An Electricity Grid for the 21st Century

2009 Energy Policy Forum

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Table of Contents

Dedication

Henry Linden

This report is dedicated to the memory of Henry Linden, Energy Policy Forum co-founder, supporter, and enthusiastic participant, whose death in 2009 saddens his many friends. A global authority in energy research and policy, Henry served the Institute of Gas Technology in various positions for 30 years, including 17 years as director and four years as president and trustee. A Ph.D in chemical engineering from the Illinois Institute of Technology (IIT), he served IIT as a faculty member from 1954, and as interim president in 1989-90, establishing a comprehensive research and education program in sustainable global energy development. He was a member of the National Academy of Engineering and a fellow of the American Association for the Advancement of Science, the American Institute of Chemical Engineers, and the Institute of Energy. He served on numerous federal advisory bodies and received many awards, including induction into the IIT Hall of Fame and the Engineering Hall of Fame of his undergraduate alma mater, the Georgia Institute of Technology.

In 1977 the Aspen Institute held its first Energy Policy Forum, then called a workshop. Henry helped make it an annual event by organizing, along with John Sawhill and Bill McCormick, a second Forum in 1978 and by offering his knowledge, support, and enthusiasm for subsequent events. From the beginning he urged a focus on energy governance and, as environmental issues became more prominent, on addressing the relationships among energy, the environment, and the economy. Until health issues limited his travel, he was an eager and valuable participant each summer, and he remained interested in the reports of the Forum when he could no longer attend. The Forum we have learned to love is in large measure a creation of this wise and generous man, and we can honor him for his contributions by renewing our commitment to the informed dialogue that he loved and fostered.

Foreword

A chorus of voices calling for enhancement of the transmission grid led to the choice of a topic for the Aspen Institute's 33rd annual Energy Policy Forum. An invited group of energy leaders and policy experts discussed "An Electricity Grid for the 21st Century" in Aspen July 8-11, 2009.

As in previous years, the format relied heavily on dialogue to explore commercial and public policy issues at the intersection of energy, the economy and the environment. Short introductory presentations kicked off each half-day session, and a spirited, off-the-record discussion followed. The diverse participants brought a variety of perspectives and areas of expertise to the table.

The dialogue was co-chaired by Susan Tomasky, President of AEP Transmission and former General Counsel of the Federal Energy Regulatory Commission; and Linda Stuntz, Partner in Stuntz, Davis and Staffier and former Deputy Secretary of Energy. Their years of experience and their active participation in electricity policy discussion made them valuable advisors in developing the agenda and allowed them to focus the discussion on key issues. They chaired the meeting with skill and good humor. The highly qualified group of speakers provided a wealth of information and a variety of perspectives, and the diverse expertise of a particularly well qualified group of participants contributed substantially to the richness of the dialogue.

The Institute acknowledges and thanks the following Forum sponsors for their financial support. Most have been participants and supporters for many years. Without their generosity and commitment to our work, the Forum could not have taken place.

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On behalf of the Institute and the Forum participants, I also thank Laura Hermann, who served as rapporteur. While no summary can capture the full richness of the discussion, she identified the important threads and wove them into this summary report. Timothy Olson managed the administrative arrangements for the Forum with his usual efficiency and dedication. His hard work was responsible for a smoothly run meeting, and I am grateful for his conscientious support.

This report is issued under the auspices of the Aspen Institute, and the co-chairs, speakers, participants, and sponsors are not responsible for its contents. Although it is an attempt to represent ideas and information presented during the Forum, all views expressed were not unanimous and participants were not asked to agree to the wording.

John A. Riggs
Senior Fellow
Energy and Environment Program

An Electricity Grid for the 21st Century

Laura Hermann
Rapporteur

I. The Goals of Transmission Enhancement

For many years, electricity transmission has been designed to provide enough interconnection to provide affordable, reliable supplies of electricity. Recent developments in market mechanisms, technologies and policy goals have begun to pose different requirements on the existing grid system. To meet the needs of all beneficiaries of transmission enhancements, new planning, siting and cost allocation strategies must be implemented.

