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Building the 21st Century Transmission Super Grid:

Technical and Political Challenges for Large Scale Renewable Electricity Production in the U.S.

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American Council on Renewable Energy (ACORE)

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Table of Contents

Table of Figures

Summary

Plans to increase the penetration of renewable electrical generation into the United States face a number of challenges. Perhaps the most significant is that the transmission infrastructure was not designed to move large amounts of power over the distances or from the areas that will be required to achieve our renewable energy potential.

While issues such as installation of additional grid level storage, improving the "intelligence" of the distribution grid, and enabling efficient transactions with distributed third party generator and electric vehicle owners are important components of establishing a 21st century electric infrastructure, all such issues pale in comparison to the need for a transmission super-grid.

The United States is currently saddled with a transmission system that is analogous to our old state and local highway system that existed in the 1950s. When President Eisenhower identified a need to be able to move large quantities of military personnel over long distances for national security reasons, he correctly identified that an Interstate Highway System needed to be overlaid on the existing state, local, and national system. The country needs exactly an analogous approach for the existing transmission system, a super-grid which overlays the existing high voltage transmission system, connecting the country from coast to coast and allowing thousands of MW to be transferred over hundreds of miles.

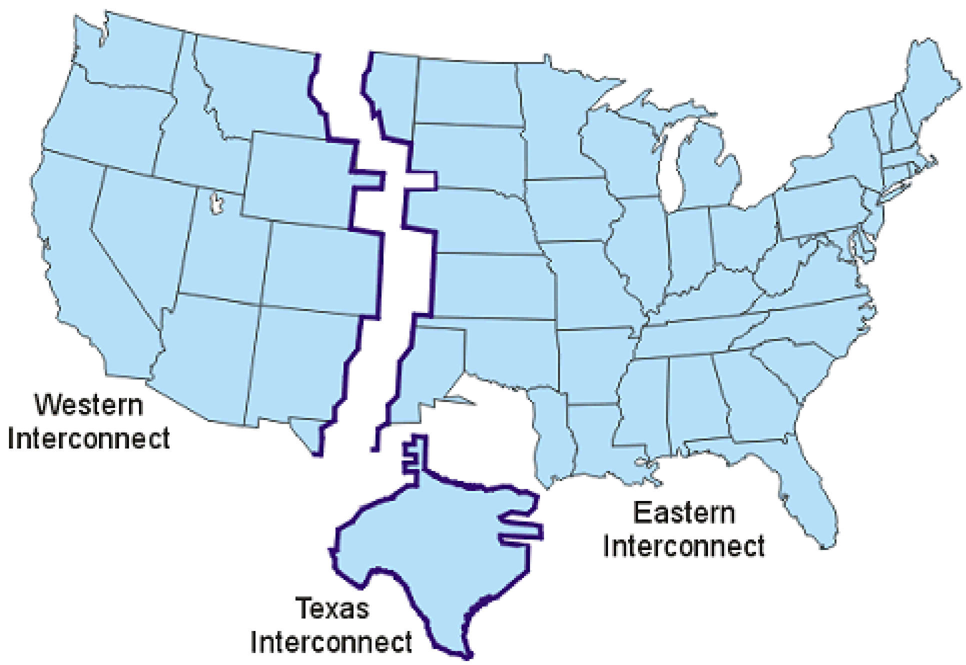
Regulatory oversight of transmission falls in under federal and state authorities with siting and line approval being primarily under state authority. While this regulatory structure has worked reasonably well in the past, today it doesn't address the issue that natural electrical regions do not conform to state boundaries and typically span multiple states. In this environment, a transmission project needs parallel reviews for each state in which they plan to operate. This process creates overlapping and duplicative efforts that slow or even stall the process. A single authority, in this case federal, needs to assert overall control of transmission line siting in the United States.

While there are some technical issues that must be resolved, there are no fundamental technologies that must be invented to enable this. All of the technology necessary to accomplish what is needed is available. The issues associated with establishing a transmission system that supports a 21st century electric network are virtually all institutional and regulatory. Transmission projects generate a significant amount of public opposition, no matter how critical the need. A strong resolve will be needed by the country's leaders to implement the required changes, but the technology is available and the industry is capable of implementing what is necessary. Public leadership and vision are what is required.

U.S. Electric Industry Structure

Understanding the challenges facing the United States as it restructures its electrical system to accommodate the additional requirements of a renewable resource base requires understanding some basic facts about the structure and history of the companies, as well as, the regulatory environment. The United States currently has approximately one hundred large for-profit utilities, almost one hundred small and medium sized for-profit utilities, about thirty state or federally owned utilities, two thousand municipally owned utilities, one thousand cooperatively owned utilities, and two thousand for-profit generating companies. Of this group, about 3,200 are load-serving entities and about fifty provide a significant amount of transmission services to the industry at large. These 3,200 utilities serve three separate electrical regions, the Eastern Interconnect, the Western Interconnect, and the Texas Interconnect. The Eastern and Western regions were established for reliability purposes. The Texas Interconnect was established to avoid federal jurisdiction over the utilities in that state.

Figure 1 – United States Electric Power Grids



Source: US Department of Energy

Prior to the late seventies, utility companies had an obligation to serve retail customers who applied for service, but they did not have an obligation to purchase power from third parties, nor did they have an obligation to sell to or transmit power for third parties. The business model for these large utilities was vertical integration focused entirely on serving the needs of their retail customers. The only reason utilities had any significant interconnections with neighboring companies was to meet emergency, reliability-based needs.

