Clean Energy-Environment Tech Forum

The Electricity Grid: Implications for State Clean Energy Policies
Background and Resources
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State clean energy programs can be influenced by the design and operation of the U.S. transmission system. As a result, states have a strong interest in the system, even though they do not have a direct responsibility for the operation of the system. This background document provides some basic information about how the electricity transmission system operates, how it is designed and regulated, and the interrelationship between the operation and reliability of the electricity grid and state clean energy policies and programs.

I. Electricity Grid Basics: How does the Transmission system work?

Transmission lines are the interstate highway of the electricity delivery system. They carry high voltage power (138 kilovolts (kV) and above) from power plants over long distances to substations. There are more than 150,000 miles of interconnected transmission lines across the country and additional transmission that connects the U.S. to power plants and load centers in Canada and Mexico. **Once the power reaches the substation, it is "stepped down" in voltage and delivered to customers through the distribution network.** Some basic physical properties of electricity influence the design and operation of the transmission system:

- Power flows follow the path of least resistance over the transmission network, not necessarily along the most direct path from generator to load
- Power dissipates in the form of heat during transmission (line losses)
- Power loses voltage while travelling long distances which can be restored with capacitors

The transmission system is built and managed to maintain stable voltage levels and minimize losses, to ensure that power can reach demand centers minute by minute without overloading transmission lines, and to accommodate equipment failures, extreme weather and other random events that influence demand or supply. The capacity of a transmission line is a factor of its engineered design, air temperatures, and operational limits that are needed to ensure reliability. However, as the load on a transmission line increases, the temperature of the line also increases. Exceeding the capacity can overheat lines and cause fires and failure. Congestion has been increasing on parts of the U.S. transmission system as demand for electricity, deregulation of wholesale electricity sales, and construction of new power plants has outpaced the construction of new transmission capacity.

II. Who owns the T&D Systems?

There are five different entities that own transmission lines:

- Fully integrated, investor-owned utilities that own transmission, distribution and generation facilities
- Investor-owned transmission-only companies that do not own any distribution or generation such as Vermont Electric Power Company
- Investor-owned transmission and distribution (T&D) companies such as National Grid in New England

- Merchant transmission companies such as American Transmission in the Midwest
- Consumer-owned and municipally-owned utilities and Federal Power Authorities, such as Bonneville Power Authority and the Tennessee Valley Authority

Investor-owned utilities own almost 80% of the U.S. transmission system. Public-owned utilities and cooperatives, along with the Federal power agencies, account for almost all of the remaining transmission.

III. Who plans, regulates, and manages the T&D systems?

Part of the challenge of building and maintaining an optimal transmission network is the number of private sector and government entities that have responsibility for parts of the system:

- **Transmission and generation owners** have the primary responsibility for the reliable operation of the existing transmission network and the expansion of the network to meet the growing demands for electricity. The high investment cost, the risk associated with the cost recovery of multi-state facilities, and the challenge of siting new power lines has led to increased collaboration between transmission owners, state regulators, and regional transmission organizations.

- **Regional Transmission Organizations (RTO) or Independent System Operators (ISO)** have formed in different regions of the country (New England ISO, NYISO, PJM ISO, Midwest ISO, CAISO, Southwest Power Pool ISO and ERCOT ISO) to ensure independent oversight of the transmission network and implementation of NERC reliability standards[1], although not every region has an RTO/ISO. Where an RTO/ISO exists, the transmission owners surrender the right to operate their lines. The RTO/ISO is also responsible for the analysis and planning of the regional transmission network and operation of the generation system and power transactions. They monitor system loads and voltage profiles; operate transmission facilities and direct generation; define operating limits and develop contingency plans; and implement emergency procedures. The ISO/RTO may recommend that certain transmission investment be made to maintain reliability and deliver generation to load centers, but the transmission owners or merchant transmission developers are responsible for building the facilities. Where RTOs/ISOs do not exist, the individual utilities or transmission owners are responsible for building and operating the system in a reliable manner.

- **Federal Energy Regulatory Commission (FERC)** oversees the cost recovery and wholesale transmission rates for interstate transmission lines. FERC also monitors the reliability of the transmission systems and the operation of energy markets governed by RTO/ISOs or individual transmission owners. FERC has the authority to preempt state and local authority to mandate construction of certain national priority transmission facilities designated by DOE. This back-stop siting authority was established in the Energy Policy Act of 2005.