This chapter describes:

- The role of electricity transmission
- Requirements of the current and future system
- Achieving the goals of the 21st century grid
  - Market design for the electricity sector
  - The balance of power – state versus federal authority

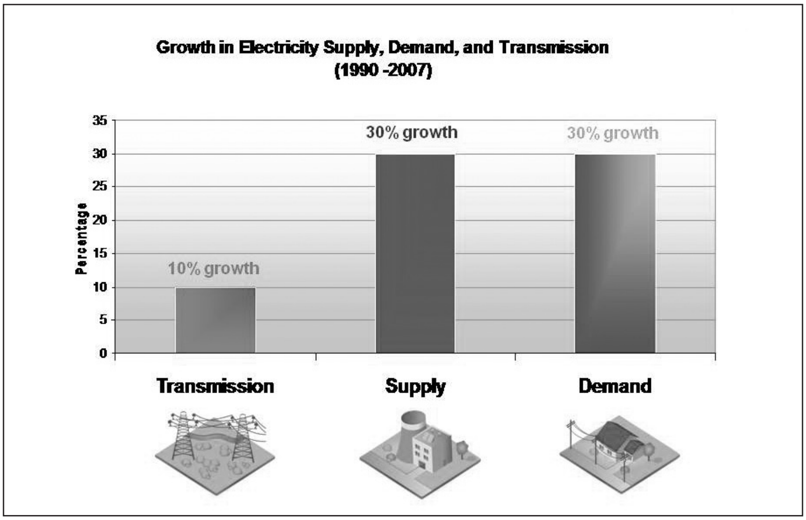
The challenges of electricity transmission today

The American electricity transmission system is approaching a breaking point. The system was devised to provide reliability and affordability. Today, additional goals make enhancing and managing the grid much more complicated. Today's electricity sector operates within a statutory framework that has existed for decades while the demands on the transmission system have evolved apart from the regulatory system that guides it. To meet growing demand, access renewable resources, and energize the country's digital economy, there must be a thorough evaluation of what the transmission system of the future might look like and what steps must be taken to build it.

Many industry participants acknowledge the need and opportunity for transmission policy changes. Generators face new requirements, from increased security to renewable portfolio standards. Transmission and distribution operators face growing demands for "smarter" systems and for the integration of new power supply sources. Some change has taken place successfully already, and the transmission system has proven to be versatile in the face of modern demands. However, each new demand draws more attention to aging transmission infrastructure, increasing performance expectations and the need to build a system for the country's energy future. The current approach, however, merely updates the transmission system in order to remove immediate reliability problems. The future of the 21st century transmission system will offer more than an electricity delivery system – it can produce secondary effects that contribute to policy initiatives to improve efficiency, "go green," or transform other energy intensive sectors.

Policy makers and the industry face the threshold question: "What are the goals of the 21st century grid?" Until this question is answered, power providers and others will face difficult negotiations to determine the relative advantages and disadvantages of the range of options. The updated transmission system will require new thinking with regard to planning, siting and cost allocation. Even after goals are specified, the electric industry will need to remain persistent in its consensus building efforts.

Transmission growth since 1990



Source: NERC

Significant investment in transmission is required in many areas of North America. Capacity increased by only 10 percent from 1990 to 2007, while electricity supply and demand rose by 30 percent.

