EISPC

EASTERN INTERCONNECTION STATES' PLANNING COUNCIL

EISPC EXECUTIVE SUMMARY

ENERGY ZONES STUDY

FINAL REPORT

OCTOBER, 2013

EISPC ENERGY ZONES STUDY FINAL REPORT

Table of Contents

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Other Acknowledgements

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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 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 others[2]:

- 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 Clean 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 lead 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 Objectives[5] one of the primary purposes of the EZ work is to provide objective, accurate and comprehensive information to policymakers at the 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

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[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. <u>*Energy Zone*</u> *– 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 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.*

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 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 categories[6] 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 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

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[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).

[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.

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 layers[8] 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 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 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

[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.

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.

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% (~7°) 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	• 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	• Agricultural residues • Wood, farmed or forested • Forest residues • Primary mill residues • Secondary mill residues o Urban wood residues (urban wood waste, tree service waste, C&D waste)

Additional Resource categories included	• 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

<u>Forest residues</u> 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	
• USGS identified geothermal systems map • SMU well database (available for analysis, but display of raw data may be restricted) o EGS temperature map at various depths (viewable on Google Earth at http://www.google.org/egs/index.html) o 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	• Conventional hydrothermal • Enhanced geothermal systems (EGS) • Co-production of electricity at existing oil/gas wells • Geopressured geothermal power • Direct use

Resource estimation	• 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
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 about 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 MIT[9] of near-term development of EGS sites show economic potential within the range of other advanced technologies. Recent estimates[10] 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

[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

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.

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. Resources 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	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 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 d 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% (~7°) 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 indentified 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

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 /m2/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 reduces 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 indentified 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 km^2, (resolution or better, if available) annual data. Criteria listed below refines the base resource data to show the greatest**
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 km2, (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.
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 formations[12].

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.

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.

[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.

[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.

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, depleted reservoirs, and/or aquifer).
Cooling Water	Proximity to sufficient cooling water sources for combined cycle natural gas power generation unit is a must. Exact requirements TBD.
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 lower48 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 ^{o}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 it 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 a 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
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
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 1968and 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
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

[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 Zone Workgroup

Identified Goals and Objectives, Desired Deliverables

And Definition of Terms

FINAL – EISPC APPROVED JULY 27, 2011

Attachment B

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.