[1] NGA and NCSL, Connecting the Grid, Appendix C. Existing Formal and Informal Regional Transmission Organizations, 2006.

- **North American Electricity Reliability Corporation (NERC)** is the entity responsible for setting reliability standards for the electricity industry. While NERC does not directly regulate the transmission system, it establishes criteria and practices for maintaining reliability and enforces the standards through civil penalties. In addition to setting the amount of excess generation that should be "in reserve" to meet potential unexpected outages, NERC requires that utilities design the transmission system to protect against certain system events that might jeopardize reliability. NERC is subject to oversight by FERC.

- **U.S. DOE** has authority under EPACT 2005 to designate National Electric Transmission Corridors – geographic areas where transmission constraints and congestion adversely affect electricity prices or the national interest in maintaining a reliable power system. DOE has designated two National Corridors – the Mid-Atlantic Area National Interest Electric Transmission Corridor, and the Southwest Area National Interest Electric Transmission Corridor based on analysis that indicates expansion of transmission in these areas would reduce persistent congestion problems.

- **State utility regulatory commissions** usually pass wholesale transmission costs through to retail customers, since transmission cost recovery is under the jurisdiction of FERC. However, the state may intervene in transmission cases pending before FERC to represent their interests. A few states including Texas, Hawaii and Alaska, have the authority to approve or disapprove the cost of transmission facilities built by utilities under their jurisdiction because the transmission system is not interconnected with other states. In some states, the regulatory commission has authority to approve the siting of transmission facilities within the state boundaries, although in some cases this authority rests with a separate agency.

- **State energy facilities siting authorities** (or the regulatory commission) exercise jurisdiction over the complex process of siting new transmission lines and expanding existing ones. Most states require the utility to submit an application to one or more state agencies for approval of the need and location of new lines, to review the environmental impacts, and once approved, to allow the utility to exercise the power of eminent domain to acquire the rights-of-way (ROW) to build the line. In Colorado, the local governments have the authority to review and approve new facilities. States like Connecticut have a single agency or "one-stop shop" for the review process. Other states have multiple agencies that must review the application simultaneously or in sequence. The **U.S. Departments of Interior and of Agriculture (Forest Service)** become involved when transmission lines cross federal lands.

- **Regional State Committees**, such as the Organization of PJM States, the Southwest Power Pool Regional State Committee, and the Organization of MISO States, have formed to encourage greater multi-state collaboration in the planning and monitoring of regional transmission networks. The state committee members work with the utilities, transmission owners, the RTO/ISO and other stakeholders. The intent of these collaborative efforts is to build greater consensus about the regional need and benefits of expanding the transmission network and best practices in operating the transmission system and maintaining reliability.

IV. Why is the T&D system important to clean energy policies & programs?

States have a number of opportunities to influence the planning, operation and cost recovery of the transmission system. State clean energy programs both rely on and have important implications for the transmission system. For example, Duke Energy and American Electric Power believe that new lines are needed to handle the distribution of wind power that is expected to be built in coming years, so they recently announced a joint venture to build 240 miles of high-voltage transmission line in Indiana. This section explores the opportunities for greater integration of clean energy programs and policies with the planning and management of the transmission system.

Planning for Transmission Needs

States may have a formal role in the planning process for new regional, multi-state transmission facilities through the regional state committee. In other parts of the country, the state's role is through an informal exchange of information with the transmission owners. The state may require that any line proposed within the state be submitted for review to determine if it is needed and may issue a "certificate of need" and other permits before construction can proceed.

An important part of the planning process is finding the right combination of approaches to flexibly resolve congestion on the transmission system, accommodate new generation, and deliver power to load centers. A number of approaches should be considered including:

- Reducing demand through aggressive energy efficiency programs
- Deploying demand response programs to reduce peak loads
- Adding central power plants in strategic locations
- Installing new transmission technologies (see Modernizing the Grid)
- Installing distributed generation such as solar photovoltaics, small-scale wind, or combined heat and power

Reducing use of electricity during periods of high demand or placing generation closer to the load centers can reduce congestion on the transmission system and may eliminate or reduce the need for expanded transmission. The right option or combination of options depends on the particular set of problems faced by grid managers. If congestion or reliability problems are the result of new generation being added at approved locations, new transmission may be the best and only solution. If congestion prevents lower-cost power from reaching load centers, demand-side load management and distributed generation close to the load center may be effective.