Requirements of the current and future system

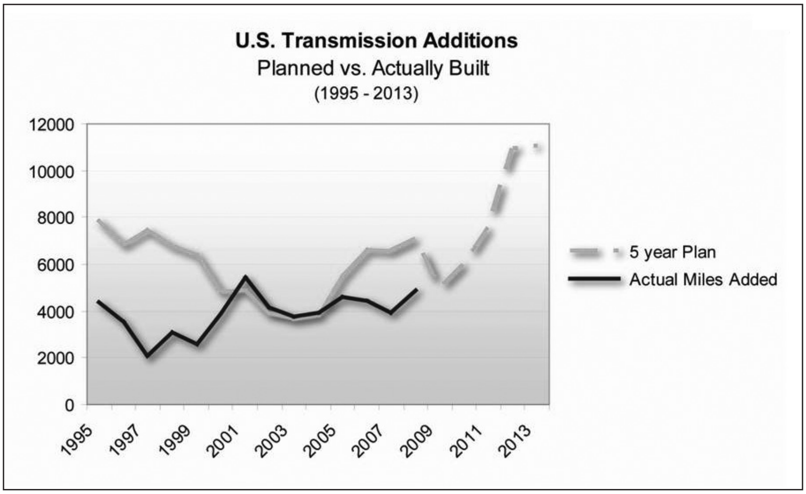
National efforts to electrify the transportation sector, improve energy security and reduce carbon emissions are distinct additional goals that will challenge the existing organization of the electricity sector. In the face of new challenges and objectives, the 21st century grid will need to rebalance the interests of diverse stakeholder groups in terms of political, financial, environmental and legal requirements. Who benefits from proposed improvements depends on one's point of view. The country's ability to reach the variety of proposed policy goals will require compromise and coordination. To pave the way for transmission investment, state and federal relationships must be negotiated, siting efforts must be streamlined and uncertainty over how costs will be recovered must be reduced.

The reorganization of the transmission system will need to support Americans' increasing demands for energy. Today's utilities strive to keep electricity reliable and costs low, but changes in the role of transmission require consideration of additional objectives. Conflicting goals often hinder efforts to define that role since the current grid is not designed to perform some of the new functions being proposed. The grid will require different modifications to move location-constrained renewable energy resources than would be required to increase the use of traditional generating resources. Many new transmission objectives call for interconnection-wide planning, which has not been done in the past. Transmission for broad purposes has few economic forces behind it to win local support. Siting processes emphasize local controls, and cost allocation difficulties and federal land management rules sometimes inhibit building additional capacity.

Regional transmission organizations and interconnections will continue to play an important role in the future of the grid. However, it is unclear how to identify beneficiaries and to allocate the costs of grid enhancement. Passing the costs of system improvements through to retail customers may create disparities among groups. The customers of particular utilities may pay for gains they do not directly receive. Some state commissions are seeking to take advantage of federal incentives to promote energy efficiency among consumers while finding ways to fulfill utilities' shareholder obligations. Also, renewable portfolio standards and the improving economics of wind power are influencing decisions and facilitating changes in the function of the grid. Other planners suggest that more end-use efficiency and distributed generation could alleviate additional transmission needs. In any case, real progress will require stronger integrated planning in order to build enhancements and to expand grid coordination once operations begin.

North American Reliability Corporation (NERC) studies show what is inadequate in terms of system reliability today. In recent years, there has been a dramatic increase in proposed transmission enhancements. Some states are also redefining the role of the transmission system without specific grid-related policy changes by adding wind capacity or high voltage lines independently. However, the recession threatens to constrict demand and slow infrastructure investment. Public utility commissions or utilities themselves may slow transmission investments even more, calling into question recent evaluations of the need for additional capacity.

Transmission plans delayed



Source: NERC

U.S. transmission miles actually built or likely to be completed from 1995 to 2013 fell behind miles planned.

But even with increased efficiency and reduced consumption, the system will remain constrained. Local interests often dismiss the importance of large scale transmission planning, and transmission has seen relatively little investment in the last twenty years. Property issues and environmental difficulties with siting, along with regulatory hurdles regarding cost allocation, make other solutions more attractive than new transmission. For example, new generation is often selected over new transmission because it contributes to job growth and economic development at the local level. Similarly, distribution investments give rise to local tax dollars, and single-state siting jurisdiction gives government officials factors they can control. With few economic forces behind it, transmission may remain underinvested.

