Corporation, et al.	Screening	2012
Tecumseh Focus Area (OH)	Ecology	OH Department of Natural Resources - Division of Wildlife	Screening	
Terminal Doppler Weather Radar (TDWR)	Communications	NOAA, et al.	Screening	2012
Terrestrial Conservation Focus Area (MT)	Ecology	MT Department of Fish, Wildlife, and Parks	Screening	2006

Layer Title	Category	Source	Layer Type	Publication Year
Terrestrial Opportunity Area (WI)	Ecology	WI Department of Natural Resources - Bureau of Endangered Resources	Screening	2008
Terrestrial Priority Area (TN)	Ecology	TN Wildlife Resources Agency	Screening	2005
Terrestrial Priority Conservation Area (AL)	Ecology	AL Department of Conservation and Natural Resources	Screening	2011
Tethered Aerostat Radar System (TARS)	Communications	NOAA, et al.	Screening	2012
Tidal - Mean Current Speed	Hydrography	Georgia Institute of Technology – Savannah	Resource	2011
Tidal - Mean Kinetic Power Density	Hydrography	Georgia Institute of Technology – Savannah	Resource	2011
Tier 1 Conservation Area (KY)	Ecology	KY Department of Fish & Wildlife Resources - Information Systems Office	Screening	2005
Tilted Photovoltaic Potential	Climate	NREL, et al.	Resource	2005
Transmission Line	Utilities	Platts/Bentek Energy	Information	2011
U.S. Populated Place		U.S. Census Bureau	Information	2010
Under Construction Landfill Methane Project	Environmental Hazards	EPA	Resource	2012
Under Construction/Unknown Anaerobic Digester	Environmental Hazards	EPA	Resource	2012
Unexploded Ordnance	Environmental Hazards	NOAA	Screening	2012
Urban Area	Demographics	U.S. Census Bureau	Information	2010
U.S. Forest Service (USFS) Roadless Area	Land Status	USFS	Screening	2003
USFS Specially Designated Area	Land Status	USFS	Screening	2000
Wastewater Treatment Facility	Utilities	EPA	Resource	2006
Water Body	Hydrography	USGS	Information	2010
Watershed	Hydrography	USGS, et al.	Information	2005
Wave Energy - Energy Period	Hydrography	NREL, et al.	Resource	2011
Wave Energy - Power Density	Hydrography	NREL, et al.	Resource	2011
Wave Energy - Significant Wave Height	Hydrography	NREL, et al.	Resource	2011
Wave Energy - Water Depth	Hydrography	NREL, et al.	Resource	2011
Well Locations (Bottom Hole Temperature [BHT] degrees Celsius)	Geology	Southern Methodist University	Information	2008
Wilderness Area	Land Status	Wilderness Institute, et al.	Screening	2010
Wind Power Density (100 m)	Climate	AWST	Resource	2012
Wind Power Density (80 m)	Climate	AWST	Resource	2012
Wind Turbine Gross Capacity Factor (100 m)	Climate	AWST	Resource	2012
Wind Turbine Gross Capacity Factor (80 m)	Climate	AWST	Resource	2012
Wind Turbine Site	Improvement	FAA	Information	2012

Appendix C: Estimating Rooftop PV Potential

C.1 Introduction

As discussed in Sections 2 and 3, rooftop photovoltaic (PV) differs significantly from the utility-scale solar resources. For completeness, this Appendix repeats some of the earlier discussion in Section 3.6.

As a local, distribution-level resource, rooftop PV needs no transmission to connect it to customer load. What matters most for transmission system planning are the degree of rooftop PV penetration in that locale and the extent of peak load reduction, potentially reducing the need for transmission. The precise location of individual solar installations within the load center has little bearing on transmission-level system planning and distribution-level issues; while important, the latter are not addressed here.

The way in which decisions regarding deployment of rooftop PV are made is also fundamentally different from that for deployment of utility-scale resources. The construction of a 200-megawatt (MW) utility-scale solar plant involves a set of decisions toward one single capital investment. In contrast, deploying an equivalent amount of rooftop PV involves many independent and fragmented decisions spread among thousands of individual customers. Residential customer decisions involve a few kilowatts (kW), whereas large industrial or commercial customers installing systems may involve as much as a megawatt (MW). In other words, the deployment of 200 MW of rooftop PV is not based on a single decision. Rather, it is the result of the aggregation of many individual decisions influenced by local, state, and federal incentives; utility practices and rate structures; as well as the quality of the local solar resource, among other variables. Estimating rooftop solar PV potential combines information about population and buildings stock (residential, commercial, and industrial) and the amount of sunshine the locality has during a typical year. The operational questions are as follows:

- How much useful rooftop space is there in a given locale?
- How much sunlight is likely to fall on rooftops during the course of a typical year?
- How much electricity can the rooftop PV provide, and how will it change peak demand?

Consequently, while utility-scale solar is a generation resource from the perspective of transmission planning, rooftop PV is a load-reducing technology.¹ Location is not the unknown variable. What affects system planning is how much load reduction might occur in a given locale due to greater rooftop PV deployment.

¹ For a particular rooftop installation, generation may exceed the building load and be fed back onto the grid. At very high penetration levels, rooftop PV might exceed the aggregate load in the local distribution system and then impact transmission.

This analysis deals with the *aggregate* amount of rooftop PV that might be available in a given locale. It does not address specifically where rooftop PV might be located. The Eastern Interconnection States' Planning Council (EISPC) Mapping Tool is not designed for analyzing the viability of specific sites or buildings.²

Panel and installation costs are also outside the scope of this analysis. Such costs are better addressed as follow-on analyses, as they would not materially affect the system-wide planning questions that this analysis aims to examine. The focus here is on how net load would change in a given locale with various penetration levels of rooftop PV.

This analysis makes no assumption about the effectiveness of state and local policies affecting financial incentives for rooftop PV. Instead, users of the tool are asked to define the level of effectiveness they assume for whatever incentives may be in place (or for programs that might be under consideration). The tool can test the system-wide results of achieving a certain level of rooftop PV deployment. It does not answer the question of what incentives might be required to achieve that level of deployment.

C.2 Rooftop Estimation

Mapping rooftop solar PV potential involves two analytical components: population and buildings stock (residential, commercial, and industrial) and the amount of sunshine the area has during a typical year.

The amount of rooftop space depends on urban density and the geographic expanse of the metropolitan area. Not all rooftops are the same, however, and many of these differences can affect the efficiency of a PV installation. In the northern hemisphere, a roof pitched facing the south generally allows a solar panel to produce more electricity than one facing another direction. Even if the roof faces south, the angle of the pitch will also affect production. If there is no shade obstructing solar exposure, a south-facing panel tilted at an angle equal to the site's geographic latitude will capture the most sunshine and produce the most electricity.

Trees and other vegetation can obstruct sunlight and affect the amount of electricity produced throughout the day. The height of neighboring buildings to the south can also limit PV output. The amount of rooftop space containing heating, ventilation and air-conditioning (HVAC) equipment will also reduce the space available for solar panels. Buildings in warmer climates tend to have more tree shading and more HVAC, resulting in less area available for rooftop PV panels. Another factor that has to be taken into account is rooftop loading (weight) limitation. This level of detail needs to be addressed in the actual permitting process.

This analysis relies on a 2008 study by Denholm and Margolis that estimates the building stock rooftop area that is potentially available for solar PV (Denholm and Margolis 2008). The methodology applies general adjustments to account for differences in roof slope, roof orientation, shading from adjacent buildings, and shading from overhanging vegetation. As of

² For a suite of publicly available site assessment tools, see http://www.nrel.gov/analysis/analysis_tools_tech_sol.html.

this writing, more precise validation for key metropolitan areas is being conducted using light detection and ranging (LIDAR) remote sensing, but results have not yet been published.

All of the adjustments listed above applied to the stock of buildings result in an estimate describing the total rooftop area in a load center capable of accommodating rooftop PV. This is an upper limit estimate based on physical rooftop configuration and yields the technical potential. The actual penetration rate will be less than 100% of the technical potential. Installations by individual homeowners and commercial property owners will be influenced by policy, expected payback, and other factors.

The total available rooftop area is estimated for commercial and residential buildings in each grid (Census Block or Block Group or a higher level aggregation such as City, County, or State). Total floor space data for each aggregated grid are obtained from McGraw-Hill (FW Dodge Building Stock Database) and then scaled to estimate the total building “footprint” area based on the number of floors in each building class (i.e., a three-story building with 3,000 ft² of floor space would be assumed to have a roof footprint of 1,000 ft²).

The average number of floors per building type was based on estimates from the Energy Information Administration’s 2005 Residential Energy Consumption Survey (RECS) (DOE 2001) and the 2003 Commercial Building Energy Consumption Survey (CBECS) (DOE 2003).

The roof footprint was assumed to equal the roof area for flat-roofed buildings and was adjusted by using a typical pitch angle to estimate the roof area for sloped roofs. Because the building footprint is based on usable floor space, this eliminates roof overhang, which is not considered usable for PV. The actual distribution between flat and tilted roofs, as well as roof orientation, was based on several factors.

For residential rooftops, Denholm and Margolis (2008) assumed that 8% of all roofs are flat, based on estimates from Navigant Consulting (Paidipati et al. 2008). For commercial buildings, Denholm and Margolis used the CBECS database to estimate the distribution between flat and pitched roofs (DOE 2003). The CBECS data indicate that about 37% of commercial buildings (corresponding to about 31% of commercial roof area) use shingles, wood, or slate; and the data assumed that these roof materials are used on pitched roofs, with the remainder of the roofs flat.

For the orientations of pitched roofs, Denholm and Margolis assumed a uniform distribution. Total roof area was then translated into usable area by using an availability factor, which accounts for shading, rooftop obstructions, and other constraints. This number is highly uncertain and will vary regionally due to several factors, including local climate and vegetation; HVAC equipment requirements; and building density (Paidipati et al. 2008). Denholm and Margolis’s base estimate was derived from Navigant Consulting data, which assumes 22% availability of roof area for residential buildings in cool climates, and 27% in warm/arid climates (due to reduced tree shading). For commercial buildings, the availability is estimated at 60% for warm climates and 65% for cooler climates.

C.3 Solar Data and Energy Conversion

Estimations of the amount of sunlight falling on rooftops in a given area draw on the same detailed satellite and ground observation data used to estimate utility-scale solar potential in Section 3.6. Most rooftop PV installations are small scale and use fixed mounting. Therefore, the raw solar potential for rooftop PV in a given area is calculated on the basis of a fixed-mounted panel tilted at an angle equal to the latitude of where the panel is installed. This is the angle that generally captures the most sunshine over the course of a year.

How much electricity comes from a square meter of rooftop PV will depend on the technology. Tracking of the best efficiencies of various PV technologies over time is shown in a chart available at http://www.nrel.gov/ncpv/images/efficiency_chart.jpg. The efficiency of panels currently in use range widely, with silicon technologies—most commonly used in rooftop arrays—ranging between 14% and 21%.³

Research for future panel technologies generally follows two tracks: new technologies with improved conversion efficiency, and production improvements that will reduce the cost of existing technologies. Achieving lower costs to end-use customers involves advancements in both areas.

Another component of the PV energy conversion system is the inverter. A PV panel generates direct current (DC) which must be converted to alternating current (AC) before it can connect to the distribution system. Inverters typically lose between 4% and 6% of the DC power generated; that is, a 100-kW DC system will be equivalent to 94 to 96 kW AC.⁴ The U.S. Department of Energy (DOE) projects that invert efficiency will improve over the next 20 years to between 97% and 98%.

C.4 Peak Load Reduction

Rooftop PV will begin to influence peak demand as its penetration increases in a given metropolitan area, county, or state. This is especially true in hot climates where sunny days and high temperatures correlate with greater use of air-conditioning, leading to higher demand for electricity.

Summer peaks tend to occur in the mid- to late-afternoon hours. PV output peaks around noon and declines in the afternoon as the sun moves lower in the sky. PV's effect on peak demand is therefore less than its full rated capacity. It tends to shift the peak to later in the day, which also complicates the task of estimating PV's value in reducing peak demand.

This analysis uses a new metric to estimate the degree to which rooftop PV reduces an area's annual peak load. It relies on the building estimation methods and solar exposure discussed previously, along with user-defined assumptions about the level of rooftop PV deployment. The index calculation is as follows.

³ Monocrystalline silicon modules range from 14% to 16%; multicrystalline silicon modules range from 17% to 21% (DOE 2012, p. 7)1.

⁴ Ibid., p 78.

1. Obtain hourly load data for the region or zone of interest, either for the most recent year or averaged across several years.
2. Obtain hourly production levels for rooftop PV during a typical year in the region or zone of interest, with production calculated as a percentage of a PV system's rated capacity for each hour.
3. Select an assumed penetration level for rooftop PV (in MW) in the region or zone of interest.
4. Calculate the net load for each hour by subtracting from load the amount of electricity generated by the assumed penetration of rooftop PV.
5. Calculate diurnal load profiles for each month of the year, based on average hourly load. Identify the month and hour with the highest average load.
6. Similarly, calculate diurnal net load profiles for each month of the year and identify the month and hour with the highest average net load.

The difference between the highest average load and the highest average net load (step 5 minus step 6) is the amount of peak reduction associated with the penetration level assumed in step 3.

Figure C-1 shows the annual load contour for the Entergy planning region, by month and by hour averaged over each day of the month. The shading for each cell indicates average load for that hour (darker cells indicate higher average load). In this example, the highest average is 26,127 MW, which occurs for the hour beginning at 3 p.m. during the month of August. This is the block during which the annual peak is most likely to occur.

Figure C-2 shows average PV production for the year, mapped in the same manner as the data for load. PV output is expressed as a percentage of installed capacity (in megawatt electric [MWe]). In this example, PV production is 41% of capacity during the period when the system peak is most likely to occur (before accounting for PV). In other words, 100 MW of installed PV will most likely reduce demand by 41 MW during the typical 3 p.m. hour in August.

After adding the effect of PV, however, the hour beginning at 3 p.m. during the month of August will no longer be the peak. August demand declines by a very small amount over the period of an hour at that time of day; however, over that same time, PV's average output drops from 41% of its rated capacity to only 24%. The effect is that the system peak tends to fall at a later hour when accounting for the effect of PV.

If total rated capacity of rooftop PV throughout the Entergy region were 6% of peak demand, or 1,747 MWe, the annual system peak net of rooftop PV would still occur in August but would shift to an hour later. The new peak with rooftop PV would occur at 4 p.m. and would be 1.8% lower than it would have been at 3 p.m. without rooftop PV. This means that rooftop PV reduces peak load by less than 1 MW for every 3 MWe of installed rooftop PV capacity, when the system-wide penetration of rooftop PV is equal to 6% of peak load.

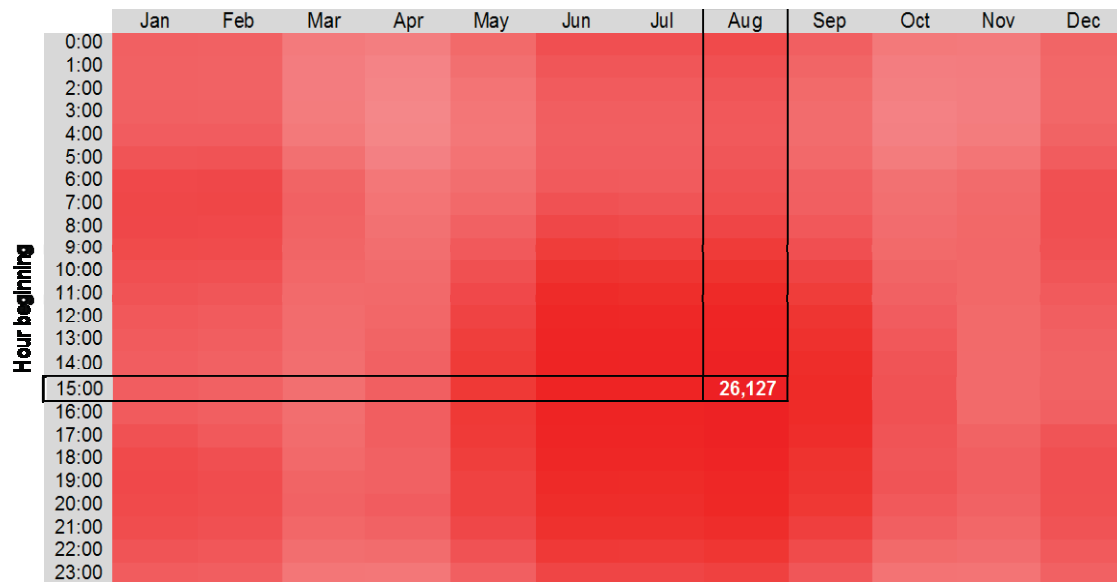


Figure C-1 Daily Demand Profiles by Month for the Entergy Planning Area (Darker shading indicates higher load. In this example, the annual peak is most likely to occur between 3 p.m. and 4 pm. on a day in August.)

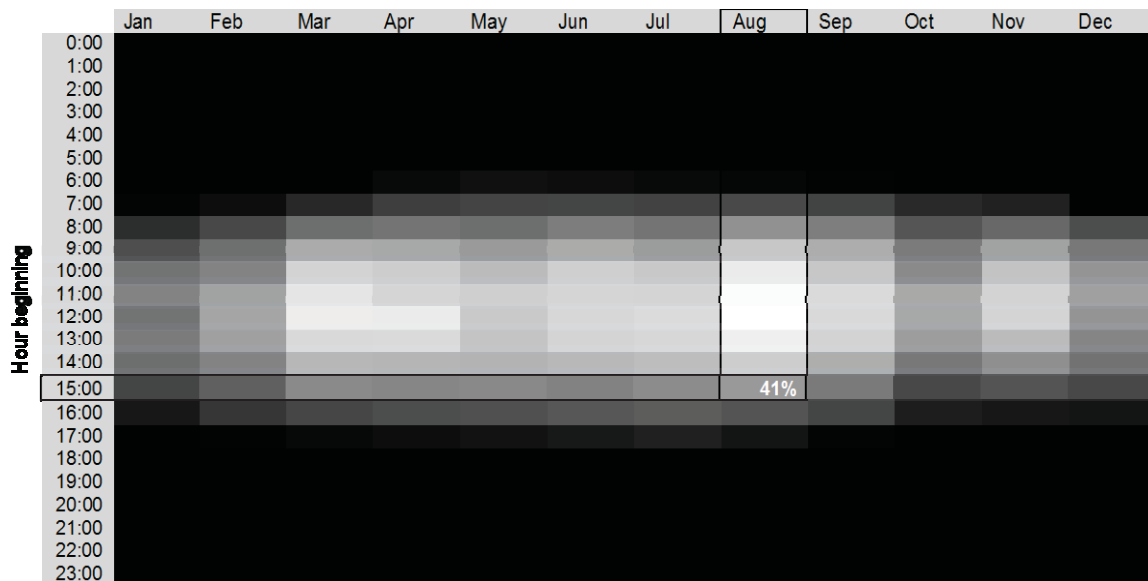


Figure C-2 Daily Production Profiles by Month for a PV Array Located in the Entergy Planning Area (Expressed as a percentage of installed capacity [assuming fixed mounting at an angle equal to latitude, with no shading obstacles]. Light shading indicates peak production; dark shading indicates no production. During the time that the annual peak is most likely to occur, the output of a PV system will most likely be 41% of its rated capacity.) (Source: NREL 2008)

Rooftop PV's peak-reducing effect is not linear, and at some point the effect tends to diminish as penetration increases (Mills and Wiser 2012). For simplicity, the above methodology was applied to three indicative penetration levels: 2%, 6%, and 10% of regional system peak. The EISPC Mapping Tool applies these values in estimating the peak reduction associated with a user-selected rooftop PV penetration level in a zone selected by the user.

