CLIMATE CHANGE POLICY PARTNERSHIP

Electrical Transmission: Barriers and Policy Solutions

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TOWARD A LOW-CARBON ELECTRICITY SECTOR

CCPP Technology Policy Brief Series

Electrical Transmission

Barriers and Policy Solutions

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Series Overview:

Toward a Low-Carbon Electricity Sector

This paper is one in a series by the CCPP at Duke University to explore the barriers facing large-scale, low-carbon electricity generation and increased efficiency in the near-term – primarily the next ten to fifteen years. Policy drivers may be necessary to provide the right price signal to develop low-carbon emission technologies, but a price signal alone may not be enough to enable broad-scale deployment.[1] Significant technical, legal, infrastructural, and social barriers prevent the implementation of the necessary technologies and efficiency improvements.

The series provides an overview of the barriers and outlines general policy options for lawmakers who wish to speed the development and/or wide-scale deployment of low-carbon energy technologies. It will include papers focusing on specific energy generation technologies, including renewable energy and energy storage, and energy efficiency, a cost-effective near-term option for displacing carbon-intensive energy generation.

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[1] Policy drivers are under consideration include a nationwide cap-and-trade system for greenhouse gas (GHG) emissions, regulation of GHGs emissions under the Clean Air Act, expanded action on the state and regional levels, or some combination thereof.

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I. Executive Summary

Successfully transitioning the United States to low-carbon electricity will require an improved transmission infrastructure. Renewable energy resources are abundant but subject to geographical limitations. The feasible sites for carbon capture and sequestration (CCS) and nuclear power are also limited. A major buildup of long-distance transmission lines may be required to ensure the delivery of new low-carbon power generation. Many groups are calling for expanding the transmission grid to accommodate more renewable energy. The American Recovery and Reinvestment Act of 2009 allows the Western Area Power Administration and the Bonneville Power Administration to borrow up to an additional $3.25 billion each to build transmission lines. Senators Harry Reid, Jeff Bingaman, and Byron Dorgan have each introduced bills to reform transmission policies to facilitate investments.

Overhauling the U.S. transmission networks, however, is challenging. A historical legacy of balkanized ownership and ineffective regulatory structure is hindering upgrades to and expansion of the U.S. transmission network. Although the diversity of owners does offer certain advantages, such as the potential for fostering innovative best practices, this balkanization of ownership hinders economies of scale and discourages investment. Complex and fragmented regulatory jurisdictions increase transaction costs, delay the permitting process, and add to the risk and uncertainty of transmission investments. The difficulties of siting and a traditional reliability-focused planning approach also impede the development of a modern national grid. Because of these barriers, there has been a sustained underinvestment in transmission for several decades.

This paper explores possible policy options to address these barriers and facilitate the development of a modern grid. Governments and the utility industry could work together to reduce ownership and regulatory fragmentation. The process must proceed cautiously with a stepwise approach. Real estate investment trust funds (REITs) may be a feasible option to restructure ownership and induce investments. Consolidating public-owned transmission assets may also be considered. Distributing the costs of transmission to ratepayers across a broad region would help to enable large-scale transmission investment.

Although mitigating local opposition to new transmission lines will not be easy, there are ways to reduce investors' risks in the siting process. States could be encouraged to jointly review interstate transmission proposals. If the government provided financial support for feasibility studies and preliminary environmental impact studies for transmission projects with national interests, investors would face lower risks. Allowing cost recovery of transmission work in progress may be an option. Providing abandoned plant protection is another option because it would allow cost recovery for all prudently incurred costs if the project is abandoned for reasons beyond the investor's control. Transmission owners are generally more willing to pursue investment opportunities if they are afforded abandoned plant protection.

Although many researchers have called for federal siting authority, consolidating siting authorities in the federal government would likely be politically difficult. Currently, the federal government's only siting authority is provided by the Energy Policy Act of 2005 in the National Interest Electric Transmission Corridors (NIETCs) process, which is strictly limited to relieving congestion. Policymakers may consider extending federal authority to promote renewable energy.

The existing transmission planning process is more focused on relieving congestion and enhancing reliability than on creating new opportunities. The most abundant renewable energy resources in the United States are concentrated in remote regions that are not well connected to the existing transmission network. A "chicken-and-egg" dilemma hinders the development of these remote renewable energy resources: renewable energy developers do not invest in building renewable power-generating capacity until transmission becomes available, while transmission investors do not invest until sufficient renewable power-generating capacities are developed. Establishing national renewable energy zones may be a logical first step to break this cycle of inaction. A broader-scale planning scheme, such as interconnection-wide planning, may be another step.

In order to establish a more robust transmission system for a clean energy future, policymakers may consider the approach of Dwight D. Eisenhower's Interstate Highway System or that of the Defense Advanced Research Projects Administration's ARPANET. The Federal-Aid Highway Act of 1956 aimed to build a whole new transportation network rather than to simply relieve existing bottlenecks. The Defense Advanced Research Projects Administration (DARPA) fully funded the development and construction of the ARPANET, which eventually developed into the Internet. Common among these projects is the recognition that there are significant economies of scale that can be achieved by building a single, high-capacity network, and because such efforts require a coordinated national effort and produce national benefits, there is an important role for the federal government.

Some promising load-balancing resources, including smart grid devices, demand response resources, and energy storage technologies, may mitigate the need for transmission expansion. To reap the fruits of demand response and energy storage technologies, more coordinated regional grid operations and significant investment are necessary. Regulatory changes and research, development, and commercialization assistance are also needed. Although it is tempting to view smart grid technology as a panacea, policymakers must understand that the large-scale deployment of smart grid technology will neither be cheap nor easy. Standardization and system integration are crucial to the interoperability of smart grid; the fragmented structure of the utility industry and lack of federal authority make such standardization and system integration challenging. Initial deployment should proceed cautiously with stepwise pilot projects and demonstration programs. Regulatory hurdles such as cost allocation, pricing schemes, and split incentives need to be overcome. The government must assume leadership in overcoming these hurdles. The challenges of de-carbonizing the power system are daunting, but brave actions and strong leadership have often succeeded in overcoming seemingly impossible barriers.