In fact, the introduction of carbon reduction goals could create pressure for rapid switching among generators, reinforcing aspects of the existing system. With one-third the carbon emissions of coal, a fraction of the capital cost of nuclear, improved supply prospects and none of the intermittency issues of renewable, natural gas becomes an easier choice. Many utilities select new generation to meet demand, and natural gas offers a bridge toward proposed carbon-reduction goals without the big bets that accompany larger capital investments such as wind or nuclear. Greater reliance on natural gas would have the least influence on the need for grid enhancements.

Achieving the goals of the 21st century grid

Working with regional transmission organizations, state and federal regulators are exploring options to reduce congestion and associated fees by adding extra high voltage lines and building better interconnections to ensure resilience of power systems. Regional organizations propose price signals through planning that can help the market function. Transmission serves as part of an industry structure that sends appropriate price signals for efficient investments and operations. The result is a system of public and private partnerships that requires regional planning to implement federal policies locally.

While many consumers do not consider what is on the other side of the sockets in their homes, others are becoming more aware of transmission and electricity issues. The Obama Administration has raised the visibility of the design of an advanced transmission system, touting wind, solar and smart grid solutions. The potential for these options to increase U.S.-based manufacturing, to create jobs, and to improve the environment has more citizens following the industry than in the past. Shifting to domestic, low-carbon energy supplies provides positive environmental and social outcomes. The grid enables these benefits because wind and solar energy sources are located far from customers, and expanded use would require new transmission. As a result, some proposals support the broad socialization of transmission costs.

Some industry observers, however, believe that "clean" and "green" politicians and advocates infuse the debate with meaningless rhetoric that prevents real solutions. Often these critics recall the failures of the 1970's when politicians attempted to pick winning technologies during the oil crises. They believe the rationale for the 21st century grid needs to be quantitative rather than qualitative and that no action will be taken to transform the grid if it costs too much.

Market design for the electricity sector

Transmission must become a strategic aspect of grid operators' businesses as they look at their energy futures. Although the 2009 American Recovery and Investment Act addresses transmission and provides stimulus money for planning, it does not answer the essential questions to catalyze new construction. Legislative solutions, such as the energy bill currently before Congress, raise a critical set of questions regarding the role of transmission. Climate change policy and the expanded focus on renewables present a fast-moving array of subsidies, regulations and mandates that will affect transmission expansion. "Going green" can imply a transformation of the electricity sector and its regulatory structures, and that transformation introduces tremendous uncertainty. These factors have great impact on investment decisions.

Stakeholders consider deregulation and restructuring as either the problem or the solution. However, restructuring presents important options that allow regulators to keep up with fast moving markets. Entities such as Regional Transmission Organizations (RTOs), Independent System Operators (ISOs), the North American Electric Reliability Corporation (NERC), State Public Utility Commissions (PUCs), Public Power Authorities, and the Federal Energy Regulatory Commission (FERC) need restructuring to allow them to meet new goals for the American transmission system.

In 1992, the idea of regional transmission organizations challenged conventional wisdom on electricity markets. Open access and bid-based economics have grown since to cover 67 percent of the country. Some argue that the economic dispatch model should be expanded to 100 percent of the country's markets. Whether or not that would allow for smarter pricing for a 21st century grid, however, remains as controversial as the original introduction of RTO's.

Although not all market players agree that RTO's are needed to support efficient competitive markets, some argue that the advantage of RTO's can be seen in the options they provide for dynamic pricing and reliability pricing. Price signals can send investment messages that would support the growth of the grid. To accommodate expansion of the system, a hybrid approach that uses competitive pricing models while socializing some costs reflects the regional scope of interconnections while incorporating a cost allocation framework where beneficiaries pay. Mandates would create RTO's to manage the operation of networks and operate voluntary wholesale markets that would allow price signals to select technologies.