C.5 Data and Sources

Modeled, satellite-based data available for annual insolation potential are the same as described in Section 3.6. Data were provided by the National Renewable Energy Laboratory (NREL) and are available at http://www.nrel.gov/gis/data_solar.html. The data include monthly average and annual average daily total solar resource for areas of 0.1 degrees in both latitude and longitude (~10 square kilometers [km²] in size). Additional data are described in Table C-1.

Table C-1 Rooftop PV Data and Sources^a

Information	Data and Source
The average number of floors per building type	EIA, 2005 Residential Energy Consumption Survey (RECS) and the 2003 Commercial Building Energy Consumption Survey (CBECS)
Total floor space	McGraw-Hill, FW Dodge Building Stock Database
Solar resource	http://www.nrel.gov/gis/data_solar.html
^a All metadata can be accessed via the EISPC EZ Mapping Tool.	

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Appendix D: Habitat Table

Dataset Name	Sensitivity Level
Appalachian Foothills Focus Area (OH)	Yellow
Aquatic Conservation Focus Area (MT)	Yellow
Aquatic Priority Area (TN)	Aquatic habitat prioritization = Very high: Orange Aquatic habitat prioritization = Medium, high: Yellow Aquatic habitat prioritization = Blank, low: Low conflict area
Aquatic Priority Conservation Area (AL)	Yellow
Artificial Reef	Yellow
Biodiversity and Wildlife Habitat Assessment (NC)	Conservation value = 5–10: Orange Conservation value = 1–4: Yellow Conservation value = -1: Low conflict area
Biodiversity (IN)	Yellow
Biological Hotspots (VT)	Yellow
Biologically Unique Landscape (NE)	Yellow
County Natural Heritage Inventory (CNHI): Core Habitat (PA)	Orange
CNHI: Landscape Conservation Area (PA)	Yellow
CNHI: Supporting Landscapes (PA)	Yellow
Cold-Water Coral Habitat	Yellow
Conservation Focus Area (NH)	Type of area = Core area: Orange Type of area = Supporting natural landscape: Yellow
Conservation Opportunity Area (MO)	Yellow
Conservation Opportunity Area (PA)	Yellow
Critical Habitat Area	Orange
Ecological Conservation Site (TN)	Biodiversity rank = B1, B2: Orange Biodiversity rank = B3, B4, B5, B?-Unknown, No Data: Yellow
Ecoregional Portfolio	Yellow
Environmental Sensitive Area (NJ)	Yellow
Focal Areas of Conservation Significance	Priority climate and current biodiversity area = Orange Priority climate area = Yellow
Focus Area (ND)	Yellow
Focus Area of Ecological Significance (ME)	Yellow
Forest Focal Areas – Atlantic Flyway	Yellow
Grand River/Mosquito Focus Area (OH)	Yellow
Great Lake Opportunity Area (WI)	Yellow
Green Infrastructure Network Characterization	Quality score = 4, 5: Orange Quality score = 1, 2, 3: Yellow
Greenway Corridor (RI)	Yellow

Dataset Name	Sensitivity Level
Habitats of Particular Concern	Yellow
Habitat Block/Wildlife Corridor (VT)	Final weighted score = 10, 9: Orange Final weighted score = 8, 7: Yellow Final weighted score = 1–6: Low conflict area
Highest Ranked Wildlife Habitat (NH)	Habitat condition rank = 1: Orange Habitat condition rank = 2, 3: Yellow
High Irreplaceability Area	Irreplaceable: Orange Not Irreplaceable: Low conflict area
Human Footprint (Northern Appalachian/Acadian Ecoregion)	Ranking of human influence = 0–20: Orange Ranking of human influence = 21–30: Yellow Ranking of human influence = 31–100: Low conflict area
Important Bird Area	Priority = Global, continental: Orange Priority = State: Yellow
Key Area for Conservation Action (NM)	Priority ranking for conservation planning = 13, 14, 15, 16: Orange Priority ranking for conservation planning = 9, 10, 11, 12: Yellow Priority ranking for conservation planning = 4, 5, 6, 7, 8: Low conflict area
Killbuck Focus Area (OH)	Yellow
Killdeer Focus Area (OH)	Yellow
Lake Erie Marsh Focus Area (OH)	Yellow
Landscape Permeability Flow Model	Flow rank = 9, 10, 11, 12: Orange Flow rank = 6, 7, 8: Yellow
Landscape v3.1 - Atlantic Coastal Region (NJ)	Conservation status of species present = State threatened, state endangered, federally listed: Orange Conservation status of species present = Suitable habitat, priority concern: Yellow
Landscape v3.1 - Delaware Bay Region (NJ)	Conservation status of species present = State threatened, state endangered, federally listed: Orange Conservation status of species present = Suitable habitat, priority concern: Yellow
Landscape v3.1 - Freshwater Mussel Habitat (NJ)	Conservation status of species present = State threatened, state endangered, federally listed: Orange Conservation status of species present = Priority concern: Yellow
Landscape v3.1 - Marine Region (NJ)	Orange
Landscape v3.1 - Piedmont Plains Region (NJ)	Conservation status of species present = State threatened, state endangered, federally listed: Orange Conservation status of species present = Suitable habitat, priority concern: Yellow
Landscape v3.1 - Pinelands Region (NJ)	Conservation status of species present = State threatened, state endangered, federally listed: Orange Conservation status of species present = Suitable habitat, priority concern: Yellow
Landscape v3.1 - Skylands Region (NJ)	Conservation status of species present = State threatened, state endangered, federally listed: Orange Conservation status of species present = Suitable habitat, priority concern: Yellow
Landscape v3.1 - Vernal Habitat (NJ)	Vernal pool habitat type = Vernal habitat area: Orange Vernal pool habitat type = Potential vernal habitat area: Yellow
Lasuan Focus Area (OH)	Yellow
Mountain Treasures Area	Priority = 1: Orange Priority = 0: Yellow
Natural Diversity Database (CT)	Yellow
Natural Heritage Area (NC)	Significance = National, state, region: Orange Significance = County: Yellow
Natural Heritage Area (RI)	Yellow
Natural Heritage Priority Site (NJ)	Biodiversity rank = B1, B1V1, B2, B2V1, B2V2: Orange Biodiversity rank = B3, B3V1, B3V2, B4, B4V1, B4V2, B4V3, B4V5, B5, B5V1, B5V2, B5V3, B5V4, B5V5: Yellow

Dataset Name	Sensitivity Level
Natural Landscape Assessment: Ecological Core (VA)	Ecological integrity score = 1, 2: Orange Ecological integrity score = 3, 4, 5: Yellow
Natural Services Network (NH)	Yellow
Natural Vegetation (IA)	Number of priorities for conservation = 10, 11: Orange Number of priorities for conservation = 2–9: Yellow Number of priorities for conservation = 1: Low conflict area
NHESP BioMap2 Core Habitat	Orange
NHESP BioMap2 Critical Natural Landscape	Yellow
National Wetlands Inventory (NWI) Dataset	Wetland type = Palustrine (emergent and forested): Orange Wetland type = Marine, estuarine, riverine, lacustrine, and palustrine (rock bottom, unconsolidated bottom, aquatic bed, unconsolidated shore, moss-lichen, and scrub-shrub): Yellow
Paint Creek Focus Area (OH)	Yellow
Potential Conservation Opportunity Area (GA)	Conservation opportunity ranking = 5, 6, 7: Orange Conservation opportunity ranking = 2, 3, 4: Yellow
Rare Species Concentration Area (MN)	Statewide biodiversity significance rank = Outstanding, high: Orange Statewide biodiversity significance rank = Moderate: Yellow Statewide biodiversity significance rank = Below: Low conflict area
Rare Species (MA)	Yellow
Rare, Threatened, and Endangered Species and Significant Community (VT)	G-rank = G1G2: Orange G-rank = G2, G2?, G2G3, G2G3Q, G3, G3?, G3G4: Yellow G-rank = G3G5, G4, G4?, G4G5, G4Q, G4T4, G5, G5?, G5?Q, G5?T3, G5?T5?, G5T1, G5T2Q, G5T3?, G5T3T4Q, G5T4, G5T4?, G5T4Q, G5T4T5, G5T5, G5T5?, G5TNR, GNA, GNR: Low conflict area
River Opportunity Area (WI)	Ecological significance = Continental: Orange Ecological significance = Upper Midwest, state: Yellow
Sensitive Species Project Review Area (MD)	Species status = Federally listed, state listed: Orange Species status = Species of concern to the Maryland Department of Natural Resources, bald eagle nest site: Yellow
Southeastern Ecological Framework Model	Identified area of Southeastern Ecological Framework = Yellow Unidentified area = Low impact
Subterranean Priority Area (TN)	Subterranean habitat prioritization = 4: Orange Subterranean habitat prioritization = 2, 3: Yellow Subterranean habitat prioritization = 0, 1: Low conflict area
Tecumseh Focus Area (OH)	Yellow
Terrestrial Conservation Focus Area (MT)	Yellow
Terrestrial Opportunity Area (WI)	Ecological significance = Global, continental: Orange Ecological significance = Upper Midwest, state: Yellow
Terrestrial Priority Area (TN)	Priority = Very high: Orange Priority = Medium, high: Yellow Priority = Low: Low conflict area
Terrestrial Priority Conservation Area (AL)	Yellow
Tier 1 Conservation Area (KY)	Yellow
VA Natural Landscape Assessment: Ecological Core	Ecological integrity score = 1, 2: Orange Ecological integrity score = 3, 4, 5: Yellow

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Appendix E: Protected Lands Table

Dataset Name	Sensitivity Level
Conserved Land (ME)	Conservation type = Fee: Red Conservation type = Easement, easement enforcer, lease, project agreement, restricted, third-party easement: Orange Conservation type = Public Access Easement, blank: Yellow
Conserved Land (NH)	Gap status = 1: Red GAP status = 2: Orange GAP status = 3: Yellow GAP status = 3A, 4, 9: Low conflict area
Cross Ranch State Nature Preserve (ND)	Red
Florida Conservation Land (FL)	Protection status = 1: Red Protection status = 2: Orange Protection status = 3: Yellow
Florida Forever Board of Trustees Project Area (FL)	Work plan priority = High, high/med, medium: Orange Work plan priority = Medium/low, low: Yellow
Marine Protected Areas Database	GAP status = 1: Red GAP status = 2: Orange GAP status = 3: Yellow GAP status = 4: Low conflict area
Marine Sanctuary	Red
National Conservation Easement Database	Orange
National Trail	Yellow
Natural Area (DE)	Yellow
Natural Heritage Inventory Managed Area (OK)	Yellow
Protected Areas Database	GAP status = 1: Red GAP status = 2: Orange GAP status = 3: Yellow GAP status = 4: Low conflict area
Scenic Byway	Yellow
Sentinel Butte State Nature Preserve (ND)	Red
State Claimed Water Body (LA)	Yellow
State Owned/Leased Land (LA)	Yellow
U.S. Forest Service Roadless Area	Red

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State-by-State Existing and Potential Clean Energy Zones: Survey of Relevant State Laws, Rules, Regulations and Orders in the Eastern Interconnection

September 2013 •



**Clean Energy States Alliance
For EISPC and NARUC
Funded by the U.S. Department of
Energy**

**Eastern Interconnection Planning Council (EISPC)
Clean Energy Zones Policy Project
Final Report**

**State-by-State Existing and Potential Clean Energy Zones -
Survey of Relevant State Laws, Rules, Regulations and Orders
in the Eastern Interconnection**

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Acknowledgement:

This material is based upon work supported by the Department of Energy, National Energy Technology Laboratory, under Award Number DE-OE0000316.

The authors would like to thank Bob Pauley, Doug Gotham and colleagues at Purdue University, Stan Hadley, and Jim Wilson for their contributions to the report as well as the EISPC and NARUC Organizations. Opinions expressed in this report, as well as any errors or omissions, are the authors' alone.

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Introduction: Purpose of the Clean Energy Zones Policy Project— and of This Report

Clean Energy States Alliance (CESA)—along with its subcontractor eFormative Options (EFO)—received a contract from the National Association of Regulatory Commissioners (NARUC) to inventory publicly enacted state and regional policies, laws, regulations, and orders that either promote, encourage, or inhibit the development of clean energy technologies. The information collected through this inventory has been included as part of the Eastern Interconnection States' Planning Council (EISPC) Energy Zones Study and Mapping Tool. Users of the Mapping Tool with an interest in clean energy development in a particular area can see and learn about public policies that are relevant to clean energy development in that area.

CESA worked under the direction of the EISPC Clean Energy Zones Workgroup and coordinated its efforts closely with the team from the National Laboratories that developed the EISPC Energy Zones Mapping Tool. NARUC provided administrative oversight of the project. We are grateful for the cooperation shown us by the National Laboratory team and for the valuable direction and advice we received from the Energy Zones Workgroup and from NARUC. We especially want to thank Commissioner David Littell, chair of the Workgroup, for the active interest he has taken in our work and for his wise counsel, as well as Miles Keogh and Sharon Thomas for their guidance and help on administrative issues. The US Department of Energy (DOE) provided the necessary funding for this project, and we very much appreciate DOE's foresight in deciding that an Energy Zones policy inventory would be useful and desirable.

EISPC and NARUC determined that the inventory should include the following technologies:

- biomass
- coal with carbon capture and storage (new and retrofitted)
- geothermal
- natural gas (EISPC added this to the list of technologies in September 2012)
- nuclear
- solar (utility-scale and rooftop photovoltaic and concentrated solar thermal)
- storage (pumped-hydro and compressed-air)
- water (new and incremental hydropower, tidal, wave)
- wind (on-shore and off-shore).

The inventory includes information about the 39 states in the Eastern Interconnection, the District of Columbia, New Orleans, and the 8 Canadian provinces that are linked to the Eastern Interconnection.

In preparing the inventory, all parties assumed from the beginning that CESA would start with the existing Database of State Incentives for Renewable Energy (DSIRE), which is separately funded by DOE and managed by the North Carolina Solar Center and the Interstate Renewable Energy Council. After assessing the accuracy and completeness of the DSIRE database, and receiving feedback on its accuracy from EISPC, CESA identified and collected additional policies to include in the Energy Zones policy inventory. The final EISPC Energy Zones

inventory is more than three times the size of the portion of the DSIRE database that is relevant to electricity generation in the EISPC region.

This report describes the process the CESA project team used in carrying out our research, data collection, and preparation of the policy inventory for incorporation into the EISPC Mapping Tool. It also includes tables with the key information included in the inventory, as well as suggestions for maintaining the accuracy and completeness of the inventory over time.

A. Organizing the Work

An important initial task was to ensure that CESA's work would be carried out in a way that would meet EISPC's needs and that would efficiently lead to a high-quality end product. We took a range of steps to make sure that this happened.

Coordination Protocols

Early on in the project, after consultation with the Energy Zones Workgroup (EZWG), we established the following coordination principles:

- EZWG and the EISPC as a whole were our clients, as well as the decision makers for the Energy Zones Study. It was essential for us to seek and receive approval from EZWG for all key decisions related to research approaches, inventory concepts, and projected final products.
- To make it possible for EZWG to make relevant decisions about our work, we needed to communicate with them regularly and provide them with information in a form and at a time that gave them the ability to make sound decisions.
- Because our work was one piece of a larger project, it was important that we deliver our work products on schedule. (Because of a delay in finalizing a contract for the project, it was necessary to make some adjustments to some of the initial deliverables dates.)
- To ensure that our work products fit seamlessly into the mapping tool, it was necessary for us to work closely with the team from the National Laboratories.

In applying these principles, we took the following steps:

- Participated in all EZWG Meetings.
- Met regularly (at least monthly) with representatives of the National Lab team.
- Submitted written inquiries and reports to the EISPC staff.
- Submitted any items that we wished to present to EZWG by the Monday preceding an EZWG meeting.
- Presented design options, information requests, and partial database drafts to the EZWG in manageable chunks as they were ready rather than waiting until right before deliverables deadlines to submit completed work products, when there would no longer be time for the EZWG to request changes.
- Submitted progress reports that clearly identified points and issues that required EZWG attention and action.
- Met deliverables deadlines, as updated in the executed contract.

Understanding the Assignment

Another important early task was to make sure that we understood the assignment and were organizing the work in an appropriate manner. By reading much of the material that had been

produced by or for the Energy Zones Workgroup, we sought to understand the perspectives, work processes, and needs of the Workgroup. We found it to be especially helpful to participate in the Friday meetings of the Workgroup, both to learn about current thinking about the Energy Zones project and to have an opportunity to ask questions that helped us develop and refine our research plan.

To understand the status of the National Lab team's efforts and to make sure that we were coordinating our work closely with that team, we held three meetings with James Kuiper and others at Argonne National Lab (ANL) during the early weeks of the project. It was important for us to understand the technical specifications for the EZ Mapping Tool so that we would be able to develop the policy material in a format that allows it to be included easily and seamlessly in the mapping tool.