II. Introduction

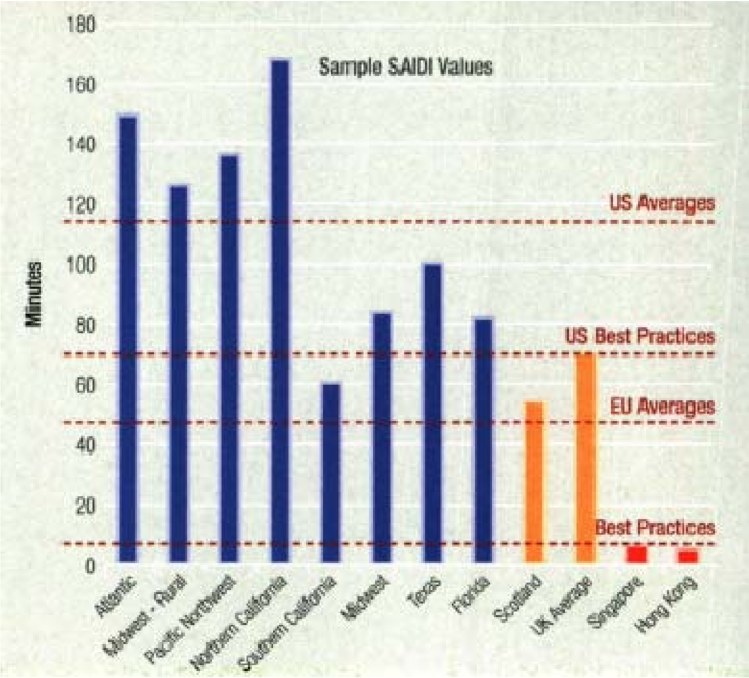
Since the 1970s, investment in transmission has lagged behind the growth of power demand and generation. There are many bottlenecks in the electric grid, and congestion is worsening in many places. Although there has been increased investment in recent years, this progress is far from sufficient to compensate for thirty years of underinvestment. Additional efforts are necessary to meet the future transmission requirements of both increasing demand and low-carbon power.

Due to chronic underinvestment, the existing power grids in the United States consist largely of technology developed in the 1950s or earlier. About 70% of all transmission lines and power transformers are 25 years old or older, and 60% of all circuit breakers are more than 30 years old (Anderson, Furey, & Omar, 2006). This antiquated transmission infrastructure is not only limiting the utilization of renewable energy resources, but it is also hindering means of mitigating their intermittency. Without a significant overhaul, inadequate transmission capacity will severely constrain the expansion of renewable energy. Revamping the outdated infrastructure, however, is very difficult. Convoluted sociopolitical and institutional obstacles have historically prevented the modernization of transmission infrastructure. There is no simple technical fix—revamping the system will require many difficult political decisions. Nevertheless, the opportunity cost of not fixing the transmission infrastructure is very high. Without a significantly improved grid, the expansion of renewable energy will soon reach its limit, and the further development of the entire U.S. power sector may be in jeopardy.

To take advantage of renewable resources in remote areas, the transmission system needs to be reinforced and expanded. The most abundant renewable energy resources in the United States are concentrated in remote areas that are served inadequately—if at all—by the existing transmission system. The existing transmission grid was designed to deliver power from conventional power generators to consumers within a local market. Transmission bottlenecks are already imposing significant constraints on daily power delivery, not to mention the effects the forthcoming expansion in intermittent renewable power will have. Immediate constraints have already caused massive interconnection queue backlogs (Radford, Tilting to windward, 2007) and forced curtailments of wind power (Goggin, 2008). Although tremendous benefits can be derived from a nationally integrated grid, the United States simply does not have one, and the sociopolitical and institutional status quo makes it very difficult for private investors to build one. These difficulties are explained in the section on barriers.

Former Energy Secretary Bill Richardson once commented that the United States is “a superpower with a Third-World grid” (BBC, 2003). The inadequacy of electrical transmission systems in the United States is clearly shown in the System Average Interruption Duration Index (SAIDI), an index of the average outage duration for each customer served and a common reliability indicator for electric power systems. The best SIADI values in the United States are about 70 minutes—significantly worse than the European average (under 50 minutes) and grossly behind the world’s best practice (under 10 minutes in Singapore and Hong Kong) (Thurston, 2008). As Energy Secretary Steven Chu and Federal Energy Regulatory Commission (FERC) Chairman Jon Wellinghoff have both pointed out, the United States is indeed far behind China in the deployment of basic grid automation technology (Trauzzi, 2009).

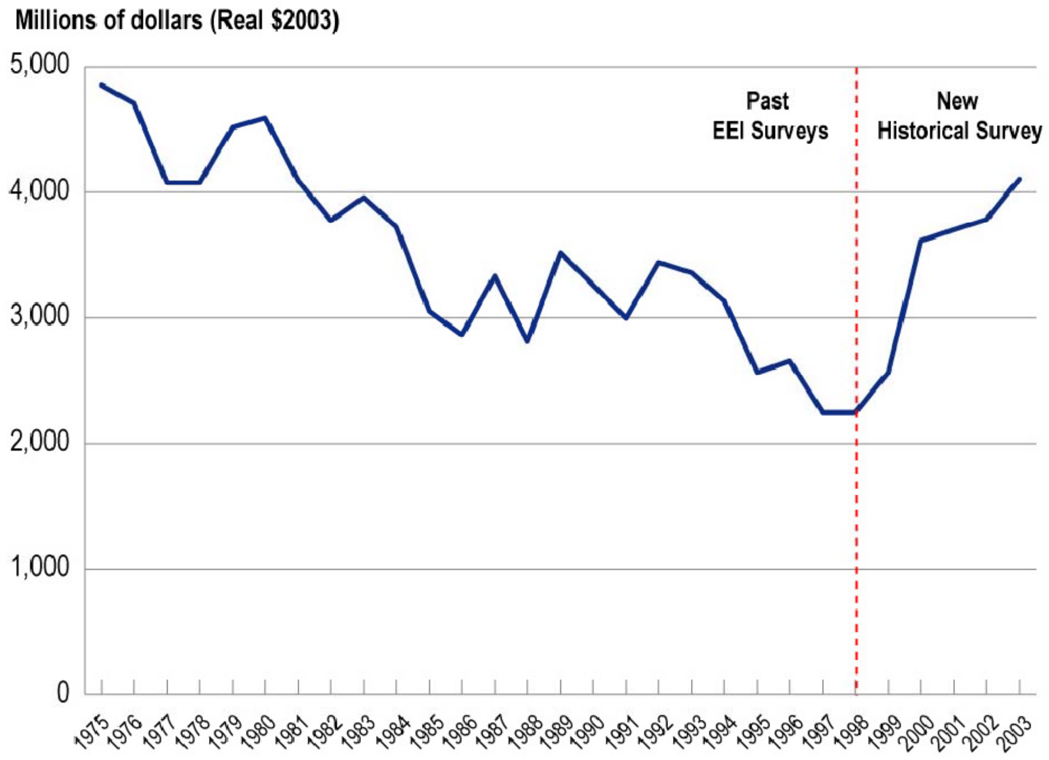
Figure 1. SAIDI comparison.



(Source: Thurston, 2008.)

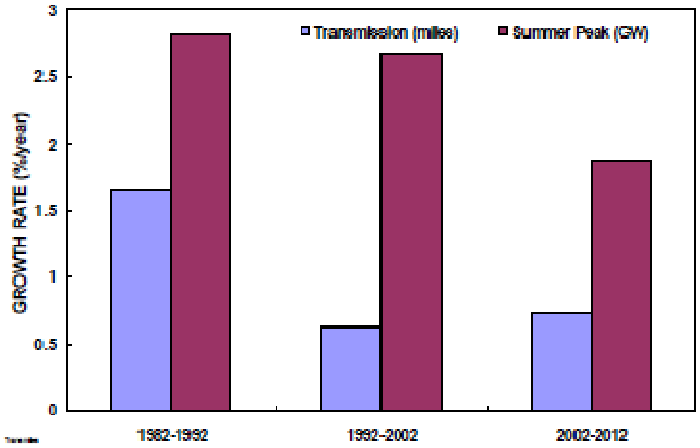
A direct cause of the underperformance of the U.S. transmission system is chronic underinvestment. Transmission investments in the United States experienced a long trend of decline from 1975 to 1998, during which time investments in transmission were barely enough for maintenance. With 40% growth in generation capacity from 1975 to 1998, the sufficiency of transmission capacity continued to decline. Although the absolute value of investments has grown since 1999, the growth rate of transmission continues to lag behind generation additions (Hirst, 2004; EEI, 2005). Some regions are more underinvested (and therefore, more congested) than others. The DOE has identified the most congested areas in the countries and classified them in one of three categories: Critical Congestion Areas, Congestion Areas of Concern, and Conditional Congestion Areas (U.S. DOE, 2006).