The balance of power—state versus federal authority

There are many opportunities to aggregate interests, but consensus will continue to be elusive as decision makers try to define clear goals that may help avoid solving state problems with federal solutions or vice versa. Regulation of the industry is necessary, but the paradoxes of balancing state and federal control will not go away. When a region agrees to core infrastructure development, generators gain the capacity to export power outside the region. That action then requires advance planning on a larger scale. If additional generation is added, regional markets will normally require additional capacity to transmit the power. State regulators can arguably fine tune these markets and take advantage of opportunities to build infrastructure more swiftly than Congress. But incremental growth of generation runs the risk that regional transmission might not be added with it. A local system that grows incrementally may not be as efficient as a regional or federal system that grows according to a fully conceived plan.

Competition has key stakeholders advocating for system attributes that keep them in compliance with regulatory definitions of allowable rates or reliable service. Too often, revenues resulting from new policy rules like RPS are insufficient to cover the cost of new lines, and externality costs have yet to be factored into cost-benefit tests. Some seek to revise what they consider to be outmoded regulation, while others suggest that market forces could define a successful transmission system. One source for guidance on how to move towards an advanced transmission system is the International Energy Agency (IEA). In 2007 the IEA offered a comprehensive review of market reforms that outlines best practices in governmental interventions in energy markets. Of course the real challenge lies in determining how to set prices so the market can respond.

From the national perspective, the transmission system can become a means to fulfill other priorities, such as national security, economic development and carbon reduction. Federal authority can take a top-down focus on transmission needs across state lines and can facilitate developing domestic energy resources. However, many states and local utilities seek to keep the state's prerogative to site facilities and solve reliability issues.

Stakeholders at the state level tend to focus first on connecting generators to loads within the utility's footprint. They add the minimum transmission required to satisfy immediate electricity delivery needs. New transmission requires a great deal of planning. It is difficult for planners throughout a multistate region to agree to proposed interstate plans when the states have not been involved, because the plans do not assess multiple impacts of new transmission lines. Increased uncertainty affects investment. Integrated planning helps to avoid this uncertainty by assuring affected stakeholders that all the impacts have been considered together.

Viewpoints differ on more than state versus federal control or market versus public solutions. Across the United States, Western and Eastern perspectives on issues exist as well. Western states tend to consider transmission from "source to sink," or generator to consumer. The Eastern grid has evolved into a much more complex web with many more interdependencies. In most scenarios, any new transmission provides at least some benefits to all generators and consumers. However, where those benefits are not apparent, stakeholder concerns can prevent progress on new or enhanced infrastructure investments. In order to make new transmission politically and financially feasible in the complex Eastern grid, identifying the beneficiaries is particularly important, although particularly difficult.

The two regions also face very different jurisdictional issues. In the East, private ownership along proposed transmission corridors creates land issues with many individual parties. This raises questions regarding appropriate FERC authority and eminent domain. In the West, 85 percent of land is owned by the government, requiring more engagement with the Bureau of Land Management, the Forest Service, and other agencies. Corridors requiring new transmission through Native American territories also raise questions about costs and negotiations with the affected tribes.

Considering electricity prices in different states and regions, one can deduce what role a national policy might play in encouraging a concerted effort to build. FERC tariffs implemented in 2005 created an incentive to invest in transmission. However, some argue that socializing those costs across multiple states made transmission essentially a free good and encouraged over-consumption. Distributed generation and energy efficiency might have emerged faster as solutions in the East if the real cost of moving electricity had been accounted for in prices. This perspective also lends itself to opposition to state level goals to develop renewable sources in favor of market solutions that maximize carbon reduction strategies. Market realities intersect with regulatory goals in inefficient ways. For example, as electricity providers struggle to deploy intermittent energy sources as mandated, their low-cost reserves are not dispatched to meet demand.