Needs Assessment

Although we started with a clear charge for our assignment, as set out by the Request for Proposals that had been issued by NARUC and by the initial guidance we received from EZWG, we wanted to make sure that we had a more complete picture of what stakeholders might want from the policy inventory and database we would be preparing. We therefore sought to find out what information various stakeholders wanted to see in the policy database and how they thought that information should be presented on the website and in our report. In addition to asking for feedback from the Workgroup and the National Lab team, we reached out to a representative sample of more than 30 state policymakers, industry representatives, and NGO stakeholders. We asked for their feedback on the DSIRE database, as well as their desires for the new policy inventory and Mapping Tool.

Those who provided responses were all familiar with the DSIRE database and used it regularly; two felt that the DSIRE material was not kept sufficiently up-to-date. Stakeholders hoped that, by linking the Mapping Tool to the EISPC policy database, they would be able to compare energy policy and finance tools among states, especially if the various layers could be linked to data charts and tables for easy comparison. In addition, stakeholders felt that incorporating local and county incentives into the Mapping Tool would be highly beneficial to them. While not directly relevant to the policy inventory, several stakeholders suggested showing transmission queue data for various energy technologies and including costs into the database for cost analysis.

B. Information Gaps

Before beginning to collect information for the policy inventory, we had to determine what types of information we needed to collect.

Assessing the Accuracy and Completeness of DSIRE

Because the DSIRE database was an important starting point for the Energy Zones policy inventory, it was important for us to understand the full scope, strengths and limitations of the DSIRE database. We therefore carried out a full comparison of the information in DSIRE for two states (Maine and Wisconsin) with information about clean energy policies available directly from those states. Our conclusions from that exercise were:

- The information in DSIRE was generally sufficiently current for the purposes of the Energy Zones policy database. In fact, in some cases, the DSIRE database had been updated more quickly than a state's own website.
- Information in DSIRE on state policies was sufficiently accurate for the purposes of the Energy Zones policy database, or could be readily modified if inaccuracies were identified and reported.
- Information in DSIRE on policies that apply only to portions of states was not always complete enough or organized in an appropriate manner to be transferred automatically to the Energy Zones policy database.

We therefore concluded that we should attempt to include the relevant information from DSIRE electronically in the Energy Zones policy inventory and EZ Mapping Tool website. We wanted especially to ensure that ongoing updates and changes made to DSIRE entries would be reflected automatically in the Energy Zones website, because that would significantly simplify EISPC's task in updating and maintaining the policy inventory over time.

Although we found that DSIRE had a high degree of accuracy for the information on the topics it covered, as we prepared the EISPC policy inventory, we referred to the websites of the individual states to cross-check the information in DSIRE and capture relevant individual policies omitted from DSIRE. One important addition we made to DSIRE's coverage of renewable energy related to the treatment of renewable portfolio standards (RPSs). We added in export market information about all of the state RPSs for which generation in a specific location can qualify. In many cases, projects can sell their renewable energy certificates to five or more states. Because this information significantly impacts a project's potential revenue stream but is not included in DSIRE, it represents a significant added value of the EZ policy inventory.

Additional Technologies

Even though DSIRE was generally sufficiently accurate for the purposes of the Energy Zones project, it did not include all the technologies that the EISPC inventory needed to cover. We therefore identified and assessed other sources of information on those additional technologies. Among the information sources we examined were:

- Coal with carbon capture and storage: the National Carbon Sequestration Database, MIT's Carbon Capture and Sequestration Technologies website, the Carbon Sequestration Leadership Forum, and other organizations.
- Energy storage (pumped hydro and compressed air): databases of the Federal Energy Regulatory Commission (FERC), the Electricity Storage Association, US DOE, and the Coalition to Advance Renewable Energy through Bulk Storage.
- Natural gas: American Gas Association
- Nuclear: resources from the Nuclear Energy Institute, the Nuclear Regulatory Commission, and US DOE.

We ultimately determined that these information sources could point us towards some specific relevant policies to include, but there were no existing databases of the additional technologies that were sufficiently comprehensive for us to rely on. For example, the Nuclear Energy Institute website has a useful policy listing that included some policies that we might otherwise have overlooked, but it is incomplete and not kept sufficiently current. We therefore searched for

policies on the additional technologies on a state-by-state basis using the legislative and regulatory agency websites of the individual states.

We also considered the existing coverage of the additional technologies in OpenEI, which is a program of US DOE and the National Renewable Energy Lab (NREL). OpenEI provides users with an easy-to-use wiki interface for contributing structured and unstructured data. It includes more policies than in DSIRE, but its “crowd sourcing” approach means that it is not always comprehensive or completely reliable. We therefore decided to search OpenEI for non-DSIRE policies that we should include, but to always go back to the state websites before including those policies in the EISPC policy inventory.

In the case of the additional technologies, we had to decide how broad a net to cast when collecting policies for possible inclusion in the inventory. In the case of natural gas, for example, it did not make sense to include all natural gas state-level policies, because some of them had little to do with electricity generation projects. Based on guidance from EZWG, we included policies related to natural gas power plants, as well as to drilling and pipeline siting, construction, safety, and maintenance. We excluded policies related to the regulation of natural gas utilities’ relationships with their customers (e.g., energy conservation programs for home heating customers).

Other Types of Policies

Beyond additional technologies, we needed to include a wider range of policies than DSIRE in order to have the EISPC inventory be a comprehensive listing of policies that promote, encourage, or inhibit the development of clean energy technologies. In particular, we concluded we should survey and include:

Economic development policies. DSIRE had good coverage of economic development policies that are specifically aimed at renewable energy projects and businesses (e.g., Montana’s Alternative Energy Investment Tax Credit and Illinois’ Green Energy Loan Program), but it did not include more generic economic development policies that can, at least in some circumstances, apply to electricity generation projects. The CESA project team, after consulting with EZWG, decided to include these policies.

The best starting point for economic development incentives that can apply to businesses developing clean energy generation projects is the database of the Council for Community and Economic Research’s State Business Finance and Incentives Resource Center (www.stateincentives.org). Although this database includes an extensive list of policies, it has significant limitations. For one thing, it is not updated often enough to encompass all policy developments at the state level. In addition, many of the incentives in the database cannot be used by clean energy businesses, because they are restricted to other industries. We therefore used the Resource Center’s database as a tool to help identify relevant incentives, but then researched the websites of state economic development agencies to find the current status and accurate descriptions of the incentives.

Environmental regulations. Environmental regulations represent the largest category of policies that restrict the installation of clean energy generation. Those regulations cover land use, air emissions, water use and water pollution, and hazardous materials. This was the most

complicated and time consuming information gap to fill, because there are no comprehensive repositories of state-level environmental regulations and many of the relevant regulations are not aimed specifically at energy projects, but are instead more general policies that impact a wide range of development projects. We held conversations with environmental regulation experts at the US Environmental Protection Agency, at ISO-New England, at the Environmental Council of the States, and in state agencies to try to get a handle on how to tackle this information gap. We ultimately used the websites of state environmental agencies to do a state-by-state search for relevant policies.

Forestry policies. Because electricity generation facilities that rely on woody biomass can be affected by the forestry policies in the states near the facility, it was desirable to include information about those policies. But a state can have many forestry policies, some of which may change frequently. EZWG therefore advised us to summarize each state's forestry policies with a single entry in the Energy Zones policy inventory. We relied on the websites of forestry-related state agencies for information about those policies.

Climate plans. In those cases where a state climate action plan is specific enough that it could potentially drive future clean energy development, we included it in the policy inventory. We used the Center for Climate Strategies' policy tracker (www.climatestrategies.us/policy_tracker/state/index) as a starting point but then reviewed the information on state websites before preparing an entry for the policy inventory.

Canadian Provinces

In the case of Canada, we included a narrower set of policies than for US states. We focused on those policies—either national or provincial—that relate to clean energy generating facilities that could export their power to one of the EISPC states. Among the policies we included were climate action plans and energy plans for those provinces that had such documents, as well as major economic development policies. We did not include policies solely related to on-site distributed generation in the Canadian provinces.

In carrying out our research on Canada, we started with the Directory of Energy Efficiency and Alternative Energy Programs in Canada, hosted by Natural Resources Canada (NRCan). The NRCan Directory includes data on all of the technologies included in this project. We initially thought that we would be able to use that Directory in a way comparable to DSIRE for the US, and that the Energy Zones Mapping Tool would be able to electronically access relevant records.

To determine whether it made sense to rely on the NRCan Directory and to bring records electronically to the Energy Zones Mapping Tool, we compared the Directory to the records from individual provincial governments. We also held conversations with Canadian government staff who work on the Directory in order to understand its strengths and limitations. After a thorough analysis, we concluded that the NRCan Directory was a useful starting point, but it was incomplete and not always kept up to date.

We therefore needed to consult the websites of the individual provinces and in some cases public utilities for Canadian policies to include in the inventory. For Quebec, this proved somewhat challenging, as many of the policy documents and program websites are online solely in French.

We used Google Chrome's ability to translate entire pages for the websites, but PDFs were not able to be easily translated.

For federal Canadian programs and policies, we first searched the NRCan Directory as a starting point and looked at individual federal departments and programs for additional potential entries.

C. Methodology and Protocols for Handling Data for the Inventory

In July 2012, we sketched out possible approaches for the design of the policy database. The options varied primarily in the amount of descriptive information that would be provided about each state's policies. From feedback we received from the Workgroup and the National Lab team, we received the following guidance:

- If possible, the finished product should include short overview general descriptions of each state's policies.
- Descriptions should be based on objective criteria and should avoid anything that appears to be opinion. For that reason, policies should not be ranked by "importance" but that significance determined by objective criteria, such as how much clean energy generation has resulted or is expected to result from the policy, could be useful to note.
- The database should be easy to maintain. It should avoid features that will be difficult to keep current. For that reason, where possible, it should incorporate electronic feeds from trusted websites and databases, including DSIRE.

Working with the National Lab team, we explored options for developing an online database and interface that would be accessible in spatial database format in the EZ Mapping Tool. We considered only options that would work both with the selected entries from DSIRE and with the new policy summaries prepared by the CESA team.

Design of the Inventory and the Online Database for Storing It

In pursuit of an efficient strategy for structuring and ultimately maintaining the policy inventory in the EZ Mapping Tool, we explored using the OpenEI wiki (mentioned above on page 6), which is separately sponsored by DOE and staffed by NREL as a "knowledge-sharing online community with an unprecedented amount of energy information and data." We assessed whether it would be feasible for the CESA team to enter and store information on all of the state policies for inclusion in the EZ inventory within OpenEI. After much careful consideration, several meetings with the OpenEI staff and consultation with Argonne and the EZ Workgroup, we concluded that this approach would be highly advantageous. We therefore moved forward in working with NREL to establish a primary storage database for the EZ policy inventory within OpenEI, and OpenEI staff worked closely with us to utilize many features of its wiki to create and facilitate review and utilization of the EZ policy data.

There are several benefits for using OpenEI to store the EZ policy information:

- OpenEI has a pre-existing, applicable database structure and an established "crowd source" process for checking, editing, and updating entries. This database interface has proven itself to be successful and user-friendly.
- The National Lab team avoided having to design a separate database for policies and setting up editing protocols for policy data within the EZ Mapping Tool.

- The DSIRE information is already in OpenEI, so the DSIRE entries selected for inclusion in the EZ policy inventory can “feed” together directly. The DSIRE entries that appear in the EZ Mapping Tool will be up-to-date whenever DSIRE information is updated in OpenEI, and the OpenEI wiki will ease future updates of the EZ policy data.

NREL OpenEI staff helped us create a tailored data entry form, establish required database fields and protocols, and import initial entries compiled in Excel spreadsheets into a consistent format. We worked together to fine-tune the EZ and DSIRE policy data entry forms with pull-down menus, check boxes, mandatory fields, and help tips; create and adjust database fields and queries; and conduct quality control and cleanup steps. The database structure now holds more than 2,300 EZ policy summaries including about 700 entries selected from DSIRE.

We worked with ANL and OpenEI staff to establish effective access of the EZ policy database from the EZ Mapping Tool. We discussed the policy user interface for the GIS viewer, the spatial aspect of policies, and maintenance options and requirements. Representatives of ANL suggested coding a search form in the EZ Mapping Tool website that would be able to query policy data and display geographic layers within the ANL mapping tool. We worked with OpenEI staff to utilize the DSIRE schema and metadata tags to assist with building the “back end” of the EZ policy inventory database structure so that all policy summaries can be queried in consistent categories in the ANL tool.

We closely reviewed the categories used in DSIRE and determined both which selections should be flagged as “relevant for EZ Mapping Tool” and what naming adjustments were needed, shown below. We developed a name mapping key to assist with converting policy information that the CESA team compiled in Excel spreadsheet format into the OpenEI database, along with notes for naming and importing entries. The mapping key also aids with translating column headings of OpenEI CSV data exports, because the property names in OpenEI are often cryptic.

DSIRE Form Technology Description	Include in EZ Inventory?	Rename for EZ Inventory
Anaerobic Digestion	Yes	Biomass/Biogas
Biodiesel	Yes	Biomass/Biogas
Biomass	Yes	Biomass/Biogas
CHP/Cogeneration	No	
Daylighting	No	
Ethanol	Yes	Biomass/Biogas
Fuel Cells	Yes	
Fuel Cells using Renewable Fuels	Yes	Fuel Cells
Geothermal Direct Use	No	
Geothermal Electric	Yes	
Geothermal Heat Pumps	No	
Hydroelectric	Yes	
Hydrogen	Yes	Energy Storage
Landfill Gas	Yes	Biomass/Biogas
Methanol	Yes	Biomass/Biogas
Microturbines	Yes	Energy Storage
Municipal Solid Waste	Yes	Biomass/Biogas

DSIRE Form Technology Description	Include in EZ Inventory?	Rename for EZ Inventory
Ocean Thermal	No	
Other Alternative Fuel Vehicles	No	
Other Distributed Generation Technologies	No	
Passive Solar Space Heat	No	
Photovoltaics	Yes	
Refueling Stations	No	
Renewable Fuels	Yes	Biomass/Biogas
Renewable Fuel Vehicles	No	
Renewable Transportation Fuels	Yes	Biomass/Biogas
Small Hydroelectric	Yes	Hydroelectric
Small Wind	Yes	Wind Energy
Solar Pool Heating	No	
Solar Space Heat	No	
Solar Thermal Electric	Yes	Concentrating Solar Power
Solar Thermal Process Heat	No	
Solar Water Heat	No	
Tidal Energy	Yes	
Wave Energy	Yes	
Wind	Yes	Wind Energy
Unspecified technologies	Review	Include if Coal with CCS, Natural Gas, Nuclear, or Energy Storage (pumped-hydro and compressed-air)

For policies where “all” technologies are affected, we designated which states should not have tidal power selected (those without ocean shorelines), and which should not have wave power selected (those without ocean or Great Lakes shorelines).

The policy type category was somewhat more complicated in that more new fields were needed for the EZ inventory, and we wanted to group some of the DSIRE fields together to simplify selections and designate policies to flag as financial incentives. We also worked with OpenEI staff to adjust the database parameters so that more than one policy type could be selected for a single entry.

Policy Type	Database	Include in EZ Inventory?	Rename for EZ Inventory	Financial Incentive
Appliance/Equipment Efficiency Standards	DSIRE	No		
Bond Program	EZ			Yes
Building Energy Code	DSIRE	No		
Climate Policies	EZ			
Corporate Depreciation	DSIRE	Yes	Corporate Tax Incentive	Yes
Corporate Exemption	DSIRE	Yes	Corporate Tax Incentive	Yes
Corporate Tax Credit	DSIRE	Yes	Corporate Tax Incentive	Yes
Energy Efficiency Resource Standard	DSIRE	No		
Energy Standards for Public Buildings	DSIRE	No		
Enterprise Zone	EZ			
Environmental Regulations	EZ			

Policy Type	Database	Include in EZ Inventory?	Rename for EZ Inventory	Financial Incentive
Equipment Certification	Both	Yes		
Equity investment	EZ			
Federal Grant Program	DSIRE	Yes	Grant Program	Yes
Federal Loan Program	DSIRE	Yes	Loan Program	Yes
Fees	EZ			
Generating Facility Rate-Making	EZ			
Generation Disclosure	Both	Yes		
Green Building Incentive	Both	Yes		Yes
Green Power Purchasing	Both	Yes		
Industry Recruitment/Support	Both	Yes		Yes
Interconnection	Both	Yes		
Leasing Program	Both	Yes		Yes
Line Extension Analysis	Both	Yes		
Local Grant Program	Both	Yes	Grant Program	Yes
Local Loan Program	Both	Yes	Loan Program	Yes
Local Rebate Program	Both	Yes	Rebate Program	Yes
Mandatory Utility Green Power Option	Both	Yes		
Net Metering	Both	Yes		
Non-Profit Grant Program	Both	Yes	Grant Program	Yes
Non-Profit Rebate Program	Both	Yes	Rebate Program	Yes
Other Incentive	DSIRE	Review		Yes
Other Policy	DSIRE	Review		
PACE Financing	Both	Yes		Yes
Performance-Based Incentive	Both	Yes		Yes
Personal Deduction	DSIRE	Yes	Personal Tax Incentives	Yes
Personal Exemption	DSIRE	Yes	Personal Tax Incentives	Yes
Personal Tax Credit	DSIRE	Yes	Personal Tax Incentives	Yes
Property Tax Incentive	Both	Yes		Yes
Public Benefits Fund	Both	Yes		
Renewables Portfolio Standard	Both	Yes	Renewable Portfolio Standards and Goals	
Safety and Operational Guidelines	EZ			
Sales Tax Incentive	Both	Yes		Yes
Siting & Permitting	EZ			
Solar/Wind Access Policy	Both	Yes		
Solar/Wind Contractor Licensing	Both	Yes		
Solar/Wind Permitting Standards	Both	Yes	Siting & Permitting	
State Bond Program	DSIRE	Yes		Yes
State Grant Program	Both	Yes	Grant Program	Yes
State Loan Program	Both	Yes	Loan Program	Yes
State Rebate Program	DSIRE	Yes	Rebate Program	Yes
Training/Technical Assistance	EZ			
Utility Grant Program	Both	Yes	Grant Program	Yes
Utility Loan Program	Both	Yes	Loan Program	Yes
Utility Rate Discount	DSIRE	Yes		Yes
Utility Rebate Program	Both	Yes	Rebate Program	Yes

Policy Type	Database	Include in EZ Inventory?	Rename for EZ Inventory	Financial Incentive
Workforce Development	EZ			

After consultation with staff from the North Carolina Solar Center, we added additional fields and properties to the DSIRE data entry forms to aid with EZ inventory queries. OpenEI staff applied our requested filters to the DSIRE entries to designate which policies are “Relevant to EZ Mapping Tool” and conducted troubleshooting to ensure only the correct technologies were selected. OpenEI staff also created a tailored EZ Inventory Map with US states and Canadian Provinces as a starting point to streamline viewing of data, with both selected DSIRE and added EZ policies “feeding” into summary tables: <http://en.openei.org/wiki/EZPolicies>

NREL’s assistance, training, and guidance were instrumental in setting up and refining the EZ policy inventory in OpenEI. The OpenEI system remains available for ongoing updates and maintenance. Both the EZ policy data and selected DSIRE entries are able to be displayed equally and are equally searchable in the EZ Mapping Tool. We are very appreciative of NREL’s and ANL’s cooperation and support in utilizing OpenEI to host the EZ policy inventory database.