State renewable portfolio standards are also creating new transmission needs. The best areas for renewable power plants such as wind and large-scale solar are often in remote parts of the country where transmission lines have not been built. States, regions and renewable energy developers are now grappling with the question of how to move renewable energy to markets where people use energy. According to the owner of Maple Ridge Farm, a 200 turbine wind farm in upstate New York, the transmission lines carrying power away from project have sometimes become so congested that the company's only choice is to shut down — or pay fees for the privilege of continuing to pump power into the lines.[2] Many of the windiest parts of the country have not been developed at all because the transmission does not exist.

Texas and the Western Governors have taken a proactive approach to identifying the transmission needs for remote renewable resources. In Texas, the Public Utility Commission working with **the Electric Reliability Council of Texas (ERCOT) has designated eight Competitive Renewable Energy Zones (CREZ)** as areas for transmission investment. These areas are prime wind energy areas, and the transmission lines will be in preparation for when the wind farms are developed. As manager of the State's largest power grid, ERCOT was designated to collect wind data and nominate a number of CREZs based on transmission cost calculations for each CREZ. In July 2007, after evaluating the potential for wind generation in about 25 areas in the state, the Texas Public Utility Commission (PUC) designated eight areas as CREZs, which were combined into five zones. The PUC's interim final order outlines four scenarios for building transmission from 10,000 MW to 22,806 MW, depending on cost and the number of wind farms that are built. The PUC's final order is expected in 2008, and will designate final transmission solutions for the CREZ areas and announce the transmission companies chosen to build the transmission lines.

In the West, a similar effort is underway to designate Western Renewable Energy Zones (WREZ). The Western Governors' Association is coordinating the collaborative efforts of 11 states, two Canadian provinces, and parts of Mexico to identify those areas in the West with high quality, developable renewable resources in order to expedite the development and delivery of electricity generated by renewable energy projects. By June 2009, the Steering committee hopes to have specific recommendations on proposed REZs with exclusion zones ready to present to the Governors, after which Phase II, conceptual transmission planning, will begin. Phase III will focus on establishing resource procurement agreements to facilitate regional renewable energy markets and Phase IV will encourage multi-state agreements to get transmission construction approvals and cost recovery needed to deliver the renewable energy to markets.

Modernizing the grid

Utilities and states are also evaluating and investing in new technologies that will enhance the ability to manage the grid. The term "smart grid" describes a wide range of technologies and communication systems that will allow the move from a centrally-controlled transmission and distribution system to a more consumer-responsive and decentralized system. Smart grid technologies promise to provide greater energy security, reliability and efficiency, while lowering emissions from the electricity generation industry. Federal legislation has been a major impetus behind investment in this area. T**he Energy Policy Act (EPACT) of 2005 (Section 1252)** recognized the national interest in development of policies and technologies that support demand response and directed FERC to survey utilities to report on the penetration of advanced meters and other smart grid technologies.

The Energy Independence and Security Act (EISA) 2007 (Section 1307) goes even further. It requires states to consider smart grid investments. The standard directs the state to consider whether to authorize rate recovery for smart grid investments and recovery of the remaining value of any equipment rendered obsolete by new smart grid equipment. It also requires states to consider adopting a policy on sharing smart grid information on time-based retail and wholesale electricity

[2] Wald, Matt, "Wind Energy Bumps into Power Grid's Limits," New York Times, Aug. 27, 2008.

prices, usage, projection of day-ahead price information, and generation sources, including greenhouse gas emissions with electricity purchasers.

One component of a smart grid that is being deployed widely in California and as a pilot in other states is **Advanced Metering Infrastructure (AMI)** (see the January 22, 2008 Tech Forum for more information and resources). AMI will provide consumers with the ability to get information about their usage and the price of electricity on an hourly or real-time basis, and will allow utilities to see customers' usage and any problems on the system immediately. Customers will have the capability to make informed choices about their electricity demands and in the long run, will be able to program their appliances to automatically respond to price signals. AMI technology will also provide valuable service to utilities including the ability to detect and fix problems in the T&D system remotely, and the ability to predict and respond to changes in demand more efficiently and resiliently.