Figure 2. Transmission investment.



(Source: EEI, 2005.)

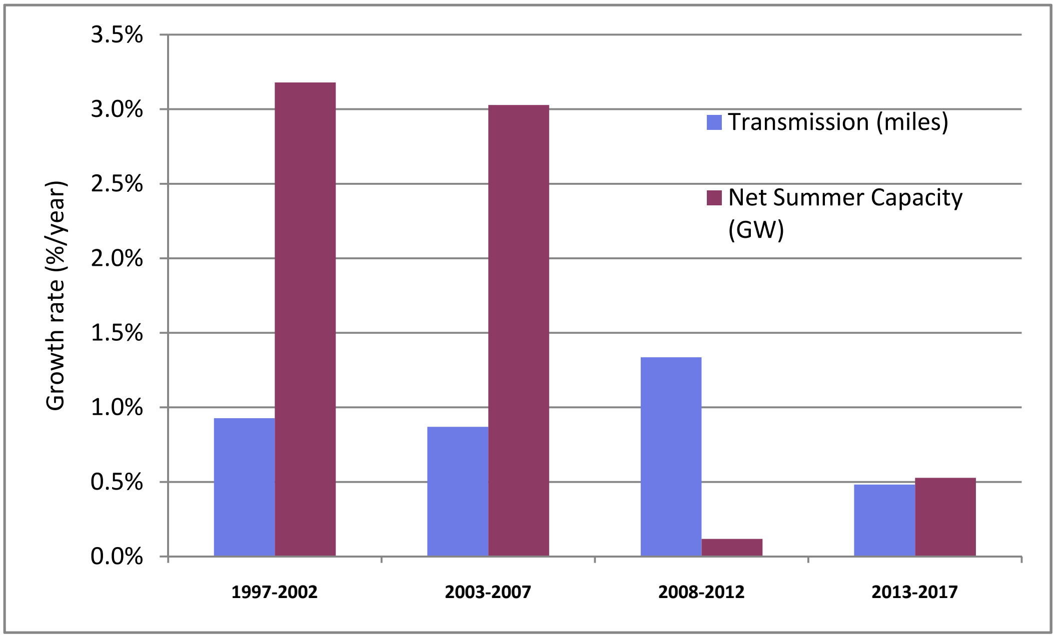
Figure 3. Historical growth of transmission vs. generation capacity.



(Source: Hirst, 2004, U.S. Transmission capacity: present status and future prospects, Edison Electric Institute.)

The projected growth of transmission from 2002 to 2012 significantly lags behind the projected additions of summer peak generation capacity (Figure 3) (Hirst, 2004). The growth in transmission is expected to accelerate in the next few years (Figure 4). The expected new investment, however, cannot compensate for nearly three decades of underinvestment. Many groups are calling for expanding the transmission grid to accommodate more renewable energy. The American Recovery and Reinvestment Act of 2009 allows the Western Area Power Administration and the Bonneville Power Administration to borrow up to $3.25 billion each to build transmission lines. Senator Harry Reid and Senator Jeff Bingaman have both introduced bills to promote investments in transmission to increase access to renewable power.

Figure 4. Recent and expected growth of transmission vs. generation capacity.



(Source: NERC Electricity Supply & Demand dataset, EIA Annual Energy Review, EIA Annual Energy Outlook.)

Although researchers generally agree that the United States has persistently underinvested in transmission, there is no simple explanation for what has hindered investments. Literature suggests there may be multiple causes, including siting difficulties, balkanized ownership, fragmented regulatory authorities, and institutional disincentives (Joskow & Tirole, 2005; Stagliano & Hayden, 2004; Fox-Penner, 2001; Joskow P. L., Transmission policy in the United States, 2005). The causes of underinvestment are further discussed in the section on barriers.

III. Transmission for Low-Carbon Electricity

President Obama has declared his goal of producing 10% of electricity from renewable sources by 2012, and 25% by 2025. Achieving this goal will not be possible without a significantly improved transmission infrastructure. The Department of Energy (DOE) concluded that achieving the goal of generating 20% of electricity from wind requires expanding the U.S. transmission grid in a manner that not only accesses the best wind resource regions of the country but also relieves current congestion on the grid. Such an expansion would entail the installation of new transmission lines to deliver wind power to electricity consumers (U.S. DOE, 2008). Limited transmission availability remains a primary barrier to wind energy (Wiser & Bolinger, 2007).

Renewable energy resources are typically location-constrained and most abundant in areas far from demand centers. Exploiting renewable energy resources will require new transmission lines to areas not already served by existing transmission infrastructure. Furthermore, existing grid systems in most demand centers are severely congested. In order to facilitate the delivery of renewable power, interconnections between existing systems must also be strengthened to relieve congestion.

Many of the most promising renewable resources are intermittent. Improved capacity in long-distance interconnections reduces the problems with intermittency because it allows many unsynchronized peaks and troughs to cancel each other out and become relatively stable. For example, the wind may suddenly stop blowing in either Texas, North Dakota, offshore Massachusetts, or on the Great Lakes, but the chances of the wind stopping in all of these places simultaneously is very low. If wind farms from geographically diverse regions are interconnected, intermittency will become a less of a problem. The capacity of long-distance transmission also makes it possible to use distant backup dispatchable capacity or storage facilities and to reduce the cost of redundant standby capacity.

In addition to facilitating renewable electricity, transmission may also play another important role in low-carbon electricity. Coal-fired power plants with carbon capture and storage (CCS) must be sited where the infrastructure exists to support them. Feasible sites for nuclear power are also limited. A major buildup of long-distance transmission lines may be required to ensure deliverability of new low-carbon power generation. Such long-distance lines present significant siting challenges because many would likely cross state boundaries.

IV. Barriers

Transmission investment renders a moderately high and predictable return over the long term. Today's financial market situation makes cash flows from existing transmission assets very attractive (FERC, 2008). FERC has provided financial incentives to encourage investment in transmission. Obviously, increasing the allowed rate of return may not be sufficient in inducing investment.

Investments in electricity transmission assets are in many ways atypical. Investments in new transmission lines are considered very risky because the siting process usually takes many years and investors are often forced to abandon their projects after spending millions of dollars on them (FERC, 2008). As a result, constructing new transmission lines can only be justified with a high rate of return. Once a transmission facility is completed and has begun operation, the asset generates a very low-risk, annuity-style cash flow. The disparity between low-risk existing assets and high-risk new projects is caused by the high uncertainty associated with new projects. Certainty and predictability are the secrets to capital formation, and they are hindered by the barriers of balkanized ownership, fragmented regulatory authorities, difficult siting processes, and near-sighted planning.