Over the 1980s and 1990s that business model was modified to require many utilities to "unbundle" their services and provide separate, open access transmission service. In some states, further unbundling was required. The degree of unbundling depends upon the type of utility – most municipal and cooperatively owned utilities were never vertically integrated – and on the regulatory philosophy of the state in which the utility serves. Some states have required additional open access unbundling of their distribution networks to enable retail customer choice. Other states have required virtually no unbundling of services supplied to retail customers. The Federal Energy Regulatory Commission (FERC), which has jurisdiction over wholesale power sales and interstate transmission tariffs (but not siting), has required utilities to unbundle wholesale generation sales from transmission sales and to offer transmission services to all applicants on a nondiscriminatory basis.

The U.S. regulatory environment that has evolved is extremely complex with multiple overlapping jurisdictional responsibilities among federal and state commissions and agencies. No single agency in the country is responsible for all transmission regulation. In many cases individual transmission lines fall under both federal and multiple state jurisdictions. As a general rule, FERC controls wholesale tariffs, and state commissions control plant and transmission siting, as well as rates charged for all services to retail customers within that state.

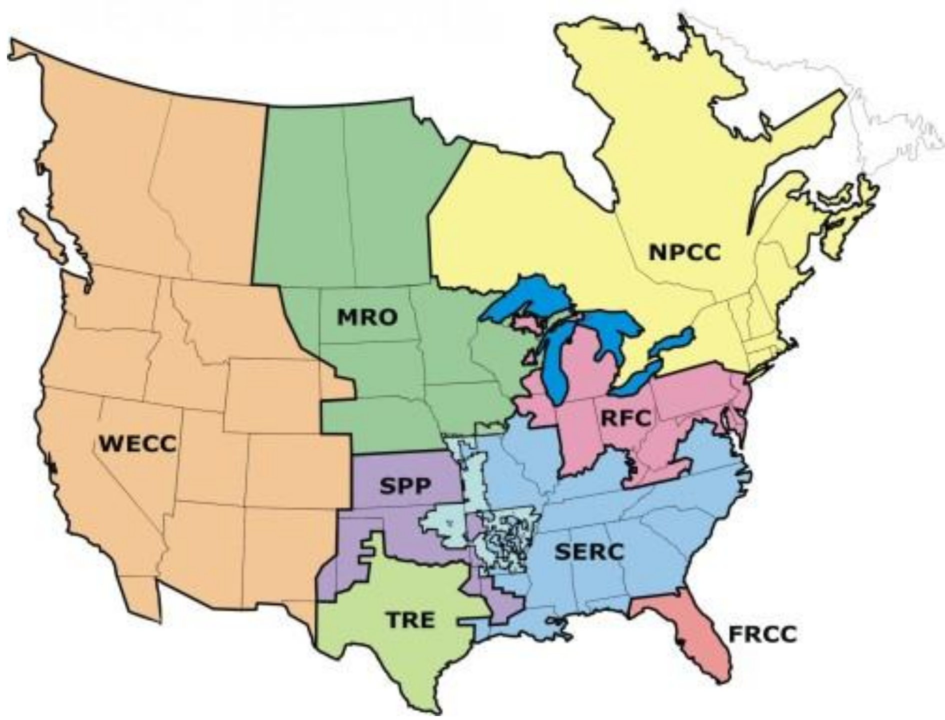
Need for Change

Prior to the northeastern blackout in 1965[1] there was no concerted effort to interconnect the country's thousands of utilities. Many smaller utilities, especially cooperative and municipal systems, were interconnected with the large investor-owned utilities, and they received transmission and generation services from them; however, these large systems were rarely interconnected in any meaningful way with other large systems, and they operated essentially as "islands of power." Interconnections, where they existed, were driven by specific situations, such as multiple utilities accessing large hydroelectric facilities. Reliability of electricity supply at an overall regional level was not managed in any systematic fashion.

The early efforts to interconnect major utilities were driven by reliability concerns. After seven northeastern states and one Canadian province were blacked out in 1965, the government and industry established ten separate regional reliability councils (since reduced to eight councils) which originally set voluntary standards and established inter-utility obligations to assist neighboring systems in time of need. The umbrella organization for these regional councils, the North American Electric Reliability Council (NERC), established voluntary standards and encouraged the interconnection of the major utilities in the country. This interconnection in most areas was designed to promote reliability, and little or no wholesale trade in electricity other than for reliability purposes was contemplated. The exceptions were the Northeastern utilities, which formed interconnections that allowed for and even encouraged both wholesale transaction and joint planning. These "power pools" included the Pennsylvania,-New Jersey,-Maryland (PJM) Interconnection, the New York Power Pool and the New England Power Pool.

[1] The Northeast Blackout of 1965 was a disruption in the supply of electricity, affecting Ontario, Canada and Connecticut, Massachusetts, New Hampshire, Rhode Island, Vermont, New York, and New Jersey in the United States. The cause of the failure was human error. Maintenance personnel incorrectly set a protective relay on a transmission line. A surge of power caused the incorrectly set relay to trip, disabling a main power line. Within five minutes the power distribution system in the northeast was in chaos as overloads and loss of generating capacity cascaded through the network, breaking it up into "islands". Plant after plant experienced load imbalances and automatically shut down. Around 25 million people and 80,000 square miles were left without electricity for up to twelve hours.