State-level utility planning and goal setting can influence a nationwide grid strategy in other ways. In May 2007, the Arizona Corporation Commission (ACC) unanimously rejected Southern California Edison's (SCE) proposed transmission line between Arizona's Palo Verde hub and Southern California. On one hand, ACC commissioners demonstrated the power of a state commission to prevent trading. On the other, they demonstrated the challenge of defining who pays for new transmission. The Commissioners were concerned that California would reap the benefits of Arizona's lower-cost generating capacity, while Arizona ratepayers would be stuck with higher costs. Despite the demonstrated need for new transmission in Southern California, without concurrence from the ACC, SCE abandoned the project.

The necessity of multi-purpose solutions for transmission planning can be understood in terms of the contradictory goals and policies that are evolving on the local and national levels. For example, carbon reduction goals may inspire statewide renewable portfolio standards; however, these standards are not sufficient to reach those goals. Energy efficiency standards fall into the same category. Market advocates contend that mandates are only necessary because regulators are not allowing consumers to receive the right information. They argue that unnecessary market interventions raise costs in addition to getting in the way of reducing emissions.

But some state regulators point out that transmission investment often reflects economic priorities more than carbon goals. There are many local and regional reasons to build new transmission, and those can also shape markets. In central Nevada, a proposed coal plant was postponed until carbon capture and sequestration becomes commercially available. Part of that postponed proposal included an interconnection between northern and southern Nevada. As a result, the state will struggle to achieve numerous goals. Without an anchor coal plant, the state loses the benefits of statewide economic dispatch. The state also loses the option to meet their renewable portfolio standard from the geothermal energy that will be trapped without a north-south transmission line. To get the federal government involved, the state can make a firm case for the economics of the line by linking the state's goals to the opportunity to harness the remote renewable resources for the benefit of the nation.

For such reasons, the role of the FERC will become increasingly important to the future of the grid. Without clarifications of the FERC's authority, uncertainty about the socialization of costs will hold back system investment. The possibility that transmission costs could be allocated to all beneficiaries within an interconnection poses what some observers consider an unacceptable socialization of costs. Traditional cost causation principles define beneficiaries as entities that benefit economically from a project, distributing costs relative to the level of their economic gain. Determining the criteria for such cost allocation remains difficult.

II. *Who Decides? Who Pays?*

The foundation for future transmission will rely on agreement on these key issues: who decides on whether to build, where any new transmission will be sited, and who will pay? These questions present controversial alternatives that are the subject of much scrutiny in energy legislation being considered in Congress. Although reaching consensus will be difficult, the climate imperative has thrust transmission issues into greater public awareness. At this unique time, utility operators and regulators are presented with the prospect of aggregating ideas and identifying a shared purpose that facilitates the cooperation and compromise needed to upgrade the existing grid to a system appropriate for the 21st century.

This chapter describes:

- Decision-making in regulated and competitive markets
- The role of the Federal Energy Regulatory Commission
- Infrastructure investment in the face of transformational challenges
- The value of transmission in addressing climate change

Decision-making in regulated and competitive markets

Controversy over the appropriate role of government in the electricity sector has given rise to varied characteristics in both regulated and competitive markets around the country. Among the differences are the decision-making practices. Deregulation sought to create incentives for cost cutting and new generation; however, consumers have failed to see lower prices. With interstate transmission connecting utilities and customers in regulated and competitive markets, it becomes difficult to let markets alone decide how to maintain and expand the transmission system. Providers, their regulators and customers inherited an infrastructure system largely created by vertically integrated, monopoly utilities. Now, they must renegotiate how that infrastructure is used, improved and enhanced.

Although they serve less than 30 percent of the total customers in the country, there are more than 2000 electric utilities owned and operated by a government entity. The majority are operated by cities and towns; others are operated by public utility districts or a consortium of public systems within a state. State governments have created fifteen of their own utilities. Their frequently smaller size makes many of these public systems more dependent on third-party transmission services than larger, investor-owned utilities. As a result, these utilities tend to push for greater proactive planning on infrastructure improvements rather than relying on market-based investment decisions. Customer-owned co-operatives, despite owning extensive transmission lines, are also often dependent on others for transmission. The majority of customers, over 100 million, are served by investor-owned utilities, which tend to be transmission owners.