Need for Fine-Tuning the Interface between OpenEI and the EZ Mapping Tool

Despite the cooperation between the Mapping Tool staff at ANL and the OpenEI staff at NREL, working in conjunction with the CESA team, the interface between OpenEI and the EZ Mapping Tool required more time and attention to get it to work smoothly and efficiently. We had regular meetings between January and June 2013 to address specific issues and develop solutions for particular problems. In between meetings, the ANL and OpenEI staff did the coding necessary to implement many of the solutions identified.

Many of the issues had to do with ensuring the information displayed by the Mapping Tool was accurate and avoiding making the query interface too cumbersome. For example, ANL limited the number of policy entries that can be returned in response to a search by a Mapping Tool user to 200 and also restricted the number of filter items from the four query boxes to 10. Selecting no filters in a given query box is equivalent to selecting all categories to display, so all technologies or policy types can be reviewed within a given state.

We also fine-tuned the procedures users would do when searching the inventory, in order to make the search process intuitive and understandable.

The CESA team identified additional issues for ANL and OpenEI to address, such as translation of the text within OpenEI and the EZ Mapping Tool. Due to security concerns, remnants of HTML code in OpenEI entries, as well as items like ampersands (&), posed challenges for the display, with extraneous text reflecting the HTML coding appearing (such as “&,” in the Policy Type “Siting & Permitting”).

Recent efforts have focused on refining the interface and display, improving the data review and approval process, troubleshooting minor errors and faulty database/interface behaviors, and adding further functionality. Some issues such as OpenEI’s query size parameter, typos, and text nuances in coding; complex queries leading to time-outs on the OpenEI server; edits made in

OpenEI flowing immediately through the query before review; and a gap in edit notifications have been resolved successfully and others are still in progress. For example, ANL intended to convert the initial “Ask query” interface to a Javascript (JSON) API (Application Programming Interface) after an OpenEI upgrade was completed. This step or utilizing OpenEI’s Simile Exhibit Transport Toolkit would make the interface more stable and remove some limitations but will require further coordination between NREL and ANL as will identifying a more complete “data dictionary” explaining abbreviations used in the DSIRE database. The “last date updated or reviewed” has been added to some records but not yet to all. However, most of the technical issues identified have been addressed and the interface seems to be working effectively for users.

D. Policy Research: Populating the Inventory

The largest amount of work for this project involved collecting information on individual policies and populating the inventory with that information. Our process was to have a junior staff member produce a draft inventory for a particular state and then have it reviewed by a more experienced staff member.

By mid-November 2012, we completed draft inventories for 25 states plus the District of Columbia and the 8 Canadian provinces. Draft inventories of the remaining states, New Orleans, and Canadian national policies were completed by the end of December.

The Process for Compiling Policy Data

We used the following overall process to compile the policy data:

- CESA policy associates prepared Excel spreadsheets for each state with policies for inclusion in the inventory, with 26 columns for tracking information such as the policy/program name, policy type, affected technologies, implementing sector, applicable sectors, funding source, program budget, start date, authority, contact information, summary, and applicable jurisdiction.
- We looked for and identified policies, laws, and data that identify specific zones for clean energy development and/or areas of exclusion.
- Additional CESA team members conducted a series of cleanup steps on the spreadsheets to ensure the entries were consistent and ready for import into OpenEI.
- We created EISPC-wide spreadsheets for policies on RPS Export Markets, climate action plans, and forestry policies.
- We submitted the Excel files to NREL for import into OpenEI.
- NREL imported the spreadsheet data first into the OpenEI “development” site to test for data issues, and then copied the data to the OpenEI “production” site for population through the server and public viewing.
- Additional CESA team members reviewed the imported data on a state-by-state basis for clarity, completeness, relevance, and consistency. In particular, we ensured that each of the policy description summaries makes sense and can stand alone without the reader having to refer to some other policy entry or other document to understand them.
- The CESA team reviewers “approved” each entry in OpenEI, which established an initial status for edit suggestions by third parties.

- CESA reviewers determined whether anything was obviously missing from each state inventory, considering that the following types of policies should be included for most states:
 - Environmental regulations, including ones related to water, air, hazardous materials, solid waste, and land use
 - Policies related to natural gas (often grouped)
 - Generic economic development policies
 - Climate policies, nuclear, mining policies, and policies related to permitting may also be included.
- For Canadian policies, we created entries directly in OpenEI using our tailored data entry form: http://en.openei.org/wiki/Form:EZFeed_Policy.
- We conducted overall quality control reviews for consistency, spell-checking, and gap analysis to ensure all searchable fields are filled in – both in the EZ and DSIRE entries.

Overviews of States

For each state, we wrote a short policy overview summary of one to two pages. When an EZ Mapping Tool user requests to see the policies for a particular state, the summary appears at the top of the search results. Our goal was to provide a general introduction to the state’s energy policies and a context for understanding individual policies.

Each state summary has the same format. It starts by listing how much total electricity was generated within the state in 2012 and follows that with a table that breaks down the generation by the percentage generated using different energy sources and technologies. The remainder of the summary is a series of bullets that point out key aspects of the state’s energy policy landscape.

Unlike all the other policy entries, which reside in OpenEI, the state summaries are PDF documents and are stored directly on the ANL website. For technical reasons, this was a more efficient process and makes it easier to display the summary at the top of the results for the selected state when users do a policy search. In the future it may be preferable for ANL to display these as web text and be more readily editable by CESA and EISPC members while still not being as openly crowd-sourced as the detailed policy entries.

Existing Clean Energy Zones

In our efforts to identify and inventory geographic zones or areas already identified by states for clean energy generation development by legal jurisdictions, we documented the following policies and incentives within the EZ policy database which apply to specific regional zones. In addition to existing energy zones, where specific priority or incentive has been placed on the development of renewable and other energy applications, these policies include enterprise zones, where new business development is promoted through tax credits or other economic incentives, as well as regionally defined ordinances and guidelines pertaining to the development and implementation of energy projects. The list below highlights 70 such entries in the EZ policy database, located in 30 U.S. States and the District of Columbia. Complete records for the following entries are included in the Excel spreadsheet attached as Appendix 3 to this report:

- | | |
|---|--|
| • Coastal Area Management Program (Alabama) | • Tax Increment Financing Program (TIF) (District of Columbia) |
| • Enterprise Zone Program (Alabama) | |

- The Enterprise Zone Program (District of Columbia)
- Energy Economic Zone Pilot Program (Florida)
- Enterprise Zone Incentives (Florida)
- Qualified Target Industry Tax Refund (Florida)
- Coastal Management Act (Georgia)
- Enterprise Zone Program (Georgia)
- Enterprise Zone Program (Illinois)
- Sales Tax Exemption for Wind Energy Business Designated High Impact Business (Illinois)
- Economic Development Project Districts (Indiana)
- Industrial Development (Indiana)
- Redevelopment of Areas Needing Redevelopment Generally (Indiana)
- Special Improvement Districts for Redevelopment of Blighted Areas (Indiana)
- Enterprise Zones (Iowa)
- Small Wind Innovation Zone Program and Model Ordinance
- Enterprise Zone Sales Tax Exemption (Kansas)
- Kentucky Economic Opportunity Zone Program (KEOZ) (Kentucky)
- Coastal Management (Louisiana)
- Enterprise Zone Program (Louisiana)
- Expedited Permitting of Grid-Scale Wind Energy Development (Maine)
- Pine Tree Development Zones Program (Maine)
- Regulation of Tidal and Wave Energy Projects (Maine)
- Charles County - Agricultural Preservation Districts - Renewable Generation Allowed (Maryland)
- Coastal Facilities Review Act (Maryland)
- Focus Area Tax Credits (Maryland)
- Job Creation Tax Credit (Maryland)
- Maryland Enterprise Zone Tax Credits (Maryland)
- Queen Anne's County - Solar Zoning (Maryland)
- Green Communities Grant Program (Massachusetts)
- Public Waterfront Act - Chapter 91 (Massachusetts)
- Nonrefundable Business Activity Tax Credit (Michigan)
- Refundable Payroll Tax Credit (Michigan)
- Renewable Energy Renaissance Zones (Michigan)
- Job Opportunity Building Zones (JOBZ) Initiative (Minnesota)
- The Border Cities Enterprise Zone Program (Minnesota)
- Wind and Solar-Electric (PV) Systems Exemption (Minnesota)
- Enhanced Enterprise Zones (Missouri)
- Renewable Energy Generation Zone Property Tax Abatement
- Empowerment Zone Tax Credit (Montana)
- Coastal Permit Program Rules (New Jersey)
- Solar and Wind Permitting Laws (New Jersey)
- Urban Enterprise Zone Program (New Jersey)
- Wind Manufacturing Tax Credit (New Jersey)
- Rural Jobs Tax Credit (New Mexico)
- New York Sun Competitive PV Program (New York)
- RPS Customer-Sited Tier Regional Program (New York)
- Statewide Empire Zone Program (New York)
- Article 3J Tax Credits (North Carolina)
- Camden County - Wind Energy Systems Ordinance (North Carolina)
- Madison County - Wind Energy Systems Ordinance (North Carolina)
- Watauga County - Wind Energy System Ordinance (North Carolina)
- Renaissance Zones (North Dakota)
- Scotia Energy Electricity - Net Metering Program (Nova Scotia, Canada)
- Alternative Energy Zone (Ohio)
- The Ohio Enterprise Zone program (Ohio)
- Oklahoma Local Development and Enterprise Zone Incentive Leverage Act (Oklahoma)
- Opportunity and Enterprise Zones (Oklahoma)
- Small Business Linked Deposit Program (Oklahoma)
- Keystone Innovation Zone Tax Credit Program (Pennsylvania)
- Keystone Opportunity Zones (Pennsylvania)
- Model Wind Ordinance for Local Governments (Pennsylvania)
- The Enterprise Zone (Rhode Island)
- Coastal Tidelands and Wetlands (South Carolina)
- Enterprise Zone Retraining Credit Program (South Carolina)
- Brownfields Revitalization and Economic Development Program (South Dakota)
- Enterprise Zone Program (Texas)
- Refund for Economic Development (Texas)
- Reinvestment Zones (Texas)
- Vermont Village Green Program (Vermont)
- Alleghany Highlands Economic Development Authority (Virginia)
- Enterprise Zone Real Property Investment Grant (Virginia)
- Port of Virginia Economic and Infrastructure Development Zone Grant Program (Virginia)
- Technology Zones (Virginia)
- Virginia Enterprise Zone Job Creation Grant (Virginia)

E. Review Process and Feedback from States

To ensure the accuracy and appropriateness of the information in the policy inventory, it is important for representatives of states governments to review it and make edits, as necessary. We structured an elaborate, but easy-to-use, review process, involving reviewing the material in OpenEI and making edits using OpenEI's regular editing process.

To help with the review process, NREL created a tailored search form and help page.

The Reviewers

The following state officials were asked to review the policy inventory for their state:

- EISPC members
- State energy office contacts for the National Association of State Energy Officials (NASEO)
- CESA members
- Those individuals listed as contacts for any of the active policies in the DSIRE database or for the additional policies added to the EISPC policy inventory.

The sum total of names on these various lists was well more than 1,000, although there was some duplication among the lists.

Instructions for Reviewers

Here are the instructions that were sent to reviewers:

1. Go to: <http://en.openei.org/wiki/EZPolicies>; use this as your starting point when you want to review or edit entries
2. Create an account and then login; check “remember” to prevent system logouts
3. Select your state; this will open a table with policies for the state.
 - Both DSIRE and added policies “feed” into the table
4. Review the table for completeness and relevance, and that the policy summaries are accurate and understandable
 - Click on column headings to sort; the EZ Policy Inventory is also searchable by technology, policy type, and other fields at <http://en.openei.org/wiki/EZPolicySearch>
 - Ensure Active status is accurate
 - Determine whether you want to make edits to any of the entries
5. Here is how to make edits:
 - Right click on Policy name in left column (open in new tab) to view summary
 - Click “Edit with form” to make revisions
 - Hover on blue ? icons for tips
 - Enter “substantial” or estimated MW of installed/expected capacity related to policy if likely to be in state’s top tier of significance for EZ study

- If policy does not affect or influence clean energy development, select No from “Relevant for EZ Mapping Tool” pull-down menu
 - Update or add any web links, contacts, shape files, authorities as needed
 - ***Save page before closing***
6. Additional review process and editing tips can be found at <http://en.openei.org/wiki/EZPolicies/Help>
 7. Any edits you submit will be reviewed before being posted in the completed policy inventory
 8. If there are other policies that you think should be in the policy inventory, send an email to Val Stori at val@cleanegroup.org.

The Timing of the Review Process

David Littell, Warren Leon, and Heather Rhoads-Weaver gave a presentation about the review process at the EISPC meeting in Nashville on November 29, 2012. At that time, 25 states and the District of Columbia were ready for review.

We followed up with an email about the review process to the lists above on November 30th for the 25 states and DC. The recipients of the email were encouraged to submit their edits, comments, and questions by December 18th. As part of the email, we offered a webinar on the review process on December 7th for those individuals who did not attend the Nashville EISPC meeting. About 40 people attended the webinar.

Another email went out in early January to representatives of the remaining 14 EISPC states plus New Orleans. It explained that their states were ready for review and offered them an opportunity to attend an informational webinar on January 9th. They will be encouraged to submit their edits, comments, and questions by the end of January.

In response to these requests for review, we received comments and edits from about 15 states. Representatives of public utility commissions, renewable energy programs, and economic development agencies have provided valuable information for the database. Contributions have included edits and updates to entries about renewable portfolio standard programs, net metering charges, and long-term contracts for renewables. Most of the edits and suggestions received have been for the imported DSIRE entries, rather than for the environmental regulations or financial incentives that were researched and included in the inventory.

Although there are probably fewer problems with DSIRE entries than with the new information, it is not surprising that most of the edits received were for the core renewable energy entries in DSIRE. The state officials with the greatest interest in the Energy Zones project are those who work specifically on clean energy and they have the most knowledge of targeted state clean energy policies. They are less familiar with some of the generic economic development incentives and environmental regulations that have been added to the inventory.

In July 2013, we requested EISPC members to review the short state summaries. We were especially interested in having these documents reviewed to make sure that they provide an adequate and appropriate introduction to each state's policies.

Although we received some good feedback from our requests to have the inventory reviewed, we did not receive as many comments and edits as we had initially hoped for. However, we will continue to encourage users of the Mapping Tool to provide feedback and edits when they detect problems with the inventory. Because of the way the inventory is housed within OpenEI, all suggested edits get recorded and can be acted upon quickly. It is possible to make changes to the inventory at any time with those changes feeding instantly upon approval into the Mapping Tool.

Canadian Review

For Canada, we conducted more targeted outreach, contacting 48 Canadian representatives, including 4-9 officials from each province and 6 Federal contacts. Instructions for Canadian reviewers were less elaborate than for US-based reviewers, without specific instructions for editing entries within OpenEI. Edits, updates or additions for Canadian policies were requested via email correspondence. Reviewers were requested to provide any feedback by May 31, 2013.

Suggestions provided by one Canadian reviewer helped us to identify a minor glitch that not all of the text fields included in OpenEI records had been incorporated in the coding to display in the Mapping Tool Results (e.g. Canada Small Business Financing Program) and to help ensure policies that are not explicitly technology-specific are reflected appropriately.

F. First Round of Updates

Starting in May 2013, we began a systematic review and updating of all the policy entries that had been placed into the inventory by the CESA team. Because some of the entries had initially be written and added to the inventory as early as September 2012, it was necessary to see if any new laws or regulatory changes had taken place since that time. We therefore looked at the state information on all policies and laws that were potentially subject to change, and updated entries as appropriate. Several members of the CESA team undertook this work.

This review of policies was done only for those policies that had been entered into the inventory by the CESA team. We did not do it for the policies in the DSIRE database. Those policies have been periodically reviewed and kept current by the DSIRE staff.

G. Recommendations for Maintaining the Accuracy and Usefulness of the Inventory

Keeping the policy database current will be a challenge, but will be very important. The utility of the database will diminish significantly if the information is not kept current. Many people will stop using the database if they start to perceive it to be unreliable.

We suggest six strategies for keeping the inventory accurate, current, and accessible:

1. ***Continue to maintain the link between DSIRE via OpenEI and the policy database in the EZ Mapping Tool.*** One of the main reasons for using OpenEI was to establish this

link. Every time an update is made by the managers of DSIRE to that database, it will flow through OpenEI into the database accessed from the Mapping Tool. This means, in effect, that the DSIRE staff through its normal activities will help to keep the EISPC inventory current.

Part way through this project, the task of maintaining the link between DSIRE and the Mapping Tool became more complicated when DOE issued a Funding Opportunity Announcement to identify a team to modify DSIRE and overcome some of its limitations. DOE required that the new version of DSIRE include increased functionality and be more user-friendly. Even though the main organizations and individuals who have long been responsible for DSIRE were awarded the new contract by DOE, there will still be some changes to their database structure. Once those changes are known, it will be important for EISPC to determine whether any of the changes will cause problems for the functioning of the policy inventory in the Mapping Tool. It will be essential to work with the OpenEI staff at NREL to make sure that updates to the modified DSIRE database continue to flow through OpenEI to the EZ Mapping Tool. Depending upon the nature of the changes to the DSIRE database, this could require considerable coordination among EISPC, ANL, OpenEI, and DSIRE, and some additional programming.