Figure 2 Current NERC Regions



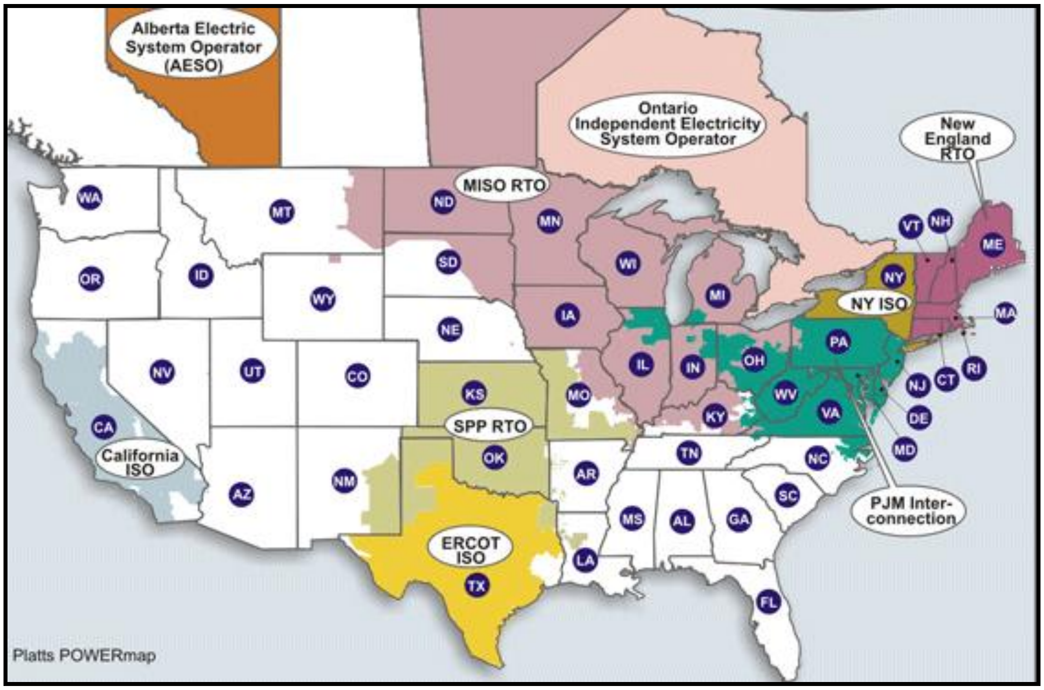
FRCC - Florida Reliability Coordinating Council
MRO - Midwest Reliability Organization
NPCC - Northeast Power Coordinating Council
RFC - ReliabilityFirst Corporation
SERC - SERC Reliability Corporation
SPP - Southwest Power Pool, RE
TRE - Texas Regional Entity
WECC - Western Electricity Coordinating Council

Source: North American Electric Reliability Council

As transmission open access requirements were adopted in the mid 1990s, non-utility power generators became a much more important participant in power markets. As a result, nondiscriminatory operation of the transmission grid also became much more important. The earlier concept of a power pool evolved to one of Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs). ISOs and RTOs coordinate all generation (including that of non-utility generators) and transmission across wide geographic regions, matching generation to the load instantaneously to keep supply and demand for electricity in balance. The grid operators forecast load and schedule generation to assure that sufficient generation and back-up power is available in case demand rises or a power plant or power line is lost.

In most cases, these RTOs and ISOs also operate wholesale electricity markets that enable participants to buy and sell electricity on a day-ahead or a real-time spot market basis. These markets provide electricity suppliers with more options for meeting consumer needs for power at the lowest possible cost.

Figure 3 – RTOs of North America



Source: Department of Energy

RTOs and ISOs also provide non-discriminatory transmission access, facilitating competition among wholesale suppliers to improve transmission service and provide fair electricity prices. Across large regions, they schedule the use of transmission lines; manage the interconnection of new generation and monitor the markets to ensure fairness and neutrality for all participants. Providing these services on a regional basis is more efficient than providing them on a smaller-scale, utility by utility. There are currently seven RTOs / ISOs that manage about two-thirds of the electricity produced and sold in the United States.

Economic Drivers of Transmission

Utilities in the United States plan and construct their systems based upon a “least cost” approach. Because it has historically been cheaper to ship the fuel consumed by generation plants than to “ship” the electricity from power plant to load center, transmission lines have been designed and built to move power relatively short distances. Historically very few lines in the United States have been designed from the beginning solely to move large quantities of energy over long distances – the key exceptions being hydroelectric facilities and some more recently-constructed nuclear plants. In addition, because these distances were short and more often than not confined to a single state, there never has been a political impetus to shift the regulatory review of transmission line siting from state utility commissions to the FERC. Presently, transmission lines that span multiple states are forced to seek regulatory approval at the commission of each state through which the line passes. Multiple state reviews (and federal resource agency approvals) can add years of delay to what is already at times a difficult and complex approval process.

Over time utilities have been able to optimize the use of existing transmission and have, in effect, "filled up" the empty capacity of the grid; transmission has grown significantly more slowly than energy production. While such an approach is entirely appropriate from the perspective of a single utility opening under least cost principles, it hasn't resulted in a regional transmission system with the capability to meet major changes in usage, as contemplated with an aggressive expansion of more distantly-located renewable energy resources.