A. Balkanized ownership

The United States does not have a "national power grid," per se. The continental United States is divided into three synchronized transmission networks: the Eastern Interconnection, the Western Interconnection, and the Electric Reliability Council of Texas (ERCOT) network. The Eastern and Western Interconnections are further divided into many system operators. System operators do not own the networks. Each system is composed of many smaller networks with highly balkanized ownership. More than 500 owners each own a small portion of the grid, which makes it difficult, costly, and risky to plan and implement expansions in transmission. Although the diversity of owners does offer certain advantages, such as the potential of fostering innovative best practices, this balkanization of ownership hinders economies of scale. To illustrate, in 2007 State Grid Corporation of China (SGCC) had an operating revenue of $133 billion (McDonald, 2009), while RTE (owner and operator of the French transmission network) had a revenue of €4.13 billion ($5.47 billion).[1] That same year, American Electric Power (AEP), the largest transmission owner in the United States, had a transmission revenue of $296 million[2]—a mere 0.2% of SGCC's revenue and 5.4% of RTE's. Every business endeavor inevitably comes with risk. Of course, it is unreasonable to expect that a U.S. company could shoulder the same level of risk, in either construction or technical innovation, that a government-backed enterprise such as SGCC and RTE can.

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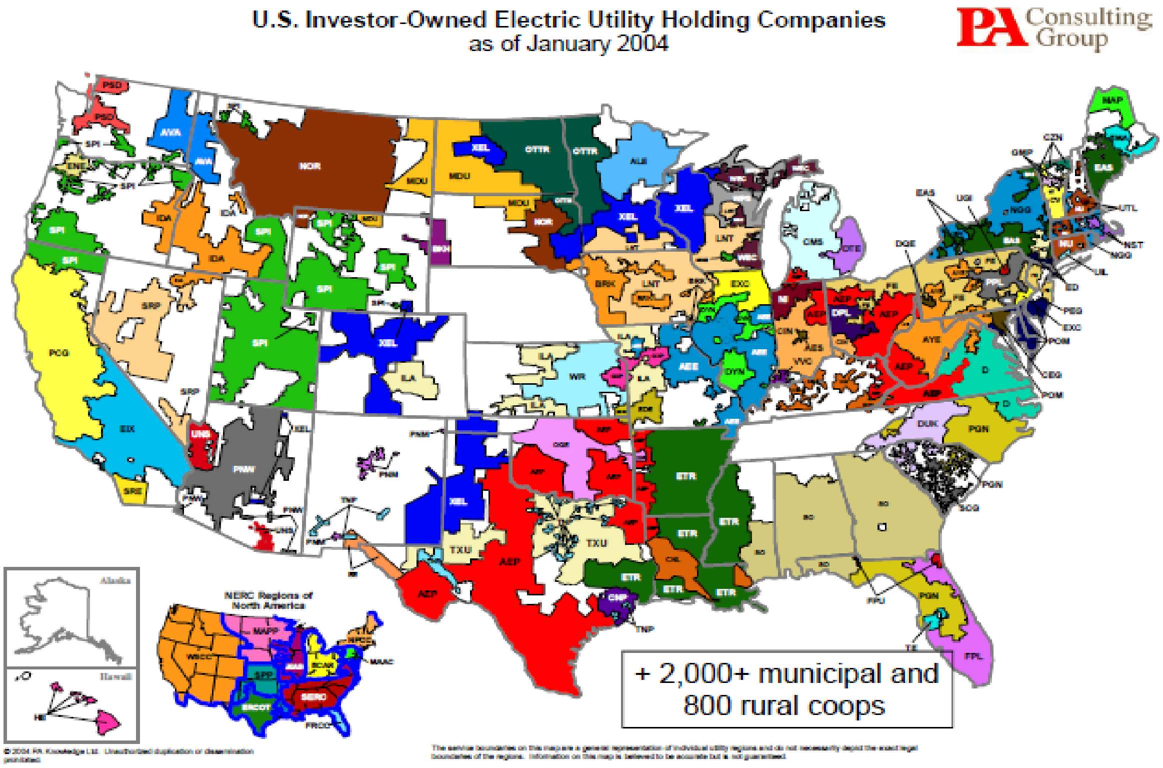
[1] http://www.rte-france.com/htm/an/qui/qui.jsp (last accessed April 14, 2009)

[2] AEP news release: http://www.aep.com/newsroom/newsreleases/?id=1525 (last accessed March 9, 2009.)

Figure 5. Fragmented transmission ownership.



(Source: Joskow, 2008.)

Transmission investment is characterized by very significant economies of scale (Joskow & Tirole, 2005) (Woolf, 2003). The textbook principles of economics suggest that a horizontally-integrated institution and ownership structure is the logical design for an electricity grid. Because the grid is jointly used, it is economically efficient to align the ownership structure with the operational realities of the network. A single horizontally-integrated entity owns, operates, and makes plans for the entire grid, and tremendous transaction costs are avoided as the entity exploits economies of scale and optimizes network planning and operation (Woolf, 2003). For this reason, authorities in many countries have organized transmission into a single monopoly with responsibility for the entire national grid (Morgan, 2007). Among the world's 15 largest national electricity systems, the U.S. transmission sector stands out as having the lowest degree of horizontal integration—an institutional weakness reflected in the system's physical vulnerability (i.e., low reliability and high congestion) (Morgan, 2007).

Figure 6. Industry structure and ownership.

Country	Electricity consumption, 2003 (TWh)	Horizontal integration in transmission
United States	3,475	Low
China	1,483	High
Japan	934	Moderate
Russian Federation	632	High
Germany	509	Moderate
Canada	504	Moderate
India	418	High
France	408	High
UK	337	High
Brazil	329	High
Korea	318	High
Italy	291	High
Spain	218	High
Australia	190	Moderate
Chinese Taipei	182	High

(Source: Morgan, 2007.)