2. ***Encourage users to submit edits and updates.*** The EZ Mapping Tool provides an email address for policy updates or edits but could make it more clear to users of the policy database that EISPC is very interested in receiving edits and updates from any and all users. The Mapping Tool should be designed to make it easy and convenient to submit policy edits and updates. EISPC will need to give some individual or group the responsibility for reviewing and approving the edits and updates that are submitted by users. This crowd-sourcing approach can be very helpful, if it is aggressively encouraged, but it will not capture all the relevant changes to the policies in the policy inventory.
3. ***Ask EISPC representatives for information about their state.*** Perhaps two or three times a year, reminders should be made during meetings and emails should go out to the state representatives in EISPC to ask them if there have been any relevant policy changes in their state and to encourage them to submit information about those changes.
4. ***Carry out an annual systematic policy review.*** As noted above, in the summer of 2013, CESA carried out a systematic review of all the non-DSIRE policies in the policy inventory. Such a review should be carried out annually in order to maintain the accuracy of the inventory. This will be especially important for those types of policies, such as generic economic development incentives, that tend to change frequently and that are relatively unfamiliar to the most likely regular users of the EISPC policy database.
5. ***Maintain and improve the display interface within the ANL Mapping Tool.*** Stakeholder input received as part of the initial needs assessment for CESA's policy inventory work confirmed the value of integrating the policy data into the EZ Mapping

Tool to be able to compare energy policy and finance tools among states, especially by linking policy data as a layer to other data charts and tables for easy comparison. In addition, displaying boundaries of sub-state policies such as local utility incentives and county-specific regulations would provide added value. The CESA team has identified several formatting improvements that would make the policy search more user friendly and the policy data more useful including allowing text searches, adding utility jurisdictions as a layer to the Mapping Tool, and polishing the results display. Ongoing maintenance to ensure the ANL policy query's functionality continues will be critical for ensuring user-friendly access of this important resource.

6. ***Promote the inventory and the Mapping Tool.*** Many of the people who would benefit from using the policy inventory are not aware of its existence, or of the existence of the Mapping Tool. It is therefore desirable to continue active efforts to promote the inventory and the Mapping Tool, and provide ongoing training sessions. For some policy-oriented audiences, the policy inventory can be the entry point that makes them aware of the Mapping Tool and stimulates them to start using it.

Appendix: The Inventory

The primary work product of this project is the policy inventory and database. It includes nearly 2,400 policy entries, 1,700 of which were prepared especially for this inventory with the remainder pulled in from DSIRE. The best way to view it is by going to the home page of the EZ Mapping Tool: <http://eispctools.anl.gov>. There is a prominent link to the policy inventory labeled “Policies and Regulations.” Alternatively, this report as well as an MS Excel file of the inventory and database can be found on the NARUC Grants and Research page: <http://naruc.org/Grants/programs.cfm?page=66>

APPENDIX – The Inventory

Introduction to Alabama

Electricity Generation

In 2012, electricity generators in Alabama generated 152,664 gigawatt-hours of electricity, using the following sources:

Natural gas	36.3%
Coal	29.9%
Nuclear	26.8%
Hydroelectric	4.7%
Biomass	2.1%
Petroleum	0.1%
Other Gases	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Alabama is a net generator of electricity and produced 75% more electricity than it used in 2012.

Coal has decreased from 62% of power generated in Alabama during 2000, and natural gas has increased from 4% in 2000 to the leading power generation source.

Alabama Power, which serves about two-thirds of the electric load in the state, agreed in 2012 to buy 404 MW of wind energy generated in Oklahoma and Kansas.

According to National Renewable Energy Laboratory estimates, if Alabama utilized 1% of its total renewable potential (from solar, wind, biomass, geothermal, and hydro), it would add 22 GW of electric capacity—nearly double the installed coal generation capacity in the state.

Alabama ranked 5th in the United States in 2011 in the generation of electricity from wood, wood waste, landfill gas, and other biomass. Nonutility power producers generated most all of that electricity.

In terms of total amount of electricity generated from renewable resources, Alabama ranked 9th nationally (primarily due to hydroelectricity and biomass), but as the percentage of total electricity consumed, it ranked 27th (6.8%).

Introduction to Arkansas

Electricity Generation

In 2012, electricity generators in Arkansas generated 65,382 gigawatt-hours of electricity, using the following sources:

Coal	43.5%
Natural Gas	26.8%
Nuclear	23.7%
Hydropower	3.3%
Biomass	2.6%
Petroleum	0.1%
Hydro pumped storage	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

As an incentive to spur renewable energy development, Arkansas law and the rules of the Arkansas Public Service Commission offer net metering for residential systems up to 25 kW and non-residential systems up to 300kW. Meter aggregation is now available in investor-owned electric utility and electric cooperative territories.

The state generates nearly half its electricity from coal-fired power plants, and most of the remainder from nuclear power facilities and natural gas.

Arkansas is a net exporter of electricity. According to EIA's Electric Power Monthly, in 2011 Arkansas generated about 61,000 GWh, and had retail purchases of about 48,000 GWh.

Under Arkansas law, the Arkansas Public Service Commission requires electric and gas IOUs to offer comprehensive energy efficiency programs and to meet annual energy savings performance targets. The ECEA defines energy conservation to include energy efficiency programs, as well as renewable technologies.

The Arkansas Energy Office, a division of the Arkansas Economic Development Commission, promotes energy efficiency and emerging technologies through education, and manages federal energy funds in the state.

Arkansas is a leader in manufacturing components for the wind industry. One of the industry's major blade manufacturers is located in the state. Arkansas performed a tall-tower wind assessment based on 2011 data that identifies areas of the state where commercial wind development in the state may be feasible, using larger rotor technology. According to the American Wind Energy Association, the state's annual potential wind generation is 26,906 GWh, placing it 27th among the states in wind energy potential.

Arkansas ranks sixth in forest residue resources, and according to the EIA, has 371 MW on nameplate capacity biomass generation.

Arkansas receives an average of 5,000 watt-hours of sunlight per day.

Introduction to Connecticut

Electricity Generation

In 2012, electricity generators in Connecticut generated 35,733 gigawatt-hours of electricity, using the following sources:

Nuclear	47.8%
Natural gas	46.2%
Other Renewables	1.9%
Hydroelectric	1.3%
Petroleum	0.3%
Coal	0.3%
Other	2.2%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Connecticut encourages the development of clean energy sources through a diverse and broad range of policies, including tax credits, net metering, virtual net-metering for municipal customers, renewable portfolio standard, and a system benefit charge fund.

Connecticut has a high renewable portfolio standard target for renewable generation, but few native resources.

The Department of Energy and Environmental Protection implements a wide range of energy initiatives and programs to ensure legislative intent and equitable distribution of clean energy funds.

The Clean Energy Finance and Investment Authority (CEFIA) was the nation's first statewide clean energy finance authority, or "green bank." CEFIA uses a flexible "finance" model that encourages entrepreneurship and private sector leadership in scaling up energy projects. A ratepayer assessment charge generated just over \$27 million in FY 2012 to fund a portion of CEFIA.

The CEFIA definition of clean energy includes conventional renewable technologies such as wind, solar, and biomass, among others, and resources and emerging technologies which have the potential for commercialization and which do not involve the combustion of coal, municipal solid waste or nuclear fission.

Utilities are required to enter into long-term contracts (15 years) for renewable energy credits from both zero and low emission Class I renewable energy facilities (on the customer side of the meter).

Several fuel cell companies have headquarters or other facilities in Connecticut and the state has encouraged the use of fuel cells for electricity generation.

Introduction to Delaware

Electricity Generation

In 2012, electricity generators in Delaware generated 8,808 gigawatt-hours of electricity, using the following sources:

Natural gas	78.8%
Coal	16.6%
Other gases	2.8%
Biomass	1.2%
Petroleum	0.3%
Solar	0.3%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Delaware encourages the development of clean energy sources through a diverse and broad range of policies, including net metering, community net metering, and public benefit funds.

Delaware significantly expanded its net metering policy in 2007 and again in 2010 to include all customer classes, add new eligible technologies, and allow community net-metered systems. The Delaware Public Service Commission has implemented these regulatory changes.

The Division of Energy and Climate's Green Energy Program provides grant incentives for renewable energy systems installed in Delaware through each participating electric utility company.

Delaware established a renewable portfolio standard in 2005, requiring retail electricity providers to purchase 10% of their electricity from renewable sources by 2020. The RPS was revised in 2010 to 25% by 2025, with a 3.5% target for photovoltaics. The RPS now applies to investor-owned electric utilities, municipal electric utilities, and rural electric cooperatives.

In 2010, the Delaware legislature amended its small wind law to declare that existing municipal or county zoning prohibitions or restrictions on the installation of small wind systems on single-family residential properties are not consistent with its wind access provisions codified in the 2009 law and therefore no longer in effect. The law applies only to wind energy systems that qualify for support under the state's Green Energy Fund.

Delaware participates in the Regional Greenhouse Gas Initiative (RGGI); revenue from RGGI's carbon emissions trading program funds the Greenhouse Gas Initiative Reduction Projects Fund, a grant program.

Delaware consumes 32% more electricity than it generates.

Introduction to District of Columbia

Electricity Generation

In 2012, electricity generators in District of Columbia generated 89 gigawatt-hours of electricity, using the following sources:

Natural gas	89.9%
Petroleum	10.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

The District of Columbia encourages the development of clean energy sources through a diverse and broad range of policies, including property tax exemptions, net metering, a renewable portfolio standard, and a system benefit charge fund.

D.C. imports almost all of its electricity, consuming 11,259 gigawatt-hours in 2012.

D.C. established its renewable portfolio standard (RPS) in 2005. It has since been amended several times, increasing the percentage of benchmarks utilities must meet and increasing the solar carve-out from .4% to 2.5% by 2023. Solar thermal facilities are eligible.

Net Metering is a program adopted by the D.C. Public Service Commission. The program allows residential and commercial customers to generate and sell excess electricity back to the grid; the customers receive a credit on their utility bills for the excess.

The District of Columbia's public benefits fund, known as the Sustainable Energy Trust Fund, is financed by a surcharge on the electric and natural gas bills of utility customers. The fund is administered by a third-party Sustainable Energy utility, charged with developing and promoting sustainable energy use throughout D.C.

The District Department of the Environment (DDOE) has wide-ranging responsibilities, and administers many programs related to energy conservation, environmental protection, renewable energy, and sustainability.

DDOE administers the Renewable Energy Incentive Program, which provides rebates to eligible applicants installing solar systems. The program is open to residential and non-residential customers and both solar systems and PV systems qualify for rebates.

In early 2013, Mayor Vincent Gray signed the Sustainable DC Act of 2012 into law and released Sustainable DC, a 20-year full sustainability plan with the goal of becoming the greenest, healthiest city in the United States. The law covers energy efficiency, renewable energy, water quality, urban agriculture, and children's health.

Introduction to Florida

Electricity Generation

In 2012, electricity generators in Florida generated 220,751 gigawatt-hours of electricity, using the following sources:

Natural gas	67.6%
Coal	20.1%
Nuclear	8.1%
Biomass	2.0%
Other	1.4%
Petroleum	0.3%
Petroleum Coke	0.3%
Hydroelectric	0.1%
Solar	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Florida does not have a renewable portfolio standard; however, Florida currently has approximately 1,400 MWs of renewable energy generation. Florida encourages the development of clean energy sources through net metering, standard offer contracts, renewable energy production tax credits, biofuels tax incentives, and renewable energy equipment sales tax exemptions. In addition, there are many local renewable energy initiatives, and the state is one of the leaders in solar and bioenergy production.

The Florida Public Service Commission adopted rules for net metering in 2008. The rules apply to customers of investor-owned utilities with systems up to 2 MW in capacity. The net excess generation (NEG) is carried forward and, at the end of 12 months, the utility pays the customer the avoided-cost rate for any remaining NEG.

Solar energy and thermal systems are exempt from Florida's sales and use tax. This exemption was made permanent upon the enactment of H.B. 805.

Florida established a renewable energy production tax credit in 2006 to encourage the development and expansion of renewable energy facilities in Florida. The credit may be used for electrical, mechanical, or thermal energy.

Gainesville, Florida, was the first municipality to create a local feed-in-tariff and offers a solar FIT for PV systems. The program is open to residential and commercial customers.

Cleantech is a fast-growing industry in Florida—the state is home to many high-tech clusters and progressive research centers conducting R&D in solar, advanced biomass, and ocean energy. In addition, leading utilities in the state have innovative solar programs.

According to a 2012 ACORE report, Renewable Energy in the 50 States, Florida leads the nation in biomass production from sugarcane, citrus, forest residues, and urban wood waste. In addition, many Florida

companies are commercializing the next generation of biofuels using algae, waste, grasses, and other cellulosic materials.

Introduction to Georgia

Electricity Generation

In 2012, electricity generators in Georgia generated 122,704 gigawatt-hours of electricity, using the following sources:

Natural Gas	34.9%
Coal	33.2%
Nuclear	27.7%
Biomass	2.7%
Hydroelectric	1.9%
Petroleum	0.1%
Pumped Hydroelectric Storage	-0.7%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Georgia encourages the development of clean energy sources through tax credits and a net metering policy. The Department of Economic Development promotes the existence of an “energy ecosystem” that lowers costs and increases competitive advantage for businesses in the solar, wind, smart grid, biofuel, battery, and fuel cell fields.

Georgia’s coal consumption has declined from 54% in 2009 to 33.2% in 2012 and the percentage of Wyoming subbituminous coal used in coal plants has increased. Newly constructed natural gas power plants have reduced the overall use of coal as a fuel source.

The Georgia Energy Challenge is a statewide, all-sector, voluntary energy initiative with the goal of reducing electricity consumption 15% by 2020.

Georgia has a significant amount of commercially available and sustainable bio-power capacity based on forest biomass resources, but it has been slow to be developed.

Plant Vogtle is in the process of adding two new 1,100 MW nuclear reactors with planned opening late 2017 and 2018.

Georgia’s offshore wind resource is much larger than its onshore resource. Approximately 1,126 square miles of ocean surface area with nearly 14,500 MW of offshore wind energy potential has been identified.

In November 2012, Georgia PSC approved the Georgia Power Advanced Solar Initiative – the largest voluntarily developed solar portfolio from an investor-owned utility – for which Georgia Power will use long-term contracts to acquire 210 MW of additional solar capacity. In April 2013, Georgia Power announced its acquisition of 250 MW of wind energy. In July 2013, the Georgia PSC approved Georgia Power’s 2013 IRP, which directs Georgia Power to acquire 525 MW of solar resources through its Advanced Solar Initiative process in addition to the 210 MW approved in November 2012. The Georgia PSC also approved Georgia Power’s request to retire approximately 2100 MW of coal and oil generating resources.

Introduction to Illinois

Electricity Generation

In 2012, electricity generators in Illinois generated 197,738 gigawatt-hours of electricity, using the following sources:

Nuclear	48.8%
Coal	40.9%
Natural Gas	5.7%
Wind	3.9%
Biomass	0.3%
Other gases	0.2%
Other	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Illinois encourages the development of clean energy sources through a diverse and broad range of policies, including tax credits, net metering, a renewable portfolio standard, and public benefits funds. The public benefits funds include the Renewable Energy Resources Trust Fund (RERTF) and the Illinois Clean Energy Community Foundation Fund. Illinois is a net exporter of electricity generating 39% more electricity than it consumes.

The Illinois Department of Commerce and Economic Opportunity (DCEO) administers the RERTF program, which is subsidized through surcharges on IOU customer electricity bills and gas bills. Program participation is voluntary for municipal utilities and electric coops. The funding mechanism for the RERTF has been extended through December 12, 2015. Approximately \$5-\$5.5 million is available each year for grants, loans, and other renewable energy incentives. The Illinois Clean Energy Community Foundation, established in 1999 with a \$225 million endowment, works to improve energy efficiency, advance the development of renewable energy resources and protect natural areas.

The Illinois Power Agency's utility procurement plans include renewable energy resources consistent with the State's renewable portfolio standard (RPS). The RPS applies to retail electric suppliers (RES), IOUs, and alternative retail electric suppliers (ARES) which are subject to cost-effectiveness constraints. There are different targets for RES and ARES.

The Illinois Commerce Commission (ICC) adopted net metering rules in 2008 for investor-owned utilities and alternative retail suppliers. Legislation in 2011 added to the list of eligible resources. The law states that net metering facilities should be equipped with metering equipment that can measure the flow of electricity in both directions at the same rate.

The Illinois Finance Authority can issue tax-exempt bonds and credit enhancements to commercial entities, non-profits, schools and community colleges for renewable energy projects. Renewable energy storage technologies, transmission lines, and associated equipment are eligible.

According to the American Council on Renewable Energy, Illinois has some of the most extensive wind and biomass resources in the U.S. By 2013, 3568 MW of wind capacity and 137 MW of biomass energy had been installed. Illinois ranked fourth in the nation for installed wind power.

Introduction to Indiana

Electricity Generation

In 2012, electricity generators in Indiana generated 114,680 gigawatt-hours of electricity, using the following sources:

Coal	80.7%
Natural gas	12.7%
Wind	2.8%
Other gases	1.9%
Petroleum Coke	0.7%
Hydroelectric	0.4%
Biomass	0.3%
Petroleum	0.1%
Other	0.3%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Indiana encourages the development of clean energy sources through a range of policies, including tax credits, net metering, and a voluntary renewable portfolio standard.

The Indiana Utility Regulatory Commission adopted the Clean Energy Portfolio Standard (CEPS) in June 2012. The CEPS sets a voluntary goal of 10% by 2025. The program and the associated incentives for eligible projects are open only to public utilities. Clean energy technologies include coal bed methane, waste heat recovery, nuclear energy, and natural gas, and renewable energy technologies such as wind and solar.

In May 2011, the Indiana Utility Regulatory Commission approved net metering final rules, increasing the maximum net metering capacity to 1 MW and opening eligibility to all electric customers.

The Indiana Office of Energy Development implemented Hoosier Homegrown Energy, the state's first new energy plan in 20 years, in 2006. The plan has three main goals: trade current energy imports for future Indiana economic growth; produce electricity, natural gas, and transportation fuels from clean coal and bioenergy; and improve energy efficiency and infrastructure.

According to the American Wind Energy Association, Indiana has a strong wind resource as is the third-fastest growing state in wind capacity. As of January 2013, the state had 930 turbines producing 1,543.2 MW of wind power. In 2009, the wind industry supported 3000-4000 jobs in the state.