Figure 4 – High Voltage Transmission and Energy

Voltage	1990	1999	Change	% Change
230 kV	70,511	76,762	6,251	8.9
345 kV	47,948	49,250	1,302	2.7
500 kV	23,958	26,038	2,080	8.7
765 kV	2,428	2,453	25	1.0
Total	**144,845**	**154,503**	**9,658**	**6.7**
Energy TWH	**2,712**	**3,312**	**600**	**22.1**

Source: US Department of Energy

FERC has recently been given limited authority to assert federal preemption in the siting of interstate transmission lines. Under section 1221 of EPACT 2005, the federal Department of Energy (DOE) may designate "national interest electric transmission corridors" within which state and local governments have limited authority to deny or condition transmission line permit requests. If a state denies a permit, places certain conditions on a permit, or has not acted on a permit within one year, FERC has jurisdiction to issue the permit. In addition, electric utilities that have received a permit from FERC to construct a power line over state objections can petition a federal court for the right to exercise the power of eminent domain over private property in order to construct new transmission lines.

Emergence of Wholesale Markets

Beginning with the passage of the Public Utility Regulatory Policy Act (PURPA) in 1978, the United States began to diverge from the business model of large vertically integrated utilities. Independent companies were allowed to construct power generation plants, and if they met certain criteria deemed to be in the public interest, were allowed to sell this electricity to the local utility at what was determined to be the utility's "avoided cost." These PURPA rules and practices are the predecessors to the modern European feed-in tariffs. In some regions of the U.S., PURPA is no longer used for this purpose, but an industry of independent power producers (IPP) has emerged and with that the issue of the need to build transmission to accommodate third party generation. This has led to a protracted debate about how such new transmission facilities ought to be financed. In some cases, utilities and regulators required the party that triggered the line construction to pay the full cost of the line either as a capital contribution or through a special tariff; in other cases, the capital costs of the new line were included in a utility or regional network tariff that all users of the transmission system pay for in proportion to their load, irrespective of their use of the particular line in question.

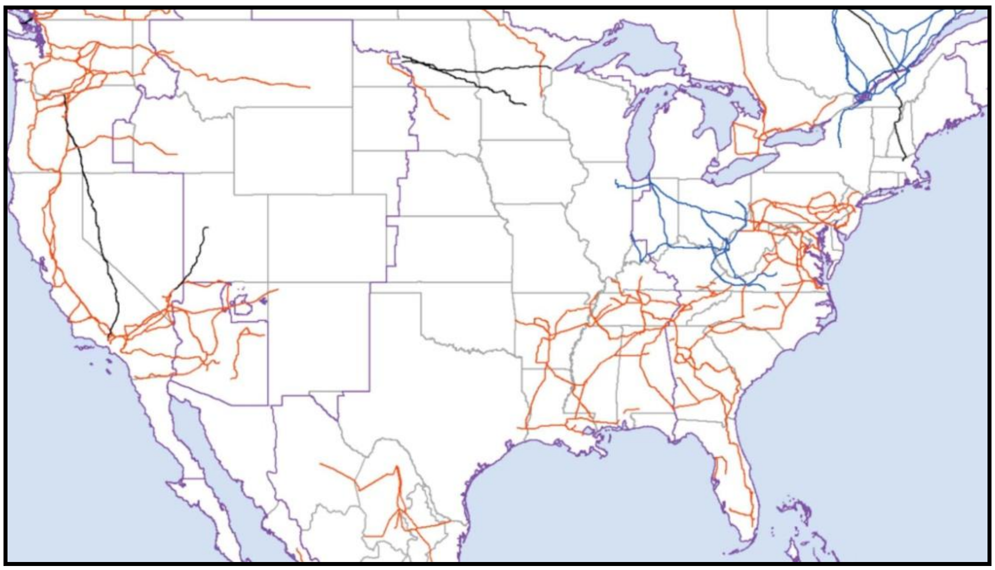
This issue of building transmission lines to support third party generation is a pivotal issue in the expansion of the renewable energy industry in the United States. As discussed later, many high quality renewable resources in the United States are not located near major transmission facilities, and developing these renewable resources will require development of more transmission facilities. The process of siting, building and cost recovery for the transmission lines to enable greater renewable penetration is critical to the success of the renewable energy industry.

Technical Challenges of Integrating Renewable Resources

Distance Between Load And Resource

Power generated from wind, solar, biofuels, geothermal, waste heat, and hydropower is almost universally unable to be transmitted to major load centers. In addition, in the United States most renewable resources tend to be in areas that are relatively remote from load centers. Perhaps the best example of this is the proximity of the best wind resource – primarily in the central, Plains States – and the major load centers – primarily on the eastern and western coasts of the country. Because the major transmission assets were designed and built to move power over relatively short distances from predominantly fossil-fueled and nuclear powered thermal plants located close to the major load centers, very little existing high capacity transmission lines were built in the Plains States, precisely where the U. S. has abundant wind, solar, geothermal renewable energy resources.