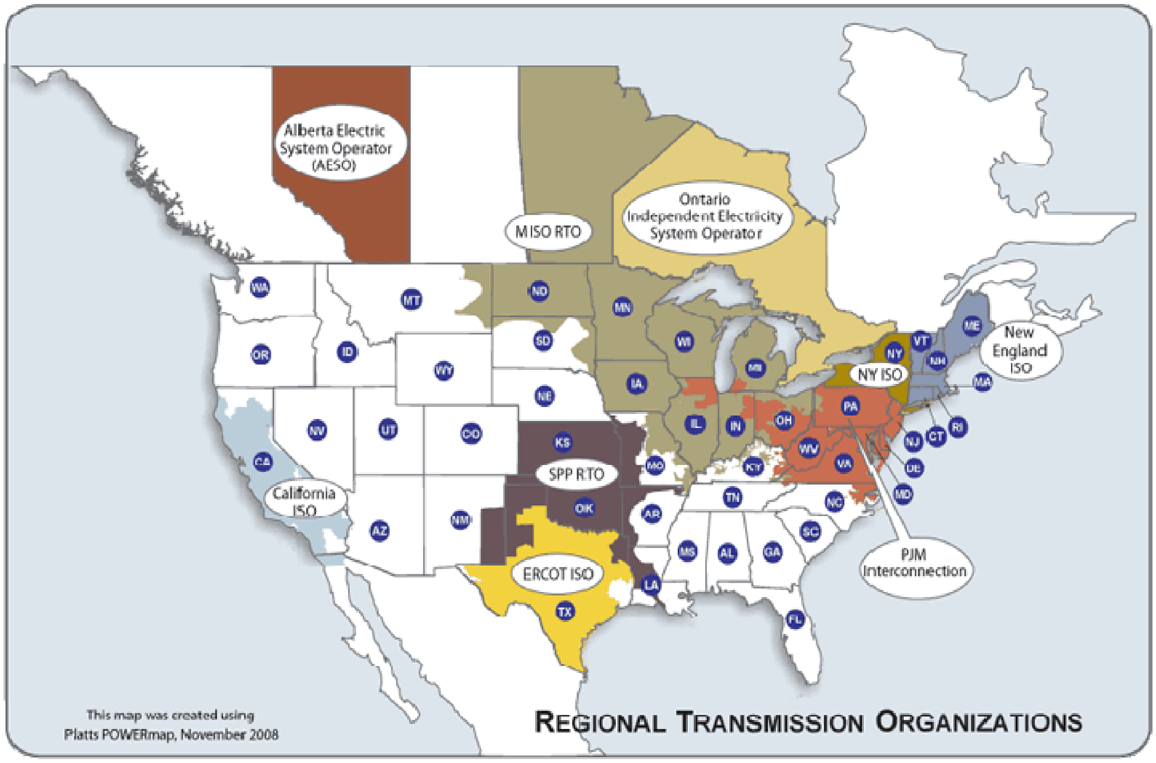
Horizontal integration, however, is particularly difficult in the United States, where most transmission assets are privately owned and the government cannot easily restructure private ownership for the sake of economic efficiency. The historic legacy of balkanized ownership is one of the greatest barriers to modernizing electrical transmission (Joskow P. L., 2005).

This balkanized ownership also makes siting new transmission corridors particularly difficult. Because the rights-of-way of existing transmission lines are scarce resources, and because obtaining permits for new routes is very expensive and risky, transmission owners find it cheaper to use their own rights-of-way than to purchase them from other owners. Transmission owners with the most rights-of-way are in the best position to develop new transmission lines. Also, if one entity owns all rights-of-way, transaction costs are minimized. Balkanized ownership increases the cost and risk of transmission investment. In order to justify such a risky investment, investors require a high rate of return. The high rate of return adds to the cost of transmission services, which arouses public opposition to new transmission proposals, which in turn add to the risk of investment. This has become a vicious cycle.

B. Fragmented regulatory authorities

The regulatory structure of the electricity sector in the United States is extremely complex. Many factors contribute to this complexity. First, the regulation of electricity utilities is historically within the jurisdictions of the states. Federal authority is very limited. Second, the U.S. move toward restructuring the electricity sector stopped halfway, rendering one half of the country with conventionally regulated utilities and the other half with competitive power markets. Third, the United States is endowed with a huge number of private, investor-owned utilities. Because the majority of transmission assets are privately owned, horizontal integration is extremely difficult. Unlike most other countries, the United States cannot easily restructure its electricity sector by divesting state-owned generation assets and consolidating transmission assets into a state-owned monopoly (Joskow P. L., 2005). In order to facilitate the transition to a competitive electricity market, the FERC can only rely on limited statutory authority to cajole and encourage the states and their utilities to voluntarily create competitive markets and organize transmission institutions. The restructuring process started in 1999, when the FERC issued Order 2000, which mandated all transmission owners to file plans to join a Regional Transmission Organization (RTO) or to explain why they could not do so (Joskow P. L., 2005). The order encouraged transmission owners to hand over the operation of their transmission assets to a RTO or an Independent System Operator (ISO) while maintaining ownership of them. A significant part of the country has opted not to join RTOs. Figure 8 shows the RTO/ISO and non-RTO regions. The Northeast, Mid-Atlantic, and much of the Midwest, Texas, and California have competitive power markets operated under an ISO or a RTO; the rest of the country has traditional vertically integrated utilities. Because the RTO and ISO regions are more populous than the non-RTO regions, these ISO/RTO regions consume two-thirds of the electricity in the United States (The ISO/RTO Council, 2005).

Figure 7. Regional transmission organizations (RTOs) and non-RTO regions.



(Source: FERC.)

For comparison, China had a similarly fragmented vertically integrated utility sector until October 2002, when the Chinese government established the State Electricity Regulatory Commission. The vertical disintegration (of grids and generators) and horizontal integration of 12 grids into two state-owned transmission companies was accomplished within three months. In the United Kingdom, the restructuring process started with the Electricity Act of 1989, which privatized state-owned electricity generation assets and turned them into competitive industries, while consolidating transmission and distribution into a monopoly company. The restructuring of the UK's electricity sector was completed in 1990 (Energy Information Administration, 1997). In the United States, the process of restructuring the electricity sector started in the 1990s, but stopped halfway. It remains uncertain whether restructuring will continue.

1. Complex regulatory frameworks

This partial restructuring has left the regulatory system in the United States complex and inconsistent. Regulations vary from place to place. A transmission project may cross multiple borders of jurisdiction and face conflicting directives. The lack of consistency in regulation is a deterrent to investment. Although some researchers have argued for the merits of deregulation and called for completing the transition to competitive power markets, some have argued otherwise (Blumsack, Apt, & Lave, 2006) (Lerner, 2003). Currently no consensus exists on whether the transition to competitive electricity markets should continue; therefore, the complex regulatory structure will likely remain in the near future.

2. Separation of ownership and control of assets in RTO regions

In the restructured half of the country, RTOs and ISOs assert the functional control of transmission assets they do not own.[3] Because they operate transmission, they have the best information and overall view regarding how to plan future expansion. It is therefore reasonable for RTOs and ISOs to make plans for transmission expansions. But because they do not own the assets, the RTOs and ISOs have neither the means nor the authority to implement their plans. Instead they rely on merchant transmission companies to make investments (Joskow & Tirole, 2005), and on the FERC to authorize financial incentives. After traditional private transmission owners surrendered the control of their assets to RTOs, they were not given sufficient incentive to invest more money into these assets.[4] In order to encourage investment, higher returns may be necessary. As explained previously, higher returns mean higher costs to consumers and likely more public opposition. Public opposition increases the risk of transmission investment, which causes investors to require higher returns to justify their risks. The separation of ownership from control of assets increases transaction and coordination costs and discourages investment and innovations (Joskow P. L., 1999). By enabling competitive wholesale electricity markets, facilitating regional planning, and improving system reliability, RTOs and ISOs have brought about many benefits and efficiencies, but encouraging transmission investment is not one of them.