Two Indiana utilities have voluntary feed-in tariffs: Indianapolis Power & Light Company has a feed-in tariff with contracts for a total of 99,849.7 kW. Northern Indiana Public Service Company also has a voluntary experimental feed-in tariff in effect through December 31, 2013, unless otherwise ordered. Northern Indiana Public Service Company has contracts for 29,710.2 kW of total capacity in its feed-in tariff program.

The state offers various tax credits for renewable energy systems, equipment manufacturing, and alternative fuel vehicle manufacturing.

Introduction to Iowa

Electricity Generation

In 2012, electricity generators in Iowa generated 56,919 gigawatt-hours of electricity, using the following sources:

Coal	62.5%
Wind	24.5%
Nuclear	7.6%
Natural gas	3.5%
Hydroelectric	1.4%
Biomass	0.3%
Petroleum	0.2%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Iowa encourages the development of clean energy sources through a range of policies, including tax credits, loans, net metering, and an obligation for the state's investor-owned utilities (IOUs) to purchase from renewable sources.

Iowa enacted the nation's first renewable generation law, called the Alternative Energy Production Law, in 1983. The law requires the state's two IOUs to own or contract for a combined total of 105 MW of renewable energy generating capacity.

All electric utilities in Iowa are required to offer voluntary Alternative Energy Purchase Program options to their customers that allow customers to contribute voluntarily to the development of alternative energy in Iowa.

The Iowa Utility Board adopted the state's net metering sub rule in 1984. Net metering is available to customers of Iowa's rate regulated utilities that generate renewable energy on their premises.

The Iowa Economic Development Authority currently administers the state's renewable energy programs, including the state energy program and the Iowa Clean Cities Coalition.

According to the American Wind Energy Association, Iowa ranks seventh in the nation in wind resources and has the second most installed wind capacity in the U.S. In 2010, the state ranked first in the U.S. for percentage of electricity derived from wind.

The state has attracted major wind industry manufacturers and has a robust supply chain. According to AWAE, over 3,200 direct manufacturing jobs in the state are attributable to the wind industry.

Iowa has a strong agricultural sector and is the country's number one producer of both ethanol and biodiesel at 27% and 17% of production respectively.

The Iowa Energy Bank, administered by the Iowa Economic Development Authority, offers Iowa's public facilities, schools, colleges, universities, hospitals, and local governments as low as a 1% financing option for cost-effective energy projects, including eligible renewable energy installations. A low-interest revolving loan fund created in 2011 finances Energy Bank programs.

Introduction to Kansas

Electricity Generation

In 2012, electricity generators in Kansas generated 44,782 gigawatt-hours of electricity, using the following sources:

Coal	62.5%
Nuclear	18.5%
Wind	11.4%
Natural gas	7.3%
Biomass	0.1%
Petroleum	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Kansas encourages the development of clean energy sources through several policies, including tax credits, loans, net metering, and a renewable portfolio standard.

Kansas adopted a renewable portfolio standard (RPS) in 2009, requiring investor-owned and cooperative utilities to purchase renewable energy at 10% from 2011-2015, 15% from 2016-2019, and 20% in 2020. The RPS is based on generation capacity—the gross capacity owned or leased by a utility less the auxiliary power used to operate the facility. The state met its 10% target by 2011 through installed wind generation.

The Kansas Corporation Commission's Energy Division administers the state's alternative energy and energy efficiency programs. The Facility Conservation Improvement Program is the Division's current active program.

According to the American Wind Energy Association, Kansas has vast wind resources and ranked fifth in the U.S. in 2010 for the percentage of electricity derived from wind. The state has several supply chain companies which manufacture for the wind industry.

Kansas is ranked ninth in the nation in bioethanol production capacity. One of the country's first cellulosic ethanol plants is located in Kansas and produces both fuel and electricity.

The Kansas Development Finance Authority can issue up to \$5 million per wind or solar project in bond financing for eligible wind and solar manufacturers.

Introduction to Kentucky

Electricity Generation

In 2012, electricity generators in Kentucky generated 89,819 gigawatt-hours of electricity, using the following sources:

Coal	91.9%
Natural Gas	3.3%
Hydroelectric	2.6%
Petroleum Coke	1.6%
Biomass	0.4%
Petroleum	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Kentucky requires net metering and offers several tax credits to promote renewable energy development and fuels production. Kentucky enacted its net metering law in 2008 requiring investor-owned utilities and rural electric cooperatives to offer bi-directional net metering up to 30 kilowatts in capacity. TVA utilities are exempt from the net metering rules.

The state is the third largest producer of coal and has some of the lowest electricity prices in the nation. The state remains largely reliant on coal to generate electricity.

The Department for Energy Development and Independence (DEDI) is investigating cost-effective and practical technologies for reducing carbon dioxide emissions from coal power plants. DEDI's goal is to investigate and develop solutions for carbon capture, sequestration, and reuse, and to develop state policy to manage greenhouse gas emissions. Kentucky provides tax credits for clean coal facilities. Businesses that construct, retrofit, or upgrade gasification facilities may qualify to recover up to 50% of their capital investment.

DEDI provides leadership to maximize the benefits of renewable energy and has oversight in implementing the renewable energy components of Kentucky's comprehensive energy strategy.

Kentucky's 2008 comprehensive energy strategy states, "By 2025, Kentucky's renewable energy generation will triple to provide the equivalent of 1000 megawatts of clean energy while continuing to produce safe, abundant, and affordable food, feed, and fiber." The plan proposed a renewable and efficiency portfolio standard to supply 25% of Kentucky's energy needs through energy efficiency and renewable resources by 2025.

According to the American Council on Renewable Energy, the state has potential to generate over 8000 GWh from biopower. Currently, biopower is produced in facilities that use black liquor and forestry residues as feedstock, and from landfill gas. Several tax incentives are available for renewable energy facilities, including biomass generators, and biodiesel producers and blenders.

Introduction to Louisiana

Electricity Generation

In 2012, electricity generators in Louisiana generated 103,770 gigawatt-hours of electricity, using the following sources:

Natural gas	57.0%
Coal	20.6%
Nuclear	15.1%
Petroleum Coke	2.8%
Biomass	2.2%
Other gases	1.3%
Hydroelectric	0.7%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Louisiana encourages the development of clean energy sources through the following policies: net metering, tax incentives, loan programs, and a renewable portfolio standard pilot program.

Louisiana enacted legislation in June 2003 establishing net metering. Investor-owned utilities, municipal utilities, and rural electric cooperatives are required to offer net-metering to residential and commercial customers that generate electricity from qualified renewable resources. Residential systems may net meter up to 25 kW; commercial and agriculture sectors may net meter up to 300 kW.

In June 2010, the Louisiana Public Service Commission approved the Renewable Energy Pilot Program to determine whether a renewable portfolio standard is suitable for Louisiana. The pilot has a research component and a request for proposal component, which applies to investor-owned utilities and cooperative utilities.

The state is analyzing its offshore wind potential to determine the viability of offshore wind development.

The state has a strong biomass resource. According to the American Council on Renewable Energy, Louisiana biopower could produce as much as 14,873 GWh per year. Several wood pellet export facilities are under construction in Louisiana and will produce over a million tons of pellets per year.

Introduction to Maine

Electricity Generation

In 2012, electricity generators in Maine generated 15,049 gigawatt-hours of electricity, using the following sources:

Natural gas	41.1%
Biomass	26.0%
Hydroelectric	23.4%
Wind	5.9%
Petroleum	0.7%
Coal	0.3%
Other	2.6%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Maine encourages the development of clean energy sources through a diverse and broad array of policies including tax credits, loans, rebates, net metering, community-based renewable energy, a renewable portfolio standard, and a system benefit charge fund.

Maine has an ambitious renewable standard. It includes a credit multiplier for community ownership of projects up to 10 MW and 40% Renewable Energy Portfolio Standard by 2017 (10% new resources added to the 30% RPS in place prior to 2007) and a statutory goal of 2,000 MW of wind energy by 2015. The goal increases to at least 8,000 MW of installed wind capacity by 2030 with 5,000 MW located in coastal waters or offshore. Natural gas is expected to remain a growing primary fuel source for electrical generation while Maine aggressively pursues increased use of energy efficiency and renewable energy technologies.

The Governor's Energy Office provides leadership in the development of public and private partnerships, works in conjunction with other state agencies, the Legislature, and private and nonprofit sectors, and oversees and administrates the federal State Energy Program (SEP) funds and priorities.

Efficiency Maine Trust was created to consolidate and integrate energy programs, acquire efficiency and alternative energy resources, and transform Maine's energy markets. In 2012, it derived approximately half of its \$34.2 million funding from a System Benefits Charge and from the Regional Greenhouse Gas Initiative.

Maine is a net exporter of electricity, as it generated approximately 30% more electricity than it consumed in 2012.

Due to the state's significant clean energy commitment, Maine has developed an energy technology infrastructure of energy equipment design, manufacturing, and professional services to support the growth of the clean energy sector.

Among other broad policy changes, the 2013 Omnibus Energy Bill directs the state Department of Environmental Protection and Public Utilities Commission to develop incentives for consumers to reduce greenhouse gas emissions by switching from oil and coal to alternative fuels such as natural gas, biomass, or other renewables.

Introduction to Maryland

Electricity Generation

In 2012, electricity generators in Maryland generated 37,815 gigawatt-hours of electricity, using the following sources:

Coal	42.7%
Nuclear	35.9%
Natural Gas	13.1%
Hydroelectric	4.4%
Biomass	1.4%
Wind	0.8%
Other	0.8%
Other gases	0.5%
Petroleum	0.3%
Solar	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Maryland encourages the development of clean energy sources through a range of policies, including net metering, a renewable portfolio standard (RPS), tax incentives, rebates, loans, and grants.

Maryland has a 20% by 2022 RPS target. All electricity suppliers are required to use renewable energy sources to generate this minimum portion of their retail sales. The requirement increases gradually for both Tier 1 and Tier 2 resources. In 2013, the state enacted legislation creating an offshore wind carve-out. A solar carve-out was established in 2007.

Maryland's net metering law was enacted in 1997 and has been expanded several times. It requires all utilities to offer net metering to their customers until a statewide aggregate capacity of 1500 MW is reached.

Maryland imports nearly half of its electricity, consuming 61,835 gigawatt-hours in 2012.

Maryland currently generates 6.7% of its energy from in-state renewable generation, which accounts for 33.5% of the state's informal in-state renewable generation goal.

The general Assembly passed the Offshore Wind Act of 2013. It modified the state's RPS to include a specified amount of energy derived from offshore wind energy and created an application process for proposed offshore wind farms. The Maryland Energy Administration (MEA) and the Maryland Higher Education Commission announced research grants to support Maryland's offshore wind development.

MEA advises the Governor on directions, policies, and changes in the various segments in the energy market. MEA works to reduce energy costs, reduce greenhouse gas emissions, increase energy efficiency, leverage public/private partnerships, and lower the operating expense of state and local governments.

Maryland has several waste-to-energy facilities. The largest is in Montgomery and processes an average of 1500 metric tons per day of waste. Maryland has 120 MW of wind on-line.

Introduction to Massachusetts

Electricity Generation

In 2012, electricity generators in Massachusetts generated 33,107 gigawatt-hours of electricity, using the following sources:

Natural gas	69.0%
Nuclear	16.6%
Coal	5.9%
Biomass	3.4%
Hydroelectric	2.7%
Petroleum	0.4%
Wind	0.2%
Solar	0.1%
Pumped Hydroelectric Storage	-0.9%
Other	2.5%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Massachusetts encourages the development of clean energy sources through a diverse and broad range of policies, including tax credits, net metering, neighborhood net metering, a renewable portfolio standard, and a system benefit charge fund.

The state's portfolio standard is one of the oldest in the country. It started with a Renewable Portfolio Standard, which was established in 1997 and whose first obligation was in 2003. Since then, the required annual percentage increase in new renewables has been raised, additional tiers and carve-outs have been added, as has an Alternative Energy Portfolio Standard, which includes coal gasification, combined heat and power, and other technologies.

The Massachusetts Department of Energy Resources has wide-ranging responsibilities, including administering the Renewable Portfolio Standard and Alternative Energy Portfolio Standard.

The "Massachusetts Clean Energy Center (MassCEC) is dedicated to accelerating the success of clean energy technologies, companies and projects in the Commonwealth—while creating high-quality jobs and long-term economic growth for the people of Massachusetts." MassCEC administers the Renewable Energy Trust Fund, which is funded by a system benefit charge on the electricity bills of investor-owned utilities and which generates about \$23 million annually.

Through the Global Warming Solutions Act, the state has an ambitious goal of cutting emissions to 25% below 1990 levels by 2020.

Strong solar incentives and policies contributed to Massachusetts being one of the top five states in adding photovoltaic capacity in 2012.

A very large offshore wind resource has encouraged the state to implement policies and programs both to advance offshore wind and to prepare a regulatory framework for it. The opportunities for large-scale land-based wind projects are much more limited.

Introduction to Michigan

Electricity Generation

In 2012, electricity generators in Michigan generated 108,726 gigawatt-hours of electricity, using the following sources:

Coal	49.1%
Nuclear	25.8%
Natural gas	20.5%
Biomass	2.3%
Hydroelectric	1.2%
Wind	1.0%
Petroleum	0.1%
Pumped Hydroelectric Storage	-0.7%
Other	0.4%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Michigan encourages the development of clean energy sources through such policies as net metering and a renewable portfolio standard.

In 2013, the Governor's Office is using a public process to solicit input on Michigan's energy future to enable policymakers to implement new policy guidelines on the state's energy framework. The results will be used to make comprehensive recommendations in December 2013.

Michigan has experienced significant investment in renewable energy since the passage of Public Act 295 of 2008, the State's renewable energy standard. Over \$1.79 billion has been invested to bring 895 MW of new renewable energy projects online in Michigan through 2012.

Michigan added 815 megawatts of new wind capacity in 2012, and now has a total of 978 megawatts from 14 operating wind farms.

The Michigan Energy Office operates as a division of the Michigan Economic Development Corporation and supports policy and program development, beneficial public-private partnerships at the local level, energy efficiency in the public and private sectors, reductions in Michigan's dependence on imported energy, the adoption of new technologies and alternative fuels in buildings, industrial processes vehicles and power generation.

The actual cost of renewable energy contracts submitted to the Michigan Public Utilities Commission to date has been cost-competitive. Contracts submitted to the Commission through 2012 total approximately 1,192 MW of renewable capacity. Almost all renewable energy contract prices have been lower than the coal guidepost rate.

As part of the Midwest Regional Carbon Sequestration Partnership, a test site in Otsego County, Michigan, will begin injecting CO₂ into a small number of oil fields within a geologic formation known as the northern Niagaran pinnacle reef trend.

Detroit Edison has filed a license application with the U.S. Nuclear Regulatory Commission to build another reactor at its Fermi site in Newport.

Introduction to Minnesota

Electricity Generation

In 2012, electricity generators in Minnesota generated 52,560 gigawatt-hours of electricity, using the following sources:

Coal	43.9%
Nuclear	22.7%
Wind	14.3%
Natural gas	13.7%
Biomass	3.3%
Hydroelectric	1.4%
Petroleum	0.1%
Other	0.8%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Minnesota encourages the development of clean energy sources through a diverse and broad range of policies, including tax credits, net metering, a renewable portfolio standard, and a system benefit charge fund.

Minnesota has an aggressive Renewable Energy Standard, requiring utilities to generate at least 25 percent of their electricity from renewable energy sources such as wind and biomass by 2025, and 30% by 2020 for Xcel Energy (altogether about 27.5% by 2025). This is roughly equivalent to 6,000 to 7,000 megawatts of renewable capacity by 2025. Under 2013 legislation, the investor-owned utilities must have 1.5% of retail sales, with some sales excluded, generated by solar by 2020. 2013 legislation also changed the net-metering threshold for investor-owned utilities from 40 kW to 1000kW, and a new Value of Solar rate option in lieu of net metering may be offered.

The Renewable Development Fund (RDF) is a utility-administered program mandated by the Legislature with oversight by the Minnesota Public Utilities Commission. The RDF receives its funding as mitigation for on-site waste fuel storage from Minnesota nuclear power plant owners. Up to \$10.9 million annually must be allocated to support renewable energy production incentives through January 1, 2021.

The Minnesota Public Utilities Commission has permitted approximately 2,600 MW of operating wind energy generation, with another 300-400 MW of wind generation permitted by the County where a project is located. Minnesota now ranks 4th in the nation for generation as a percentage of its portfolio. Minnesota leads the nation in community-owned wind projects with total installed capacity of 545 MW.

Federal Energy Regulatory Commission (FERC) approval of the Midwest Independent Transmission Service Operator (MISO) Multi-Value Project (MVP) method of cost allocation for certain large transmission projects is expected to reduce transmission constraints. The MISO Transmission Expansion Plan (MTEP) portfolio of MVP projects, which spread costs across the entire MISO footprint, includes the 240-mile Brookings, SD-Twin Cities transmission line to be completed between 2013-2015.

Introduction to Mississippi

Electricity Generation

In 2012, electricity generators in Mississippi generated 54,193 gigawatt-hours of electricity, using the following sources:

Natural gas	70.6%
Nuclear	13.5%
Coal	13.3%
Renewables	2.6%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Mississippi's energy policy and initiatives touch on six broad areas: encouraging exploration and extraction of natural resources; manufacturing, processing, and conversion of energy products for added value; promoting energy efficiency; building capacity through transportation and distribution infrastructure; leveraging assets for research, development, and commercialization of new energy technologies and solutions; and developing a robust energy-sector workforce.

The Mississippi Clean Energy Initiative provides an incentive for companies that manufacture systems or components used to generate renewable energy, including biomass, solar, wind and hydro generation. Manufacturers of components used in nuclear power plants are also eligible for this incentive.

Although investor-owned utilities, along with the Tennessee Valley Authority (TVA), municipal utilities, and rural electric cooperatives generate most of the electricity (75%) in Mississippi, some electricity (25%) is generated by independent power producers and by industry on site for industrial use.

Despite being a natural-gas-producing state, much more natural gas is consumed in Mississippi than is produced. To meet demand, Mississippi purchases more than one-half of its natural gas.

Mississippi has more natural gas flowing across its borders than any other state and is fourth in miles of interstate natural gas pipelines.

Plant Ratcliffe, a 582-MW coal gasification facility in Kemper County, Mississippi, will open in 2014 and will feature a carbon capture technology to reduce carbon dioxide emissions by 65%.