Figure 5 High Voltage Transmission Lines (>500 kV)

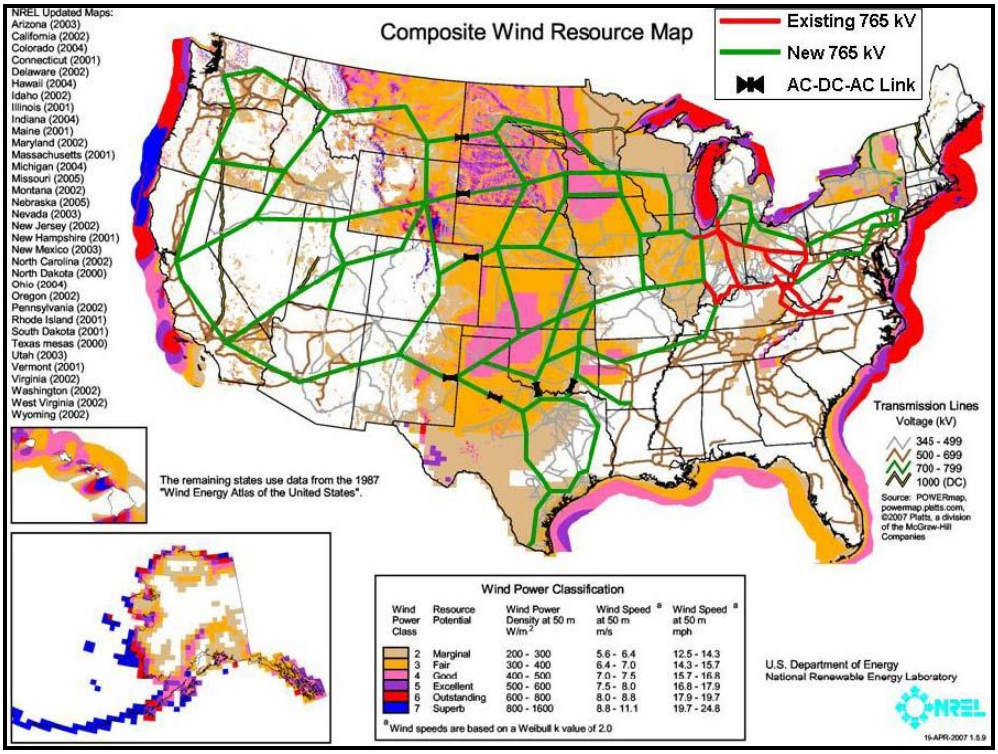


Source: Presentation by Jon Wellinghoff, 2008

In an earlier era of tapping large hydroelectric resources, transmission lines designed to deliver bulk power over long distances were constructed. An example of this is the 3100 Megawatt 846-mile Pacific high-voltage direct-current intertie that connects the hydroelectric resource in the Oregon-Washington State area with the loads of Los Angeles, California (shown in black on Figure 5). Several similar lines exist in other areas of the United States, but all are radial in nature, designed to connect a resource with a load center.

Several national studies have been prepared that consider the scope and potential costs of implementing a transmission upgrade to facilitate a large penetration of renewable resources. Most either consider extremely high voltage AC (765 to 1300 kV), 500 kV DC systems, or a mix of both high voltage AC and DC. A representative study was prepared by American Electric Power, a large Midwestern utility, for the National Renewable Energy Laboratory (NREL) and the American Wind Energy Association (AWEA). The study addressed a nationwide 20 percent penetration of wind and concluded that the resource could be accommodated with 19,000 miles of additional 765kV AC transmission overlaid on the existing US transmission system. The projected cost of this transmission upgrade was $60 billion. In the past two years, Texas and California started regulatory proceedings to build transmission lines into regions that will support large scale development of wind and solar resources. The Texas plan, adopted in late 2008, would add $5 billion in new transmission by 2012 to support a total of 18,000 MW of wind in the region.

Figure 6 – AEP Conceptual Super-Grid



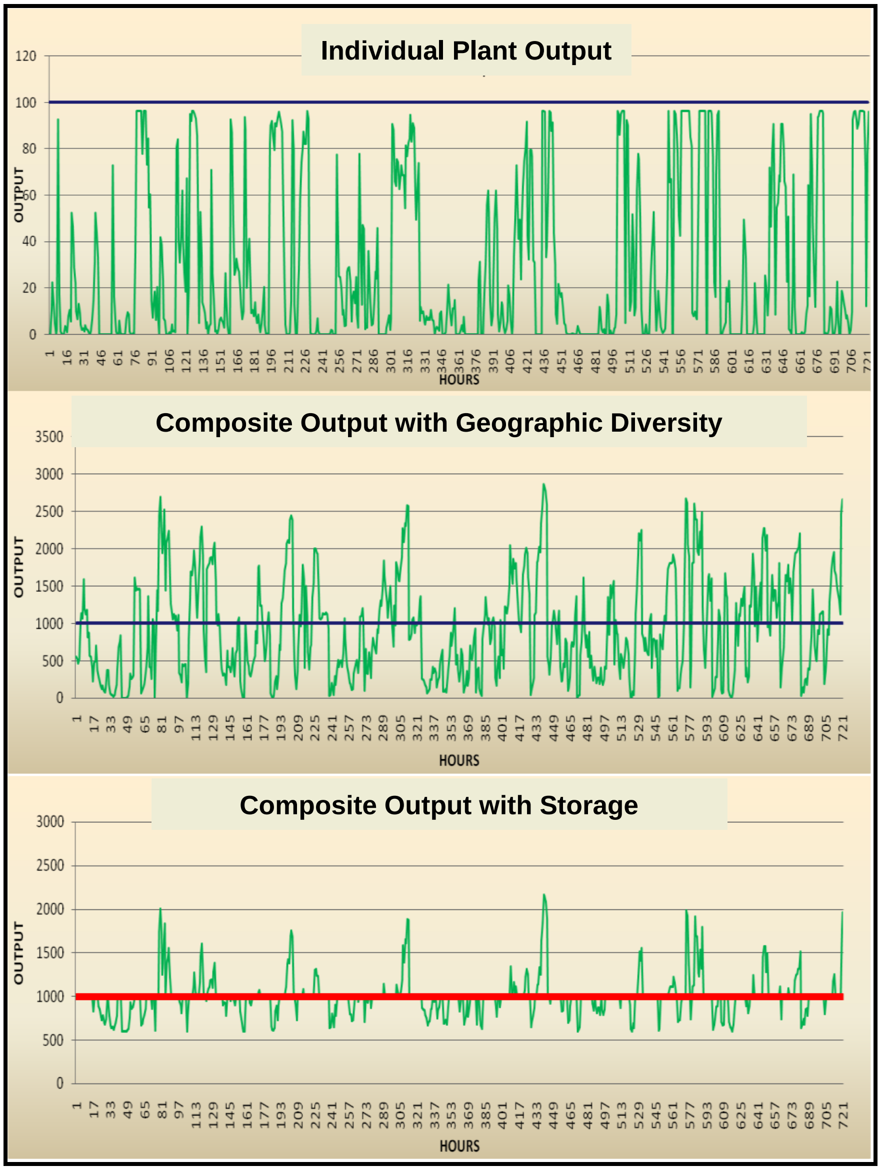
Source: "Interstate Transmission Vision for Wind Integration" American Electric Power