C. Siting difficulty

1. Local opposition

Local opposition, especially in densely populated areas, has made transmission lines among the most difficult facilities to site. Negotiations often delay, and sometimes prevent, projects from being built. As a result, transmission permitting, siting, and construction can take seven to ten years (NERC, 2008).

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[3] RTOS and ISOs assert functional control of transmission and assure equal access to the grid, as well as administer a single regional tariff. Transmission owners maintain operational control and assume the maintenance of their transmission assets.

[4] Transmission owners are obligated to maintain their existing transmission assets, but the reduced control over their assets likely reduces incentives to invest.

Siting an electric transmission line often involves a series of media inquiries, contentious municipal hearings, and legislative and litigative attempts to stop the project. The process can be circuitous, repetitive, time-consuming and costly (Randell & McDermott, 2003). In some cases, local opposition and legal challenges have continued after the approval of site permits. If the opposition succeeds in having the project stopped, investors may not be able to recoup their expenses on a transmission line that was not built.

2. Fragmented jurisdiction

Utilizing renewable energy resources often requires long-distance transmission across many states. When new transmission lines are planned to cross state borders, the siting process is particularly difficult. States historically enjoy full and plenary authority over transmission siting, and each state has its own transmission siting process—a process that is often contentious. Differences in state statutes and regulations pose significant obstacles to siting interstate lines. Some statutes provide guidance on state utility commissions' actions when considering interstate transmission siting, while others do not. Coordination among states is often unsatisfactory: there are 12 states without explicit statute language on coordination[5] (Friedman & Keogh, 2008). To complicate matters even further, different states use different parameters and terminology when evaluating transmission projects.

Furthermore, the various counties, townships, and communities along the transmission line may require local approval. And if the line crosses any federal lands or waterways, it will require additional approval from relevant federal agencies. Federal agencies frequently wait to conduct their reviews until state reviews are completed and a final route has been selected. After a transmission investor completes state reviews, a federal agency may require a route change, leading to another time-consuming and costly iteration of the state process (Fox-Penner, 2001). The permitting process may take many years and cost millions of dollars before the project is denied or approved. The fragmentation in transmission oversight authority imposes substantial regulatory risks to transmission investment (Nieto, 2006).

3. Local consumer interests

Consumers inevitably face higher electricity rates when a new transmission investment is allowed into the rate base. In the past few years, rising commodity prices (e.g., copper wire and steel) and construction costs have led to a rise in the cost of transmission projects; these higher costs in turn have led to rate hikes. Some consumer groups believe that the increased investments in transmission are the cause of rising rates of electricity and oppose investment in transmission (Mills, 2008). In some cases,

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[5] Colorado, Iowa, Louisiana, Maine, Massachusetts, Montana, Nebraska, Oklahoma, Pennsylvania, Virginia, and West Virginia.

transmission projects may incur costs to local communities while the benefits are shared throughout a broader region. In many cases, however, improvements to the transmission network may actually expand users' access to a broader range of energy resources and reduce their electricity bills in the long run (Woolf, 2003). Because state regulators are charged with protecting the interests of consumers within their states, the prospect of near-term rate hikes may lead them to be critical of transmission investments. Negotiating acceptable compensation packages for local communities and/or convincing them to make sacrifices for national interests could present a challenge.

D. Traditional reliability-focused planning

Existing transmission networks in this country were not designed to meet the needs of competitive wholesale markets or the needs of low-carbon electricity.[6] No agency in the United States is charged with the mission of addressing the need for electricity delivery on a national scale, with the goal of promoting low-carbon energy. Current planning processes focus primarily on the minimum reliability needs for maintaining the existing system (National Grid, 2006). The existing practice of transmission planning focuses mainly on remedying problems rather than creating opportunities.

Under the existing planning scheme, proposed projects must secure long-term transmission contracts from existing or potential power generators. If they do not secure a sufficient number of contracts, investors will not be willing to finance the proposed project. Many projects have failed because they cannot secure long-term commitments on the future demands for their transmission services (Energy Security Analysis, Inc., 2005). Remote renewable energy developers will not commit resources to their projects until they are sure that transmission will be available; transmission in remote areas will not be available unless transmission investors have secured commitments from power generators. Within RTOs, the generators are either partially or fully responsible for initial funding of transmission construction. The financial burden associated with this construction is a major barrier for developers of remote renewable energy resources. NIETCs do not address the problem of building transmission to new areas, as they were designed to relieve congestion—which is obviously not an issue in places without transmission lines. Only proactive planning can break this chicken-and-egg dilemma.

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[6] When the existing transmission networks were built, there was no competitive electricity market.

VI. Policy Options to Address Barriers

A. Reducing ownership fragmentation

Restructuring ownership of transmission assets in the U.S. context is extremely difficult (and perhaps impossible). Nevertheless, there are possible steps toward reducing the fragmentation of ownership.

1. Enable transmission REIT

A real estate investment trust (REIT) is designed to provide a similar structure for investment in real estate as mutual funds provide for investment in stocks (Watkiss, 2007). When a corporation puts its asset in an REIT, it can eliminate or reduce its corporate income taxes from these assets. In return, an REIT is required to distribute 90% of its income to shareholders. REITs can be listed on public stock exchanges and traded like shares of common stock. Transmission assets generate high returns (>12%) with very low risk and therefore may potentially attract significant investment interest if they are available to broader groups of investors.

REITs provide an opportunity to attract a broader investor group to electric transmission projects and further the vertical disintegration between transmission and generation (Toy T. , 2008; Toy & Watkiss, 2008; Watkiss, 2007). Investor-owned utilities may willingly divest their transmission assets by restructuring them as REITs for liquidity and lower taxes. When a state-regulated vertically-integrated utility restructures its transmission assets as an REIT, it would effectively transfer the jurisdiction of its transmission facilities from the state to the FERC, thus providing an opportunity to consolidate the jurisdiction of transmission facilities.

Existing tax codes are ambiguous on the REIT-eligibility of electric transmission assets (Toy T. , 2008). Congress may modify certain REIT provisions of the Internal Revenue Code of 1986 to enable electric transmission REITs. Such legislative changes can be revenue-neutral.

2. Consolidate public-owned transmission assets

A significant portion of transmission assets are publicly owned (by federal agencies and municipalities). Legislation to transfer these publicly owned assets under a single public entity may be a step toward decreasing the fragmentation of ownership (Oren, Gross, & Alvarado, 2002).

B. Streamline siting process and mitigate siting risk

There is no simple solution to local opposition. Nevertheless, studies suggest that a significant portion of delays involve issues other than local opposition (Fox-Penner, 2001) (Friedman & Keogh, 2008). Lack of coordination among state and federal agencies has in many cases delayed site approval and added costs. Reducing investors' financial risks associated with siting uncertainties through financial assistance or cost-recovery arrangements is also possible.

1. Encourage interstate siting compacts

Consolidating siting authority in the federal government would likely be politically difficult. Researchers have suggested that states could be encouraged to participate in a regionally coordinated "one-stop" siting process (Meyer & Sedano, 2002). California is considering consolidating the nine state authorities charged with permitting into a one-stop siting agency (Kahn, 2009). A regional (multi-state) one-stop siting process may be the next step (Friedman & Keogh, 2008). An interstate compact could promote coordination without depriving states of their authority. Some states[7] have initiated such a compact. Congress may facilitate interstate coordination by requiring that all interstate transmission siting use a joint interstate siting process or by providing incentives for states to participate in a joint siting process.