Introduction to Missouri

Electricity Generation

In 2012, electricity generators in Missouri generated 91,985 gigawatt-hours of electricity, using the following sources:

Coal	79.2%
Nuclear	11.7%
Natural Gas	6.8%
Hydroelectric	0.8%
Wind	1.4%
Petroleum	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Missouri encourages the development of clean energy sources through its renewable electricity standard and net metering. In addition, it has various technology-diverse policies supporting biomass, solar, and wind through tax incentives, loans, and production incentives.

Missouri requires investor-owned utilities to generate 15% of their load from renewable resources by 2021. Two percent of this target must come from solar. Renewable resources include solar, wind, various forms of biomass, pyrolysis and thermal depolymerization of waste materials, and biogas from landfills, agricultural operations, and wastewater treatment plants.

Missouri requires all electric utilities to offer net metering to customers with renewable energy systems up to 100 kW. Net metering is available until the total rated generating capacity of net-metered systems equals 5% of a utility's single-hour peak load during the previous year.

Missouri ranks third in biodiesel capacity nationwide. According to the American Council on Renewable Energy, Missouri could generate as much as 13,986 GWh from biopower.

The Missouri Department of Natural Resources Division of Energy works to advance and promote renewable energy technologies across the state. It administers the Missouri Energy Revolving Fund Loan Program, offering loans for solar PV and thermal, wind, and biomass systems in public schools, universities, colleges, cities, and counties.

Missouri's wind resource is ranked 13th in the U.S. It is a fast growing wind market, tripling its wind installations over 2009 and 2010.

Introduction to Montana

Electricity Generation

In 2012, electricity generators in Montana generated 27,726 gigawatt-hours of electricity, using the following sources:

Coal	51.2%
Hydroelectric	40.8%
Wind	4.5%
Natural gas	0.6%
Petroleum	0.1%
Other	1.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Montana encourages the development of clean energy sources through a diverse and broad range of policies, including tax credits, net metering, a renewable portfolio standard, and a system benefit charge fund.

Montana's Renewable Portfolio Standard (RPS) currently requires regulated utilities to purchase 10% of their annual electricity supply from renewable sources and increases the standard to 15% in 2015. The RPS includes provisions for community renewable energy projects, defined as projects less than or equal to 25 MW where local owners have a controlling interest.

The Montana-Alberta Tie Line (MATL) is expected to be completed in summer 2013. MATL will be the first intertie between Montana and the Alberta Electric System Operator as well as having the distinction of being the first entirely "merchant" transmission line constructed in the Western Interconnection. The MATL represents a significant accomplishment and took over 7 years to complete from the original permit application submission to finish. So far, it has resulted in over \$1 billion of investment.

During 2012, 260 MW of wind power were installed in Montana. The projects represent \$546 million of private investment.

Future wind power projects will require new or upgraded transmission connections to serve out-of-state populations centers.

Recent hydroelectric dam projects include updates to existing systems that improve efficiency or capacity of the power generation.

The Big Sky Carbon Sequestration Partnership (BSCSP) will soon start an eight-year, large-scale carbon storage research project in northern Montana.

Twice as much electricity was generated in state than Montanans consumed in 2012.

Introduction to Nebraska

Electricity Generation

In 2012, electricity generators in Nebraska generated 34,645 gigawatt-hours of electricity, using the following sources:

Coal	72.5%
Nuclear	16.7%
Hydroelectric	4.3%
Wind	3.7%
Natural gas	2.5%
Biomass	0.2%
Petroleum	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Nebraska encourages the development of clean energy sources through policies such as tax credits and net metering.

Nebraska is unique in that all electric utilities in the state are public power or electric cooperatives.

Nebraska's two largest utilities, Omaha Public Power District (OPPD) and Nebraska Public Power District (NPPD), have adopted the voluntary goal of having wind power account for 10% of their electricity by 2020.

In 2010, a "wind for export" law was passed, providing a specific approval process for entities other than public power utilities to build renewable generation facilities in Nebraska. Nebraska utilities have the option of negotiating to purchase up to ten percent of the electricity from these facilities, and the remaining electricity must be sold outside the state to markets where it is needed.

The National Renewable Energy Laboratory estimates that almost 92% of land in Nebraska has suitable conditions for wind-powered electricity generation.

Almost all of the coal transported to Nebraska for electricity generation and industrial plants comes from Wyoming.

Nebraska ranks 12th in the least expensive cost of electricity and 8th in energy consumption per capita.

Introduction to New Hampshire

Electricity Generation

In 2012, electricity generators in New Hampshire generated 19,270 gigawatt-hours of electricity, using the following sources:

Nuclear	42.5%
Natural gas	36.5%
Hydroelectric	6.7%
Coal	6.6%
Biomass	5.8%
Wind	1.3%
Other	0.4%
Petroleum	0.2%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

New Hampshire encourages the development of clean energy sources through a diverse and broad range of policies, including net metering, a system benefit charge to fund energy efficiency, local property tax relief for residential renewable energy systems, and a renewable portfolio standard (RPS).

New Hampshire generates 77% more electricity than it consumes.

New Hampshire's RPS requires the state's electricity providers (except for municipal utilities) to acquire renewable energy certificates. There are four classes of energy resources, and utilities must meet the standard according to a compliance schedule that varies by class.

The New Hampshire Office of Energy and Planning operates several energy programs, including low-income fuel assistance and efficiency and promotes energy conservation and renewable resource use.

New Hampshire adopted the Regional Greenhouse Gas Initiative (RGGI) in 2008 to reduce GHG emissions from electric generation.

The state Public Utilities Commission (PUC) oversees regulated utilities to ensure that customers receive safe, adequate, and reliable service at reasonable rates. In 2008, the Sustainable Energy Division was created to assist the PUC in implementing renewable energy legislative directives and promoting renewable energy and energy efficiency throughout the state.

The PUC administers the Renewable Energy Fund (REF), created in 2007 as part of the RPS. Electric service providers who cannot obtain sufficient numbers of renewable energy certificates are required to make Alternative Compliance Payments; these payments feed the REF and are used to support electric and thermal renewable energy initiatives. The PUC administers rebate programs and competitive grant solicitations through the REF.

In 2009, former Governor John Lynch's Climate Change Policy Task Force developed the state's Climate Action Plan which recommends a long-term reduction in GHG emissions of 80% by 2050. The Plan recommends 67 measures to achieve substantial reductions and provide the greatest economic opportunity to the state. While some measures have been implemented, full implementation will require authorizing legislation.

Introduction to New Jersey

Electricity Generation

In 2012, electricity generators in New Jersey generated 64,092 gigawatt-hours of electricity, using the following sources:

Nuclear	51.7%
Natural gas	42.5%
Coal	3.0%
Biomass	1.4%
Solar	0.5%
Petroleum	0.1%
Pumped Hydroelectric Storage	-0.3%
Other	0.8%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

New Jersey encourages the development of clean energy sources through a diverse and broad range of policies, including property tax exemptions, net metering, a renewable portfolio standard, and a societal benefit charge fund.

The State's Renewable Portfolio Standard (RPS) requires that 22.5% of retail electricity sold in the state come from renewable energy sources by 2021, with 3.47% from solar energy.

The RPS contains provision for the nation's first offshore wind renewable energy standard, designed to accommodate at least 1,100 megawatts by 2021. The Offshore Wind Economic Development Act requires the RPS to include a carve-out for Offshore Renewable Energy Certificates (ORECS).

New Jersey's robust and mature Solar Renewable Energy Certificate (SREC) market and various types of long-term contracts have helped make project financing possible for solar developers. Since January 2010, growth in the development of solar capacity in New Jersey has increased nearly sevenfold. Approximately 881 MWs of the state's 1,114 MWdc of total installed solar capacity, or approximately 87%, was installed in just over three years.

The Oyster Creek nuclear reactor, which began operation in 1969, is the oldest operating nuclear power plant in the United States.

New Jersey averaged the 9th highest electricity prices in the nation in 2012.

The New Jersey Clean Energy Program provides financial and other incentives to the State's residential customers, businesses, and schools that install high-efficiency or renewable energy technologies. The program is authorized and overseen by the New Jersey Board of Public Utilities.

The New Jersey Global Warming Response Act mandates the statewide reduction of greenhouse gas emissions to 1990 levels by 2020, followed by a further reduction of emissions to 80% below 2006 levels by 2050.

Introduction to New Mexico

Electricity Generation

In 2012, electricity generators in New Mexico generated 36,574 gigawatt-hours of electricity, using the following sources:

Coal	68.3%
Natural Gas	23.9%
Wind	6.1%
Solar	0.9%
Hydropower	0.5%
Petroleum	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

New Mexico encourages the development of clean energy sources through its renewable electricity standard (RPS), net metering, and various tax incentives.

In 2007, New Mexico required investor-owned utilities (IOUs) to generate 20% of total retail sales from renewable resources by 2020; it also established a 10% by 2020 target for rural electric cooperatives. In 2012, the New Mexico Public Regulation Commission made significant changes to the RPS, which amongst other things increased the wind carve-out from 20% to 30%.

IOUs and electric cooperatives must offer net metering to customers with renewable systems up to 80 MW in capacity. Combined heat and power systems are eligible for net metering.

New Mexico has vast solar resources. It has enough solar resources to produce 6.5 to 7 kWh per square meter, or 16 million GWh annually. The Cimarron Solar project is among the nation's largest PV plants and a 5MW concentrating photovoltaic plant in Hatch is also one of the largest in the U.S. Solar projects are supported through various state tax incentives.

The Energy Conservation and Management Division (ECMD) develops and implements effective clean energy programs to promote environmental and economic sustainability. ECMD's programs and initiatives involve both distributed-scale and utility-scale generation

The Renewable Energy Production Tax Credit supports utility-scale wind, biomass, and solar projects.

The state is ranked tenth in the nation for wind resource.

Introduction to New York

Electricity Generation

In 2012, electricity generators in New York generated 136,966 gigawatt-hours of electricity, using the following sources:

Natural gas	43.8%
Nuclear	29.8%
Hydroelectric	18.3%
Coal	3.3%
Wind	2.2%
Biomass	1.5%
Other	0.7%
Petroleum	0.4%
Pumped Hydroelectric Storage	-0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

New York encourages the development of clean energy sources through a diverse and broad range of policies, including a renewable portfolio standard (RPS), net metering, tax incentives, production incentives, grants, loans, and a system benefits charge.

The New York Public Service Commission adopted an RPS in 2004, further expanding the target to 30% by 2015 in January 2010. The RPS has several tiers to encourage new renewable resource generations. Unlike most state RPSs, the New York RPS uses a central procurement model. The New York State Energy Research and Development Authority (NYSERDA) procures roughly 78% of the eligible new resources and manages an RPS fund derived from a surcharge on each kWh sold by the state's IOUs.

NYSERDA is a public-benefit corporation tasked with developing and promoting innovative technologies to improve the state's energy, economic, and environmental well being. NYSERDA administers the emissions allowance auctions of the Regional Greenhouse Gas Initiative (RGGI).

Long Island Power Authority (LIPA) is a corporate municipal instrumentality and political subdivision of the state, serving Nassau and Suffolk counties and the Rockaway Peninsula in Queens, New York. LIPA, with 1.1 million retail electricity customers, has installed over 52 MW of photovoltaic generation in the past four years bringing total PV installed capacity to over 100 MW. LIPA has also fully subscribed its first 50 MW FIT program and a 280 MW renewable procurement by year-end 2013 and offers clean energy programs as authorized by its Board of Trustees.

New York ranks among the top ten states for solar PV capacity due to its strong solar incentives. It is also one of the nation's top generators of electricity from hydropower, landfill gas, and municipal solid waste, according to the American Council on Renewable Energy. Hydropower supplies nearly 17% of the state's total electricity demand.

The state mandates that IOUs offer net metering for various renewable technologies.

According to the American Wind Energy Association, New York ranks twelfth in the nation in total wind capacity installed.

Introduction to North Carolina

Electricity Generation

In 2012, electricity generators in North Carolina generated 116,024 gigawatt-hours of electricity, using the following sources:

Coal	44.0%
Nuclear	33.9%
Natural gas	16.7%
Hydroelectric	3.0%
Biomass	2.0%
Petroleum	0.2%
Other	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

North Carolina encourages the development of clean energy sources through a range of policies, including renewable energy tax credits, net metering, and a renewable portfolio standard.

The state's Renewable Energy and Energy Efficiency Portfolio Standard (REPS) contains carve-outs for solar, poultry and swine waste.

The State Energy Office, now in the North Carolina Department of Environment and Natural Resources, operates energy efficiency and renewable energy programs in various sectors including buildings, transportation, and energy assurance. A public buildings energy efficiency program is very active with energy goals for state agencies, universities, and community colleges.

The U.S. Bureau of Ocean Energy Management announced on December 12, 2012, the release of the Call for Information and Nominations for potential wind leasing areas offshore from North Carolina. The call covers large offshore areas in the Atlantic Ocean known as Call Area Kitty Hawk, Call Area Wilmington East, and Call Area Wilmington West.

Currently ranked fifth in the nation for photovoltaic capacity, North Carolina has a well-developed network of solar developers that install utility scale projects.

North Carolina ranked fifth in the U.S. in net electricity generation from nuclear power in 2011, producing 5.1 percent of the nation's total.

The coal for North Carolina's coal-fired power plants primarily arrives by rail and truck from West Virginia and Kentucky.

Introduction to North Dakota

Electricity Generation

In 2012, electricity generators in North Dakota generated 36,179 gigawatt-hours of electricity, using the following sources:

Coal	78.0%
Wind	14.7%
Hydroelectric	6.8%
Petroleum	0.1%
Natural gas	0.1%
Other gases	0.1%
Other	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

North Dakota encourages the development of clean energy sources through a number of policies, including tax credits, a renewable portfolio standard, and a net metering policy.

In March 2007, North Dakota enacted legislation establishing an objective that 10% of all retail electricity sold in the state be obtained from renewable energy and recycled energy by 2015. The program is voluntary and there are no sanctions or penalties.

North Dakota is a significant net exporter of electricity, as it generated approximately 2½ times as much electricity as it consumed in 2012.

The Great Plains Synfuels Plant is the only commercial-scale coal gasification plant in the U.S. manufacturing natural gas. Average daily production is about 153 million cubic feet, the majority of which is used in the eastern United States. The Synfuels Plant—where between 2.5 and 3 million metric tons of carbon dioxide is captured per year—supplies carbon dioxide to the world's largest carbon capture and storage project in the world in Saskatchewan, Canada, for use in enhanced oil recovery.

Research and development funding from the Coal Trust Fund is used to investigate new ways to beneficially use carbon dioxide and to understand the intricacies of carbon capture and storage.

There are 16 natural gas processing facilities in western North Dakota and industry investment of \$3 billion in natural gas infrastructure will allow four more facilities to come online in 2013, a 389% increase in natural gas processing capacity.

Through its Oil and Gas Research Council and their private partners, North Dakota has invested more than \$2 million in new technologies to capture and use natural gas at well sites.

Since 2010, the North Dakota Public Service Commission has approved wind projects with total investments estimated at \$930 million. In total, it has permitted 2,900 megawatts of wind generation and ranks third in the U.S. for wind generation as a percentage of its portfolio.

Through its network of higher education and private investment, North Dakota has invested in research for hydrogen, solar, and geothermal applications.

Introduction to Ohio

Electricity Generation

In 2012, electricity generators in Ohio generated 129,307 gigawatt-hours of electricity, using the following sources:

Coal	66.5%
Natural gas	17.5%
Nuclear	13.2%
Petroleum coke	0.8%
Wind	0.8%
Biomass	0.5%
Hydroelectric	0.3%
Other gases	0.2%
Petroleum	0.2%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Ohio encourages clean energy development through a range of policies, including a renewable portfolio standard (called the Alternative Energy Portfolio Standard), net metering, tax incentives, loans, and grants.

Ohio enacted the Alternative Energy Portfolio Standard in 2008 requiring investor-owned utilities and retail electric suppliers to provide 25% of their retail electric supply from alternative resources by 2025. The statute classifies eligible technologies as advanced or renewable resources. Half the standard can be met with any new, retrofitted, refueled, or repowered generating facility located in Ohio, including fossil fuels. The Standard's 12.5% renewables portion includes a 0.5% solar carve-out.

Ohio enacted its original net metering law in 1999; it was last amended in 2008 and currently has neither a project nor aggregate capacity limit. The law limits net metering systems to those which offset part or all of the customer-generator's requirements for electricity.

The Ohio Development Services Agency (ODSA) issues competitive solicitations to increase jobs, reduce energy use, and reduce greenhouse gas emissions through the adoption of renewable energy and energy efficiency technologies.

Ohio's Advanced Energy Fund was created in 1999 through electric restructuring legislation. It is administered by ODSA and provides grants and loans for renewable energy and energy efficiency projects. It was initially funded by a small surcharge on investor-owned utility customers' electricity bills. Additional income may be distributed to the Fund from alternative compliance payments.

The Energy Loan Fund, whose funding is provided by the Advanced Energy Fund and the State Energy Program, provides low-cost financing to small businesses, manufacturers, and public institutions for energy efficiency and renewable energy systems.

In March 2012, Governor John Kasich released a proposed comprehensive state energy plan, which included 10 pillars for energy reform. The plan includes support for waste heat recovery, fracking regulations, and funding for coal carbon capture and sequestration.

Ohio has strong on and offshore wind resources and a strong wind manufacturing base. According to the American Wind Energy Association, over 50 companies currently manufacture wind energy components in Ohio. The state ranks fourth in the U.S. in wind industry employment.

Introduction to Oklahoma

Electricity Generation

In 2012, electricity generators in Oklahoma generated 78,267 gigawatt-hours of electricity, using the following sources:

Natural Gas	50.4%
Coal	37.4%
Wind	10.5%
Hydroelectric	1.5%
Biomass	0.4%
Hydro pumped storage	-0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Oklahoma has vast potential for renewable energy development. The state ranks eighth in the nation for most installed wind capacity and sixth for solar power potential.

Oklahoma has a large wind industry that continues to expand, and which is supported by new transmission lines to export wind-generated electricity. The state's renewable development is further supported by net metering, various tax incentives, and a renewable portfolio goal.

Oklahoma established a voluntary renewable energy goal in 2010 to achieve 15% renewable generation capacity by 2015. Energy efficiency may be used to meet up to 25% of the overall goal. The Oklahoma Corporation Commission (OCC) administers the program and approves eligible renewable energy resources.