Variable or Intermittent Nature of Renewable Resources

Several of the renewable resources are variable or intermittent in nature – i.e. the wind doesn't always blow, the sun doesn't always shine. This creates additional challenges for the load-serving utility as it labors to keep loads and resources precisely balanced. Today this can require keeping additional fossil-fueled power plants running but in "standby" or "spinning reserve" mode waiting to compensate for the potential loss of a renewable resource. As variable resources, like wind and solar, increase their share of generation, the variable nature alone can imperil the reliability of the electric grid, a key engineering issue for the industry.

Small hydroelectric, wind and solar resources have daily and seasonal variations that the electrical system must accommodate. Solar generates power only when the sun is shining. In many areas the wind resource is most abundant at night. Small hydroelectric resources typically provide much of their energy in the spring when the snow delivered during the winter melts. These resources are inherently more difficult to integrate into grid operation than "dispatchable" plants.

Figure 7 – Impact of Geographic Diversity and Storage



Source: "Presentation for REFF West", Grasslands Renewable Energy LLC

Viewing and dispatching the grid over a larger region can ameliorate this concern. The reliability of the grid is much higher than the reliability of any single unit connected to the grid. Numerous studies indicate that the variability of the aggregate wind resource connected to the grid falls significantly as multiple plants scattered over a geographically-diverse region are included in the supply portfolio. Several studies indicate that the variability of the wind portfolio could be half that of a single plant if at least 3-4 plants spaced 100-150 miles apart are included in the system level portfolio. Other studies indicate that modest amounts of grid connected storage – batteries, compressed air, flywheels, or pumped storage – can play a very beneficial role in reducing the grid level variability associated with wind, and solar.

Forecasting and Planning

System operators have fewer planning tools than needed to manage a portfolio of resources that includes a significant amount of variable resources such as wind. Day-ahead and hour-ahead forecasting tools, while much improved, are not always well integrated into the operations of utility dispatchers.

The need for better planning tools was dramatically demonstrated on February 26, 2008 when the Electric Reliability Council of Texas had to implement emergency procedures to stabilize the grid following a frequency decline that was caused by a combination of a drop in wind energy production at the same time the evening electricity load was increasing, accompanied by multiple fossil-fired power providers falling below their scheduled energy production. The wind production dropped from over 1700 megawatts (MW) three hours before the event to a low of 300 MW; the system load increased from 31,500 MW to 35,500 MW in approximately 90 minutes; and approximately 400 MW of other scheduled capacity was unavailable. The system operators activated ERCOT's demand response program, which dropped approximately 1,100 megawatts of controllable load within a 10-minute period. These loads are typically large industrial and commercial users who are paid to curtail their electricity use as needed for reliable grid operation. Most of the interruptible loads were restored after approximately an hour and a half.

Political Challenges Facing Integration of Renewables

Transmission Siting

The current situation of state jurisdiction of transmission line siting, especially where lines cross multiple jurisdictions poses challenges to the industry. In addition, developers are reluctant to commit to plant construction without knowing that sufficient transmission exists. But transmission owners are reluctant to commit to transmission line construction without assurance of plants that need the lines – a “chicken and egg” problem.

The federal government has the authority under EPACT 2005 to designate transmission zones as National Interest Electric Transmission Corridors. Two such areas – includes some or all counties in DE, OH, MD, NJ, NY, PA, VA, WV, and DC; and seven counties in Southern California and three counties in western Arizona – are under current review. The FERC has the authority to expedite approval of transmission lines in such areas. Even designating an area as a National Corridor appears to be extremely controversial. The seven public hearings held by DOE on these two corridors generated almost 1,000 pages of public comment in the form of letters, testimony, and petitions, most of these opposed the proposed designation.

As noted earlier, Texas and California adopted processes to address the “chicken and egg” problem by building transmission lines into areas that contain favorable renewable resources *in advance* of the building of those plants. Cost recovery for line owners is assured by including the lines in the statewide network tariff of the transmission operators.