2. Fund feasibility studies and preliminary environmental impact studies

Significant investments are made on feasibility studies and environmental assessments. If a proposed project fails to acquire a site permit or is forced to cancel due to post-approval obstructions, the investments in feasibility studies and environmental impact assessments become financial losses. If the government funds feasibility studies and preliminary environmental impact studies for projects within which there is a potential national interest, the investors' risk could be significantly reduced.

The European Commission is implementing the trans-European energy networks (TEN-E) project to facilitate the integration of a European energy system. The European Union (EU) budget funded pre-investment feasibility studies and other preparatory activities as a catalyst for investment (European Commission, 2004) (European Commission, 2008). The United States may draw lessons from the European program. Senator Reid's recently announced bill—The Clean Renewable Energy and Economic Development Act of 2009 (S. 539)—would also authorize the DOE to make grants to states and planning entities to implement the planning and siting described in the bill (Senator Harry Reid's Office, 2009).

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[7] For example, Idaho, Montana, Oregon, and Washington entered into an interstate compact (Friedman & Keogh, 2008). Iowa, Minnesota, North Dakota, South Dakota, and Wisconsin formed the Upper Midwest Transmission Development Initiative (UMTDI).

3. Allow cost recovery for work in progress

A transmission project typically requires a high upfront investment, and investors can only recover their costs after the project is completed. There is a high financial risk if the project is not complete because of local opposition. If transmission investors are allowed cost recovery for transmission works in progress, their financial risk will be lower.

4. Provide abandoned plant protection

A major risk to a transmission project is the possible failure in obtaining site approval from multiple jurisdictions. There have been cases where transmission projects were cancelled due to continued local opposition even after site approval. For example, Florida Power proposed a 44-mile Lake Tarpon-Kathleen (LTK) line in 1984 and the site permission was approved in 1994, after ten years of regulatory and legal challenges by opponents. The continued opposition after site approval eventually forced Florida Power to cancel the project. Florida Public Service voted to allow Florida Power to recover the $23 million it spent on this line, which was never built (Electric Utility Week, 1995).

FERC has allowed cost recovery for all “prudently incurred” development and construction costs in the event the project is abandoned for reasons beyond the project owner’s control. Such allowance for cost recovery is known as “abandoned plant protection.” Currently, the approval of abandoned plant protection is determined on a case-by-case basis. If Congress stipulates in law to in principle allow abandoned plant protection for new transmission projects with a clear definition of “prudently incurred” costs, it will reduce the financial risk of transmission investments.

5. Expand federal siting authority

FERC already exercises federal siting authority for interstate natural gas pipelines. A similar federal siting authority for electrical transmission would significantly expedite the siting process. In spite of the political difficulty, EPACT 2005 did authorize limited federal siting authority, but this authority has not been exercised so far. Incrementally expanding such authority for the sake of national interests may be possible. Existing statutory language limits the definition of “national interest” in NIETC to alleviating congestion; in the future, it may be possible to extend the definition of national interest to include the promotion of low-carbon energy. Courts have determined that the federal siting authority in the NIETC process only grants the FERC backstop authority to act in case of state inaction, but does not grant the federal authority to overrule a state decision to reject a project. A recent joint study by the American Wind Energy Association (AWEA) and Solar Energy Industries Association (SEIA) recommends giving FERC the approval and permitting authority for regional extra-high-voltage transmission lines (Gramlich, Goggin, & Gensler, 2009). Senator Bingaman’s energy bill–the American Clean Energy Leadership Act (S.

1462)–would authorize the FERC to grant a certificate of public convenience and necessity for the construction of a high-priority national transmission project if states delay the siting process for over a year or reject an application for such a project. The American Clean Energy and Security Act of 2009 (H.R. 2454), as approved by the House on June 26, 2009, would also provide backstop siting authority to FERC for interstate transmission lines in the Western Interconnection. H.R. 2454 would instruct the FERC and other federal agencies to streamline the transmission permitting process in the Western Interconnection.

C. Proactive planning

1. National renewable energy zones

Senator Harry Reid's bill (S. 539) would direct the President to designate renewable energy zones, give the FERC planning authority for interconnection-wide green transmission grid planning, and provide the FERC with backstop siting authority for green transmission projects (Senator Harry Reid's Office, 2009). This federal siting authorization allows the FERC to grant site permits after consulting the affected states. The FERC may decide not to adopt states' recommendations if it finds the recommendations infeasible or not cost-effective.

2. Interconnection-wide transmission planning and broad regional cost allocation

The AWEA and SEIA recommend that transmission planning should be considered on an interconnection-wide basis (Gramlich, Goggin, & Gensler, 2009). They also recommend that green power superhighways—proposed ultra-high-voltage transmission lines developed to support the expansion of renewable electricity—should be eligible for broad, regional cost allocation.[8] The power system planning authorities in eastern North America are forming an Eastern Interconnection Planning Collaborative (EIPC) to develop interconnection-wide transmission plans. Bill S. 1462 would direct the FERC to develop interconnection-wide transmission plans.

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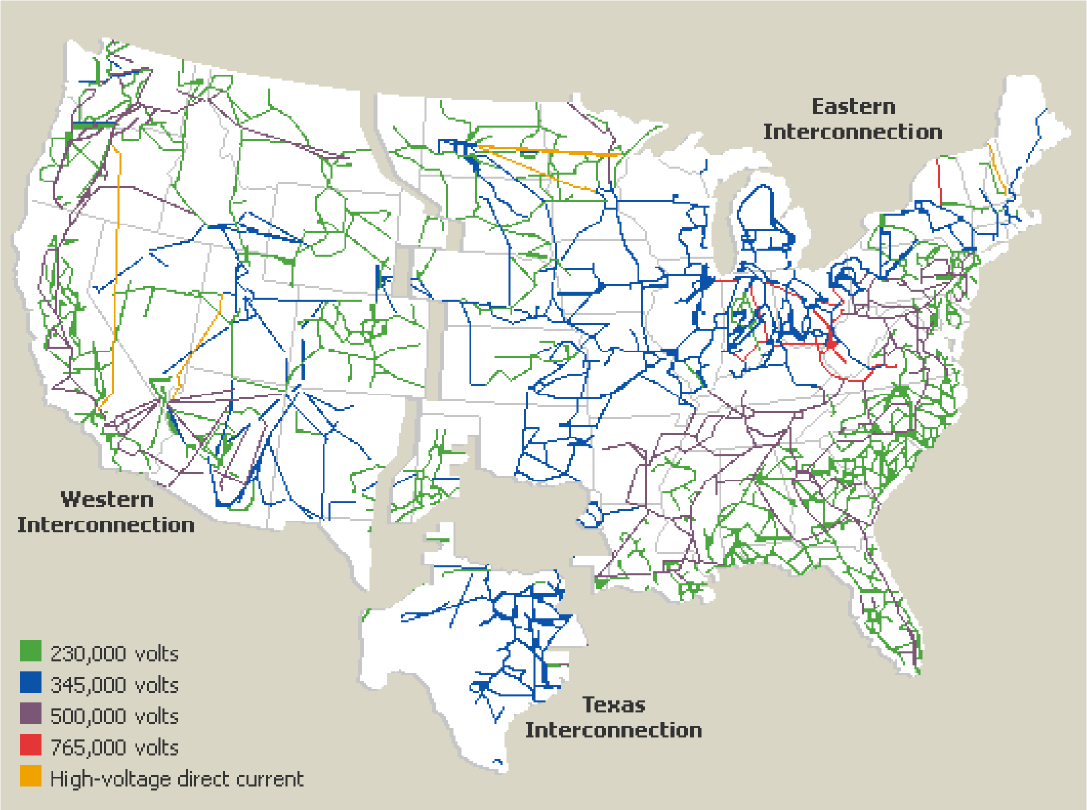
[8] This is known as cost socialization.