The OCC adopted net metering rules in 1988, requiring investor-owned utilities and electric cooperatives under its jurisdiction to make net metering available to all customer classes. Renewable energy systems and combined heat-and-power facilities up to 100 kW in capacity are eligible.

The State Energy Office, under the Oklahoma Department of Commerce, promotes the development of renewable energy and looks at energy efficiency as a tool for economic development.

According to the American Wind Energy Association, Oklahoma added the fifth most new wind capacity in 2011. The state offers various tax incentives for certain wind manufacturers and wind power generators.

Tax credits are also available for zero-emission facilities that generate renewable power for third parties and for eligible biodiesel and ethanol production facilities.

The Oklahoma Department of Commerce operates a revolving loan fund that distributes loans up to \$150,000 for local governments to install certain renewable energy systems.

Introduction to Pennsylvania

Electricity Generation

In 2012, electricity generators in Pennsylvania generated 224,714 gigawatt-hours of electricity, using the following sources:

Coal	39.2%
Nuclear	33.5%
Natural gas	23.6%
Biomass	1.1%
Hydroelectric	1.0%
Wind	1.0%
Other energy sources	0.4%
Other gases	0.3%
Petroleum	0.1%
Hydro pumped storage	-0.2%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Pennsylvania has an alternative energy portfolio standard and requires investor-owned utilities (IOUs) to offer net metering. Although there are also other policies supporting clean energy development, exhaustion of state funding and program revisions have limited the number of incentives, grants, and loans available.

The state is a net exporter of electricity; it generates 56% more electricity than it consumes.

Pennsylvania enacted its Alternative Energy Portfolio Standard (AEPS) in 2004, requiring each electric distribution company and electric generation supplier to supply 18% of its electricity using alternative energy sources by 2020. The AEPS includes two tiers: one tier is primarily for new and existing renewable sources, and the other for alternative energy resources. The AEPS also has a solar carve-out, mandating that a certain percentage of electricity be generated by solar PV. Alternative energy sources include waste coal and coal gasification, coal-mine methane, and coal gasification. All facilities located within PJM Interconnection meeting the definition of an alternative energy source qualify.

Pennsylvania requires IOUs to offer net metering to residential customers up to 50kW in capacity, non-residential systems up to 3 MW, and emergency and micro-grid systems between 3 and 5 MW. In 2012, the Pennsylvania Public Utilities Commission approved the use of third-party ownership models in conjunction with net metering, subject to a restriction that the system is not designed to produce more than 110% of the on-site electricity needs.

Pennsylvania has been successful at attracting wind and solar manufacturers to the state. According to the American Wind Energy Association, Pennsylvania is home to at least 22 facilities manufacturing components for the wind industry. Gamesa, a global wind turbine manufacturer, has its U.S. hub in Pennsylvania.

The Pennsylvania Sunshine program offers rebates to residences and small commercial facilities that install Solar PV and solar thermal systems. The program is administered by the Pennsylvania Department of Environmental Protection.

Introduction to Rhode Island

Electricity Generation

In 2012, electricity generators in Rhode Island generated 8,370 gigawatt-hours of electricity, using the following sources:

Natural gas	98.2%
Biomass	1.5%
Petroleum	0.2%
Other	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Rhode Island encourages the development of clean energy sources through a diverse and broad range of policies, including tax credits, net metering, a renewable energy standard, and the nation's first public benefits fund.

Rhode Island established its Renewable Energy Standard (RES) in 2004, requiring the state's retail electricity providers to supply 16% of their retail sales from renewable energy resources by 2019. In 2006, the state increased the goal to 20% by 2014.

The Rhode Island Office of Energy Resources (OER) is the principal agency authorized to integrate and coordinate the state's renewable energy policies.

The Rhode Island Public Utilities Commission manages the electric distribution companies' charges and has jurisdiction over the state's Renewable Energy Standard (RES). Alternative Compliance Payments made to comply with the RES mandate are paid to the Rhode Island Renewable Energy Fund (RIREF). RIREF "is dedicated to increasing the role of renewable energy with business development and energy supply in Rhode Island's electric grid." The Rhode Island Economic Development Corporation (RIEDC), which administers RIREF, supports projects in the following areas: municipal renewable energy programs, pre-development consultant and feasibility studies, non-profit housing renewable energy investment programs, and renewable energy development. RIEDC uses funds from the systems benefit charge on electric bills and Alternative Compliance payments to fund renewable energy programs.

The Office of Energy Resources manages, administers, and oversees efforts to transform the state's energy system by promoting energy efficiency, renewable energy, and alternative energy assurance.

The Office of Energy Resources notes that the state "has made significant investments in offshore wind development," including zoning the Oceanic Special Area Management Plan for offshore wind activities.

Introduction to South Carolina

Electricity Generation

In 2012, electricity generators in South Carolina generated 96,510 gigawatt-hours of electricity, using the following sources:

Nuclear	53.0%
Coal	29.5%
Natural Gas	14.6%
Biomass	2.1%
Petroleum	0.1%
Other	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

South Carolina provides tax incentives for the installation of certain renewable energy systems.

In 2009, the South Carolina Public Service Commission issued an order mandating net metering by the state's investor-owned utilities. The Governor's Energy Office provides leadership in the development of public and private partnerships, works in conjunction with other state agencies, the Legislature, and private and nonprofit sectors, and oversees and administrates the federal State Energy Program (SEP) funds and priorities.

The South Carolina Energy Office promotes the use of renewable energy throughout the state. It manages the ConserFund, a low-interest revolving loan program for energy efficiency upgrades in public buildings and private non-profit organizations.

South Carolina offers a corporate Biomass Energy Tax Credit that can be applied to an individual's income taxes. A limited liability company utilizing the biomass tax credit is allowed to pass through the credit to the shareholders of an S Corporation. Eligible resources include landfill gas, biomass, CHP/cogeneration, and anaerobic digestion.

The state has significant potential to develop renewable energy from its biomass resources, with the potential to generate over 8000 GWh annually from biopower. One quarter of the state's biomass resource comes from mill waste.

The state's wind resources are located primarily offshore and could support the installation of 133 GW.

There are at least 17 facilities in South Carolina that manufacture components for the wind energy industry, including GE, a leading wind turbine manufacturer in the U.S.

South Carolina is a net exporter of electricity. It generates 25% more electricity than it consumes.

Introduction to South Dakota

Electricity Generation

In 2012, electricity generators in South Dakota generated 12,168 gigawatt-hours of electricity, using the following sources:

Hydroelectric	49.0%
Coal	24.4%
Wind	23.9%
Natural gas	2.6%
Petroleum	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

South Dakota encourages the development of clean energy sources through a range of policies, including tax incentives and a voluntary renewable energy objective.

Recent enacted legislation titled Building South Dakota contains provisions for sales tax rebates to developers of projects over \$20M.

Most of South Dakota's wind farms only sell to local utilities or pay fees to use Midwest Independent Transmission Operator's (MISO) transmission lines. Most of the state is not part of MISO. Wind farms on MISO's grid can sell power to any customer in the MISO area, which covers much of the Upper Midwest and will soon extend south to Arkansas and Louisiana.

South Dakota is among the states with the highest percentage of electricity generation from renewable resources.

In 2011, South Dakota became the first U.S. state to have at least 20% of its electricity generation come from wind power.

The National Renewable Energy Laboratory estimates that 88% of South Dakota's land area has high wind power potential.

Retail electricity costs in South Dakota are among the lowest in the United States.

• Introduction to Tennessee

Electricity Generation

In 2012, electricity generators in Tennessee generated 77,449 gigawatt-hours of electricity, using the following sources:

Coal	46.0%
Nuclear	32.4%
Hydropower	10.3%
Natural Gas	9.9%
Biomass	1.3%
Petroleum	0.2%
Wind	0.1%
Pumped Hydro Storage	-0.2%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Tennessee offers several tax incentives to spur the development of the green economy, including supply chain manufacturers.

The Tennessee Department of Environment and Conservation is the lead state agency developing and managing the Clean Tennessee Energy Grant Program. The program provides financial assistance to municipal and county governments, utility districts, and other entities created by statute to purchase, install and construct energy projects in three categories: 1) Cleaner Alternative Energy (solar, wind, biomass, geothermal); 2) Energy Conservation; and 3) Air Quality Improvement.

Tennessee is a net importer of electricity, consuming 25% more electricity than it generates.

Tennessee has vast biomass resources and is home to the Oak Ridge National Laboratory and several other research centers developing pilot biomass, biofuel, and bioenergy projects.

A 2012 National Renewable Energy Lab report estimates that Tennessee's total solar potential would amount to 2,295,918 GWh annually.

The Tennessee Energy Education Initiative (TEEI), in conjunction with Pathway Lending and other statewide energy resource providers, provides in-depth training and educational tools to support the implementation of energy efficiency, renewable energy, and energy management projects.

The Tennessee Energy Efficiency Loan Program (TNEELP), in collaboration with the state, TVA, and Pinnacle Bank, TNEELP operates a \$50 million revolving loan fund to provide low-interest financing for energy efficiency and renewable energy projects.

In partnership with the Tennessee Energy Education Initiative, the Tennessee Advanced Energy Business Council (TAEBBC) produced a 40-page report outlining the State's advanced energy assets, including clean energy manufacturers, program and technologies, research institutions and installation service providers.

The report is accessible at <http://tnenergy.org/wp-content/uploads/2013/09/TAEBC-Energy-Asset-Inventory.pdf>.

Introduction to Texas

Electricity Generation

In 2012, electricity generators in Texas generated 431,017 gigawatt-hours of electricity, using the following sources:

Natural gas	50.0%
Coal	32.0%
Nuclear	8.9%
Wind	7.4%
Biomass	0.4%
Hydroelectric	0.1%
Other	0.2%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Texas encourages the development of clean energy sources through a diverse and broad range of policies, including tax credits, net metering, and a mix of state, utility and local renewable portfolio standards.

Texas accounted for 28% of U.S. marketed natural gas production in 2011, making it the leading natural gas producer among the states.

Texas is the 5th largest coal producer in the nation, accounting for 4% of U.S. coal production.

The Texas Clean Energy Project (TCEP), a \$2.5 billion, 400 MW integrated coal gasification combined-cycle (IGCC) plant at Penwell, Texas, is scheduled to begin construction in mid-2013. It will incorporate carbon capture and sequestration (CCS) technology. It will be the first coal-fired power facility in the U.S. to combine both IGCC and CCS.

Texas leads all states in the net generation of electricity from burning coal.

To attract new generation, the Texas Public Utilities Commission adopted a policy to raise the price caps on generators offering into the wholesale market. The cap was raised 50% effective August 1, 2012 to \$4,500 per MWh and an additional 100% (to \$9,000 per MWh) effective 2015.

Texas is the national leader in overall wind installations and was the first state to reach 10,000 MW of wind energy installations. Wind resource areas in the Texas Panhandle, along the Gulf Coast south of Galveston, and in the mountain passes and ridgetops of the Trans-Pecos offer Texas some of the greatest wind power potential in the United States.

In early 2012, a five-phase, 400 MW solar PV installation was announced for the San Antonio area. Developed via a public-private partnership, it is expected to be one of the largest solar projects in the nation.

Transmission lines tailored to renewable energy sources continue to be an area of focus in Texas. Investment in the state's Competitive Renewable Energy Zones (CREZ) grew to \$7 billion in 2012, and will allow an even greater amount of electricity to flow from rural wind generation sites to high-demand urban sites.

Introduction to Vermont

Electricity Generation

In 2012, electricity generators in Vermont generated 6,708 gigawatt-hours of electricity, using the following sources:

Nuclear	74.4%
Hydroelectric	17.8%
Biomass	6.0%
Wind	1.6%
Other	0.1%
Petroleum	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Vermont encourages the development of clean energy sources through a range of policies, including tax credits, net metering, group net metering, state incentives, a feed-in-tariff, and the Sustainably Priced Energy Enterprise Development (SPEED) Program, which requires utilities to enter into contracts with renewable energy generators.

The SPEED Program has some similarities to a renewable portfolio goal or standard (RPS), but is unique to Vermont. It was enacted in 2005 to promote the development of in-state renewable energy and to ensure that economic benefits of those resources flow to the Vermont economy and the state's ratepayers. SPEED set out several goals with the most significant being that the state's utilities enter into sufficient contracts to supply 20% of Vermont's load with new SPEED resources by 2017, and that each retail electricity provider's portfolio consist of 55% renewable energy by 2017 increasing by 4% each year until reaching 75% in 2032 as Total Renewables Targets. A Standard Offer program added in 2009 covers projects 2.2 megawatts and smaller and provides approved projects with fixed-price payments for every megawatt-hour of electricity they produce. The price is determined through a competitive solicitation undertaken once each year. Unlike an RPS, the SPEED program does not require the utilities to retain or retire the renewable electricity certificates associated with the generation.

Net metering is available for qualified renewable energy systems up to 500 kW in capacity and for combined heat and power systems up to 20 kW. Group net metering is also available in Vermont.

The Clean Energy Development Fund (CEDF), managed by the Vermont Public Service Department, promotes the development and deployment of renewable energy through grants and other incentives.

The Renewable Energy Resource Center administers the Vermont Small Scale Renewable Energy Incentive Program, a solar and wind incentive program established by the Legislature in 2003 and funded by CEDF.

According to Biomass Energy Resource Center, Vermont has vast biomass resources and is capable of producing 894,000 tons of biomass.

119 MW of wind power were on-line in the state as of August 2013, according to the Vermont Public Service Department.

Introduction to Virginia

Electricity Generation

In 2012, electricity generators in Virginia generated 70,895 gigawatt-hours of electricity, using the following sources:

Nuclear	40.5%
Natural Gas	35.4%
Coal	20.2%
Biomass	3.2%
Hydropower	1.4%
Other	0.7%
Petroleum	0.5%
Hydro pumped storage	-1.9%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Virginia offers an array of incentives and policies supporting clean energy, including a voluntary renewable energy portfolio goal, net metering, loans, grants, a public benefits fund, and tax incentives.

Virginia established a voluntary renewable energy portfolio goal in 2007 for investor-owned utilities (IOUs) to procure 15% of the power they sell in Virginia from renewable sources by 2025. The goal, which has been expanded several times, allows IOUs to meet up to 20% of the goal through certificated research and development activity expenses related to renewable and alternative energy sources. IOUs may recover the costs of new systems. Onshore wind and solar power receive double credit, and offshore wind receives triple credit, towards the goal.

Virginia requires IOUs and electric cooperatives to offer net metering to residential customers with renewable energy systems up to 20 kW in capacity and to non-residential customers with systems up to 500 kW.

The Department of Mines, Minerals, and Energy is the primary state energy responsible for the development and regulation of energy resources. It administers the 2010 Virginia Energy Plan, which recommends growing both traditional and alternative energy production, jobs, and investment. The state's primary energy sources include natural gas, oil, biomass, coal, and nuclear, but the greatest potential for renewable electric generation comes from onshore and offshore wind, and waste- or biomass-to-energy facilities.

Virginia created the Clean Energy Manufacturing Incentive Program in 2011 to replace two other grant incentive programs which will be phased out. The incentive program is open to biofuel producers, renewable energy manufacturers, nuclear equipment and product manufacturers, or products used for energy conservation, storage or grid efficiency. The program is administered by the Virginia Economic Development Partnership Authority.

The American Wind Energy Association estimates the offshore state wind resource potential to be 94,448 MW.

Virginia is a net importer of energy, consuming 51% more electricity than it generates.

Introduction to West Virginia

Electricity Generation

In 2012, electricity generators in West Virginia generated 73,326 gigawatt-hours of electricity, using the following sources:

Coal	95.9%
Hydroelectric	1.8%
Wind	1.8%
Natural gas	0.3%
Petroleum	0.2%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

West Virginia encourages the development of clean energy sources through a range of policies, including tax credits, net metering, and an Alternative and Renewable Energy Portfolio Standard.

The state accounts for nearly one-third of U.S. coal production east of the Mississippi River and over one-tenth of total U.S. coal production. West Virginia has more estimated recoverable coal reserves at producing mines than any other state except Wyoming.

West Virginia is a significant net exporter of electricity, as it generated approximately 2½ times more electricity than it consumed in 2012.

The Marcellus Shale formation has attracted increasing development interest in leasing land or acquiring acreage with shallow natural gas wells for the purpose of expanding natural gas production.

The even deeper Utica Shale has the potential to produce even more natural gas than Marcellus. It is thicker than the Marcellus, geographically larger, and has proven its ability to support commercial production.

American Electric Power canceled a carbon capture and sequestration project at its Mountaineer coal plant in 2011 due to concerns about recovering project costs.

It is estimated that landholding companies own over half of the land in West Virginia.

Introduction to Wisconsin

Electricity Generation

In 2012, electricity generators in Wisconsin generated 64,484 gigawatt-hours of electricity, using the following sources:

Coal	50.8%
Nuclear	22.2%
Natural gas	18.3%
Hydroelectric	3.1%
Biomass	2.6%
Wind	2.4%
Petroleum	0.1%
Other	0.1%

Note: These numbers represent **generation**, not consumption, of electricity. They do not include behind-the-meter generation. The data comes from the US Energy Information Administration's *Electric Power Monthly* (www.eia.gov/electricity/monthly).

Policy Context for Clean Energy

Wisconsin encourages the development of clean energy sources through a diverse and broad range of policies, including tax credits, grants, net metering, a renewable portfolio standard, and a system benefit charge fund.

Utilities' renewable portion reached 8.88% by the end of 2011, before Wisconsin's largest wind project commenced operations in 2012. Wisconsin's Renewable Portfolio Standard (RPS) requires utilities to obtain 10% of their electricity from renewable energy by 2015. The standard was amended in 2011 to allow utilities to count generation from large Canadian hydroelectric sources toward their renewable requirements.

The Wisconsin Public Service Commission's utility-funded Focus on Energy, the statewide energy efficiency and renewable energy program, has enabled more distributed installation activity than in other Midwest states. Annual renewable resource incentive funding for each of 2013 and 2014 makes 75% of the renewable resource incentives available for biomass, biogas, and geothermal technologies, and 25% available for solar thermal, photovoltaic, and wind technologies.

Dominion Resources, a Virginia-based utility holding company, will shut down and decommission the 560 MW Kewaunee Nuclear Power Plant near Green Bay, Wisconsin, in 2013.

Biomass facilities located in Wisconsin produce electricity through landfill gas power, gasification, anaerobic digestion, and incineration. They use municipal solid waste, forestry residue, manure, organic waste and other feedstocks for power.