Integration and Cost Recovery of Storage

Increased storage will be a requirement to maintain grid reliability and achieve customer savings from high penetration of renewable resources. Control and ownership of storage could have significant implications for the deployment of this resource.

- If storage is considered a technology used to augment or even avoid transmission expansion, it could logically be treated as a traditional transmission investment paid for by the transmission owner and the cost recovery would be via traditional utility cost-based tariffs.
- If storage is considered just one more energy service that the “market” will provide, then such plants will more likely be owned by independent generators and the pricing would be determined based upon market value.
- Or, if storage is viewed as a required transmission ancillary service, it could have mixed regulatory treatment.

Net Metering

Some renewable resources lend themselves to distributed generation – solar PV and small scale wind being two examples. Using the distribution grid to absorb the output of this generation when it exceeds the load of the home or building to which it is attached can potentially provide useful energy and grid support on extreme days. Creating a supportive environment for third party owned distributed generation requires a provision for the distributed generation to “sell back” excess energy to the host power company. The approach most commonly used in the United States is referred to as “net metering” where the customer's bill is based upon the net amount of energy he or she consumes, with credit given for the energy sold back to the host utility. Facilitating this requires interconnection standards and power purchase tariffs that protect the load serving utility while encouraging the spread of distributed generation has been a challenge for state regulators.

Since distributed generation is virtually always connected at voltages below those which the FERC has asserted federal jurisdiction, net metering appears to be an issue that will be dealt with at the state jurisdiction level. FERC has adopted distributed generation interconnection standards in FERC in Order 2005, but implementation of these standards and the pricing of the energy received by the host utility seem likely to remain the province of the individual state utility commissions.

Implications for the Transmission Grid Infrastructure

Planning & Forecasting

Improved forecasting tools will enable system operators to anticipate and predict the availability of variable resources such as wind, solar and hydropower. Accurately forecasting the availability of those resources will allow grid operators to optimize and reduce the capacity of fossil fueled plants which are running, but only partially loaded. Accurate forecasting will also minimize the need to declare system emergencies and reduce the probability of blackouts.

Design and Construction

A key unresolved issue in design is determining the best voltage level(s) for the super-grid and whether it should be AC, DC or a mix. Higher voltages provide significantly greater energy transfer capability and lower losses, but require larger right-of-ways. High voltage DC offers the potential for lower losses than a comparable AC line, but does not allow for cost-effective interconnections by generation located along the route. On a positive (if not inexpensive) note, some forms of high voltage DC can be undergrounded, which may be useful for siting transmission in urban or environmentally sensitive areas. What seems abundantly clear is that there is a technical answer to this question that will not ultimately be difficult to decide.

Operation

A robust transmission backbone supporting the existing transmission grid would produce a plethora of system benefits in addition to enabling greater penetration of renewable technologies. Currently many areas in both the East and West are transmission-constrained. A transmission overlay that allows transmission of several thousand additional MW into congested areas would alleviate many system problems and potentially alleviate the need to build a substantial amount of lower voltage transmission lines. It certainly avoids the need to construct pollution-emitting power plants in already constrained areas.

Markets

Most of the transmission improvements will also provide significant improvement to the efficiency of the electricity markets. Larger, more transparent markets are inherently more efficient. Congestion in current markets provides well placed generators with the opportunity to exercise market power and collect "economic rents." Where used, storage will, to an extent, decouple the requirement that generation resources exactly match electrical loads at all periods of time. This should reduce the price volatility of markets on high load days. Implementation of a smart grid could open entirely new types of storage, such as the onboard batteries in plug-in electric hybrid vehicles. One million plug-in electric hybrid vehicles could, if accessible via a smart grid, supply 1,000 – 2,000 MW of capacity for several hours, relieving electric congestion on peak days in densely populated urban areas.

Regulation

Many experts believe that the authority provided to DOE and FERC in the EPACT 2005 is unlikely to prove sufficient to streamline the permitting process for the needed upgrades in the transmission grid. As evidenced by the number and passion of the comments that were submitted when DOE began the process to establish National Transmission Corridors in the northeast and southwest. The transfer of siting authority to federal regulators will not occur without a significant additional political discussion.

Policy Recommendations & Potential New Alliances

Policy Recommendations

1. **Federal Siting Authority for Large Transmission Projects.** The country needs a new model for its regulation of the siting and approval of transmission lines. The natural size of an electrical grid has grown larger than the jurisdictional boundary of any single state. The areas encompassed by individual RTOs, developed to deal with existing transmission issues, are multi-state, demonstrating the need for a planning and oversight system that is at least regional in scope. Analogous situations exist where federal planning is the basis for siting. Natural gas pipelines are both sited and rate-regulated at the FERC today. This was not always the case but in 1947, siting was transferred to the Federal Power Commission (the predecessor of FERC) due to a realization that needed natural gas was not able to be transported from production regions in the Southwest U.S. to consuming regions in the Northeast U.S. It is appropriate to consider this kind of change in the interstate power industry as well. One way of easing into this regulatory regime is to limit federal siting authority to only the largest transmission lines ($\geq$ 345 kV).