Figure 8. Transmission interconnections in continental United States.



3. Build a national electrical transmission grid

Some are proposing a national (instead of a regional or state) transmission network to facilitate the development of low-carbon energy resources (American Electric Power, 2007) (Krapels, 2008). The federally funded Dwight D. Eisenhower National Interstate Highway System may serve as a model for developing a national transmission grid. The Federal-Aid Highway Act of 1956 established a highway trust fund which paid for 90% of highway construction costs. States were required to pay the remaining 10%. The Interstate highways were centrally planned by the U.S. Bureau of Public Roads. Instead of amending existing roads and alleviating local congestions, the Dwight D. Eisenhower National Interstate Highways built a whole new network of transportation.

The development of ARPANET, the technical backbone that later expanded and evolved into the Internet, is another example. The ARPANET was not built by amending existing communication networks. The Defense Advanced Research Projects Administration (DARPA) funded the entire cost of building the ARPANET. A modern transmission grid may be developed by following the footsteps of the internet.

The impact of a national transmission grid would not be limited to renewable energy. Expanding transmission capability enables the utilization of low-cost remote energy resources to satisfy high-price demand at locations that currently lack sufficient energy resources. Because coal is a low-cost fuel, the regions that rely heavily on coal for electricity generation tend to have relatively low marginal generation costs. Without a constraint on carbon emissions, it is possible that a national grid will increase the power flows from remote coal-fired plants to urban centers. The increased emissions from the increase in coal-fired sources may offset the emissions reductions from enabled renewable sources (Vajjhala, Paul, Sweeney, & Palmer, 2008). In the near term, if a specific transmission line is required to carry only or mostly renewable electricity, it will be difficult to justify the transmission project financially. An economy-wide carbon constraint (or renewable electricity standard) with national grid construction may be an effective approach to further the transition to a sustainable electricity system. Senator Bingaman's bill, S. 1462, would direct the FERC to develop plans for a national interstate transmission system but would still rely on merchant investors to fund and build the system.

D. Offsetting transmission via demand response resources and energy storage

There are some promising load-balancing resources, such as smart grid devices, demand-response resources, and energy storage technologies, that may reduce the amount of transmission capacity needed. A significant number of regulatory changes as well as substantial efforts in research, development, and commercialization assistance are needed to facilitate the development of these resources and technologies. FERC may promote contractual and operational arrangements to facilitate better integration of variable energy resources. These measures may include coordination of balancing areas, faster scheduling and dispatch mechanisms, and better integration of demand response (Gramlich, Goggin, & Gensler, 2009).

While those load-balancing resources may mitigate problems with intermittent renewable energy and reduce the burden on transmission, they do not resolve the problems with the geographical mismatch between renewable resources and electricity demand. Eventually, more long-distance transmission lines will be still required to deliver low-carbon electricity.

The potential of smart grid technology offers tremendous promise. For example, if smart thermostats can automatically turn off thousands of air conditioners for 20 minutes a day to prevent transmission overloads, they can prevent blackouts with minimal costs. Nevertheless, policymakers must recognize that widespread smart grid deployment will be neither easy nor cheap. In order to deploy the smart grid at the household level, meters must be replaced, wiring retrofitted, and appliances replaced in every household. A hasty deployment of the smart grid may be risky. If a "not-so-smart" meter mistakenly turns off computer servers or home-care life-support systems due to a malfunction or flawed design, the result could be disastrous. The possibility of cyber attacks to the grid is another concern. There are certainly technical solutions to these potential problems, but the solutions will not be free or immediate. To improve the efficiency of large-scale smart grid operation, significant standardization and system integration efforts are necessary. The fragmented structure of the utility industry and lack of federal authority in the United States may make the standardization and system integration slow and costly.

Smart grid technology is a capital-intensive investment; i.e., the upfront cost of deploying the technology is high, but it is relatively inexpensive to operate. Once a capital-intensive facility is in place, it would be economically beneficial to keep it in use for as long as possible (at least for several decades). Currently, most smart grid technologies are still developing and evolving. It is quite possible that the first movers will end up with the most expensive and least sophisticated technologies, a prospect that gives utilities incentive to suspend their smart-grid investment until they can learn from the first movers' experiences and mistakes. The initial deployment of the smart grid should proceed with caution and be preceded by step-wise pilot projects and demonstration programs (Butler, 2009).

According to one estimate, the upfront smart metering investment per household may be in the range of \$200–\$700 (Tai & hÓgáin, 2009). The nationwide investment would be \$20–\$70 billion with approximately 100 million households across the country. In addition to the upfront cost, a smart meter must maintain real-time communication with the grid operator. There are many candidate technologies (e.g., GPRS, WiMax, and several third-generation wireless telecommunication technologies) that may provide this communication service. Although it is still unclear which technology will be chosen, there is little doubt that none of these communication services will come without a cost. It remains unclear who is going to pay. For an individual household, it may take many years to recoup this investment from savings in electricity bills with time-of-use pricing. Without time-of-use pricing, households will receive no return on their smart-grid expenditures. The split incentive between landlords and tenants will also be a barrier: landlords have no incentive to pay for the retrofits to reduce tenants' bills, and tenants have little incentive to pay for investments in houses they do not own. Utilities may not be willing to make investments that would reduce their electricity sales. Transforming the utility and ratepayer incentive structure would be an important first step (Hoppock, Monast, & Williams, 2008). The government must assume leadership in such a transformation to reap the benefits of a smart grid.

VII. Conclusion

The electrical transmission system is not only the platform for competitive wholesale electricity markets, but also the essential infrastructure for the development of new low-carbon electricity technologies. Many barriers have historically prevented adequate investment in transmission. A unique historical legacy left the United States with an outdated transmission infrastructure and an ineffective institutional structure. Now these same barriers pose a significant hurdle to achieving the country's goal of reducing greenhouse gases. Although there are many attempts in various parts of the federal government to address some of the problems, more efforts are needed. It will require a strong political commitment to overhaul the institutional and regulatory system, upgrade the antiquated transmission infrastructure, and stimulate investments in the buildup of a delivery network for clean electricity resources so the economy may move toward a sustainable path.

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