Other longer-term components of the smart grid include technologies and communication systems that will monitor the health of the system moment to moment, integrate the information coming in from both sources and users on the system for a comprehensive picture of our regional and national electricity system. This system would also accommodate new storage technologies and clean, distributed generation more seamlessly.

V. Upgrade Challenges

The task of building new transmission facilities is challenging for a number of reasons:

- Multiple jurisdictions and entities responsible for overseeing and investing in transmission infrastructure
- The high capital cost of these investments
- The long lead times needed to plan, permit, site, and build facilities which increases the risk for the developer
- The deregulation of the generation industry, which means that many generation developers no longer coordinate the siting of new generation with transmission owners
- The mismatch between state benefits of regional transmission infrastructure and the location of the facilities

Besides public opposition, **one of the biggest hurdles for transmission developers and generators is the risk that they will not be able to recover the costs.** Most transmission investment costs are reviewed and approved by FERC and the costs are passed on to retail electricity consumers through the distribution utility. Costs are allocated to transmission companies and generators who need new transmission infrastructure to deliver power to customers. There are two basic approaches to cost allocation:

- **Socializing the costs** by spreading them among all users of the transmission system, or
- **Participant funding** which assigns some or all of the costs to the generator that requires the transmission upgrade.

Many new transmission lines are funded through a combination of both approaches, assigning cost directly where it is appropriate and socializing the remaining costs.

One of the challenges for states is balancing the state's costs and benefits of transmission expansion with the region's needs. Typically the state's analysis of the need and benefits of multi-state transmission facilities stops at the state line, which may neglect the larger regional picture. As electricity markets have evolved to require transmission of power over longer distances and across many jurisdictions, the need for multi-state transmission projects but many states are unwilling to pass through costs when other states receive the bulk of the benefits in the form of reduced power for major load centers.

Even where states do not have a direct role in approving the cost, they may intervene in the cost recovery proceeding before FERC to prevent allocation of the cost to state utilities or they may refuse to issue the certificate of need and siting approvals required to construct the portion of the line in their state. Cost of multi-state transmission is reviewed and approved by the FERC, included in wholesale transmission rates, then passed on to retail ratepayers through the utilities' wholesale prices. Neither FERC or states have jurisdiction over transmission investments made by government or consumer-owned utilities

Since 2005, when FERC was granted back-stop siting authority for transmission lines in National Interest Corridors, states have an even greater incentive to work together with the transmission planners to find viable solutions to cost-recovery and siting where transmission is found to be the best solution in combination with clean energy goals and programs.

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http://www.westgov.org/wga/initiatives/wrez/UPDATE11-08.pdf

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http://www.westgov.org/wga/initiatives/wrez/index.htm

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http://www.demandresponsecommittee.org/Final_NCEP_Report_on_DR_and_SM_Policy_Actiona_08.12.pdf

RTO/ISO Regions and related links	
ISO/RTO Council	http://www.isorto.org/
California Independent System Operator (CAISO)	http://www.caiso.com/
Electric Reliability Council of Texas (ERCOT)	http://www.ercot.com/
Southwest Power Pool (SPP)	http://www.spp.org/
Midwest Independent Transmission System Organization (MISO)	http://www.midwestiso.org/home
PJM Interconnection	http://www.pjm.com/index.jsp
New York Independent System Operator (NYISO)	http://www.nyiso.com/public/index.jsp
Independent System Operator New England (ISO-NE)	http://www.iso-ne.com/
Midwest ISO – PJM Interconnection Joint and Common Market	http://www.miso-pjm.com/
ISO MOU	http://www.isomou.com/
Demand Response Links	
The Demand Response Coordinating Committee	http://www.demandresponsecommittee.org/
Demand Response and Smart Grid Coalition	http://www.drsgcoalition.org/