2. **Push for Smart Grid and Standardization.** The distribution grid was not built to accommodate the information needs and complexity of distributed generation and storage. Transforming these lower voltage networks to "smart grids" will be necessary to capturing the benefits of distributed generation and storage. Perhaps the most pressing need in this area is standardization. Industry standards, analogous to what is seen in the computer industry, are needed to simplify and accelerate the transformation process.

3. **Determine Rate Recovery Treatment.** Enhanced storage will be an enabling technology for high penetration for variable renewable energy resources. A combination of utility owned and third party storage is likely to be appropriate. Investments for reliability improvement have always had the highest priority in utility planning. Storage necessary for system reliability should be treated as any other critical transmission upgrade. To speed investment, policies determining the rate recovery treatment of storage for reliability and economic purposes should be developed in advance of such investment.

4. **Establish Standards for PHEV Interconnection.** Future penetration of PHEV offers the potential for significant distribution connected storage. The distribution grid currently lacks the "intelligence" to facilitate the use and contracting for such transactions with individual vehicle owners. A single commercial model for a utility-consumer relationship, where the utility contracts for the use of a parked PHEV's battery would facilitate the availability of this resource to the grid.

Potential New Alliances

Manufacturers are accustomed to dealing with liquid fuels suppliers in the design and development of their vehicles. Such a relationship doesn't really exist between the electric utility industry and the vehicle manufacturers today. As PHEV are designed, the electric utilities of the country need to be involved in decisions concerning charging stations, charging cycles, the potential for bi-directional sales, and a host of other issues. Interfacing with a mass produced product like a PHEV and a prerequisite for any industry scale-up will be the setting industry standards for technical interfaces, as well as, establishment of model contracts for the business relationship between consumer and utility.

Conclusion: Areas for Future Research and Transatlantic Cooperation

European regulatory changes in the electric power industry roughly parallel and in some cases lead those that have taken place in the U.S. Unlike the U.S., many European countries did not begin with a privately-owned electric power industry prior to implementing transmission open access, wholesale and retail customer choice and generation plant divestiture. Nonetheless, as regards large-scale development of renewable resources, the two regions are in a similar position: rich resources distant from major load centers and a balkanized regulatory structure impeding their development.

A survey of best practices and lessons learned from restructuring to date in both regions would be a useful place to start. Much has been written on this from diverse viewpoints. It would be useful to first pull these analyses together to see what we already know.

To move to the core issue of the proposal, we recommend a comprehensive analysis of the two regions' abilities to integrate large amounts of renewable energy and recommendations on policy initiatives to improve the widespread adoption of renewables. Some or all of the following topics would be the areas of focus:

- What is the location of underdeveloped renewable resources relative to load today? Is it appropriate to consider adjacent regions in this analysis (e.g., Mexico, Canada, North Africa, Russia)?

- What is the present ability of transmission to transfer this power to the load? Are there new transmission technologies to assist this effort?

- How is transmission across the regions presently planned, licensed and financed today? Should that be changed?

- Does the grid authority have sufficient tools and capability to oversee, analyze and administer a system with more variability of input?

- What is the capability of the lower-voltage distribution to integrate distributed generation resources?

- What is the capability of both the lower and higher voltage grids to integrate storage technologies? What technologies could be available to enable more storage utilization?

- Does the current regulatory model stimulate innovative solutions to all of these issues? Does it allocate the risk of these solutions to the parties that can best manage that risk?

- What do renewable resources developers and customers need to have in order to enable a more responsive system? Apart from a price on carbon, are any publicly-financed programs required? Do any particular areas merit government-sponsored research and development? What is the cost implication of these?

- Do the relevant governmental actors have the authority to provide for any or all of these recommendations

Appendix

List of Abbreviations

AC: Alternating Current

AWEA: American Wind Energy Association

DC: Direct Current

DOE: United States Department of Energy

EPACT 2005: Energy Policy Act of 2005

ERCOT: Electric Reliability Council of Texas

FERC: Federal Energy Regulatory Commission

ISO: Independent System Operator

MW: Megawatts

NERC: North American Electricity Reliability Corporation

NREL: National Renewable Energy Laboratory

PHEV: Plug-In Hybrid Electric Vehicle

PJM: Pennsylvania-New Jersey-Maryland Interconnection

PURPA: Public Utility Regulatory Policy Act of 1978

RTO: Regional Transmission Organization

About the Authors

Pat Wood, III is a Principal at Wood3 Resources and has a long career in energy and energy infrastructure development. Today his project development focus is on clean power generation, independent power transmission and natural gas facilities. He also serves as a strategic advisor to Natural Gas Partners and is an independent director of four infrastructure companies: SunPower, Quanta Services, Xtreme Power Solutions, and Range Fuels. He is a member of the National Petroleum Council and is on the Board of the American Council on Renewable Energy (ACORE). Until December 2007, Wood led the North American Advisory Board of Airtricity, an international wind energy firm.

Wood is also the past Chairman of the Federal Energy Regulatory Commission (FERC) and of the Public Utility Commission of Texas. During his four years at the helm of the FERC, Wood led the response to the 2000-2001 California energy crisis, the bankruptcy of Enron, the significant rise in fuel prices and the 2003 Northeastern power blackout. In doing so, he promoted the development of a cleaner, more competitive power generation fleet, liquefied natural gas (LNG) import terminals, and a more robust power transmission grid, all in the context of well-ordered competitive energy markets. Wood holds degrees from Texas A&M University (civil engineering) and Harvard Law School. He can be reached at: pat[at]wood3resources.com

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