Lawrence Berkeley National Lab (Demand Response Technologies, Programs and Policies)	**http://eetd.lbl.gov/ea/EMP/drlm.html**
Lawrence Berkeley National Laboratory (Demand Response Research Center) Publications	**http://drrc.lbl.gov/drrc-pubsall.html**
EnerNOC Demand Response Resources	**http://www.enernoc.com/resources.html**
Highlights of Edison Electric Institute Member and Non-Member Residential/Commercial/Industrial Efficiency and Demand Response Programs for 2008	**http://www.eei.org/industry_issues/retail_services_and_delivery/wise_energy_use/programs_and_incentives/progs.pdf**
Other Transmission Resources	
Regulatory Assistance Program – Transmission Documents	**http://www.raponline.org/Feature.asp?select=79**
Mid-Atlantic Distributed Resources Initiative – Interconnection Documents	**http://www.energetics.com/madri/docs.html**
National Wind Coordinating Collaborative – Transmission Publications	**http://www.nationalwind.org/publications/transmission.htm**
Utility Wind Integration Group	**http://www.uwig.org/**
(WREZ) Western Renewable Energy Zones home page	**http://www.westgov.org/wga/initiatives/wrez/index.htm**
(SECO) Texas Competitive Renewable Energy Zones	**http://www.seco.cpa.state.tx.us/re_wind-transmission.htm**
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Selected Reports by Year	

(DOE) **The Smart Grid: An Introduction** **(No Year)**	http://www.oe.energy.gov/DocumentsandMedia/DOE_SG_Book_Single_Pages.pdf
(NRDC, EEI) **Joint Letter Calls on State Regulators to Help Electric Utilities Make Energy Efficiency a Durable Business Proposition** **(November, 2008)**	http://www.eei.org/about_EEI/advocacy_activities/National_Association_of_Regulatory_Utility_Commissioners/081118EEINRDCNARUCEfficiency.pdf
(DRCC) **Demand Response and Smart Metering Policy Actions Since the Energy Policy Act of 2005: A Summary for State Officials** **(November, 2008)**	http://www.demandresponsecommittee.org/Final_NCEP_Report_on_DR_and_SM_Policy_Actiona_08.12.pdf
(WREZ) **Western Renewable Energy Zones Project Update** **(November, 2008)**	http://www.westgov.org/wga/initiatives/wrez/UPDATE11-08.pdf
(NGA Center for Best Practices) **Regional Electricity Transmission Planning** **(September, 2008)**	http://www.nga.org/Files/pdf/0809ELECTRICITYTRANSMISSIONBACKGROUNDER.PDF
(NGA Center for Best Practices) **A Governor's Guide to Energy Assurance: Roles and Responsibilities For Ensuring a Robust, Secure and Reliable Energy Infrastructure**	http://www.nga.org/Files/pdf/0612GOVGUIDEENERGY.PDF
(NCSL) **Connecting the Grid: A Review of State and Regional Transmission Practices**	http://www.nga.org/Files/pdf/0610CONNECTINGGRID.PDF
(The National Council on Electricity Policy) **Coordinating Interstate Electric Transmission Siting: An Introduction to the Debate** **(July, 2008)**	http://www.oe.energy.gov/DocumentsandMedia/Transmission_Siting_FINAL_41.pdf

(EPRI) **Developing the Smart Grid – An Approach for California** **(April, 2008)**	**http://www.energy.ca.gov/load_management/documents/2008-04-29_workshop/presentations/8%20(EPRI)%20-%20California%20Smart%20Grid%20Summary%20and%20Recommendations%20-%20Mark%20McGranaghan%20-%20EPRI.pdf**
(FERC) **Assessment of Demand Response and Advanced Metering Staff Report** **(September, 2007)**	**http://www.ferc.gov/legal/staff-reports/09-07-demand-response.pdf**
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(DOE) **Benefits of Demand Response In Electricity Markets and Recommendations for Achieving Them** **(February, 2006)**	**http://www.oe.energy.gov/DocumentsandMedia/congress_1252d.pdf**
(The Keystone Center) **Regional Transmission Projects: Finding Solutions (June, 2005)**	**http://www.keystone.org/spp/documents/FINALREPORT6_2005Regional%20Transmission%20Projects.pdf**
(FERC) **Staff Report on Cost Ranges for the Development and Operation of a Day One Regional Transmission Organization** **(October, 2004)**	**http://www.ferc.gov/EventCalendar/Files/20041006145934-rto-cost-report.pdf**
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