Two-thirds of the nation's customers are in competitive wholesale markets managed by RTOs or ISOs. These markets use locational marginal pricing to manage the use of the transmission system. Marginal pricing is the idea that the market price of any commodity should be the cost of bringing the last unit of electricity—the one that balances supply and demand—to market, and it can result in very high prices when congestion occurs in particular locations. Arguably this removes the incentive for companies that benefit to undertake infrastructure investment that would reduce congestion. Also, if their region has sufficient electricity production locally, they have little incentive to improve interconnections with adjacent regions.

This intersection between public and private entities and regulated and competitive markets becomes more significant as the role of the transmission system evolves in the 21st century. With all generators seeking to deliver their product to consumers served by various retailers, a hybrid system becomes inevitable. Decision making will be responsive not only to market signals but to central planning as investor-owned utilities, co-ops and public utilities harmonize their use of the grid.

To accommodate these developments, the FERC encouraged the creation of Independent System Operators to help utilities to satisfy the requirement of providing non-discriminatory access to transmission. Later, the formation of Regional Transmission Organizations encouraged voluntary participation in administering grid operations on a regional basis. But increased reliance on long distance transmission continues to challenge the segregation of regulated and competitive markets. As the role of the transmission system evolves, so too must the way decision making takes place.

The Southwest Power Pool (SPP) provides an example. A group of 54 members across 9 states, the SPP represents investor-owned utilities, municipal systems, cooperatives and others as a Regional Transmission Organization. Its existence reflects a significant achievement; it took SPP three attempts just to form its RTO. Its balanced portfolio approach avoids potential disputes by evaluating the benefits of a group of upgrades rather than making decisions on a project-by-project basis. This increases the opportunities for negotiated outcomes that distribute the cost of projects across multiple parties even if they may benefit one zone more than others.

Without regional planning, allocating the costs for new facilities promised to become a contentious process. But the formation of the SPP allowed industry participants to take ownership of issues and succeed by working on necessary reliability upgrades first. The success of this negotiated solution has SPP now tackling riskier investments in the integration of renewables and an extra high voltage overlay.

The experience of the SPP demonstrated how markets and planning could work together. The difficulties were not in transmission planning, but cost allocation. Once the stakeholders had agreement on how to address payments for improvements, planning could commence. However, decision-making still lags behind transmission needs, with scenario planning that is still reactive.

While voluntary organizations are achieving success, agreements are often not binding. State planning committees, separately incorporated, cannot preempt state regulatory authorities. So while active facilitation is a meaningful process, the extent of success of those plans relies on the authorities of state commissions. Industry leaders are considering ways to make those plans binding, as the approach requires some obligation to implement solutions.

The Kansas Electric Transmission Authority Act passed in 2005 requires participatory planning to define needs, cost allocation and recovery with regional third parties. With state renewable portfolio standards in place, how interstate electricity imports and exports are measured against these standards will become relevant. The dilemma comes as regional planning could appear to be dictating to state commissions the terms for their statewide RPS. However, as Congress is considering a federal RPS mandate, it may become more attractive for states to sign off on regional plans and make federal pre-emption less likely.

The role of the Federal Energy Regulatory Commission

The FERC is waiting for Congress to answer the threshold question: “What are we planning and siting *for*?” SPP and Texas were able to design answers to this question regionally. On a national level however, questions remain regarding renewable portfolio standards, electric vehicle systems, green job creation and energy security. These questions suggest many of the ways to plan, site and allocate costs for an advanced transmission system.

During the evolution of the regulated market structure, no one expected requirements to move electricity across the country. By the time competitive markets emerged, long distance transmission was becoming more commonplace. So-called "long-distance" transmission was typically used for load balancing or to reduce reserve requirements for commonly owned or neighboring utilities, or to move power from hydroelectric sites to load centers. Energy legislation currently being considered proposes new roles for federal planning, and private and public participants in both regulated and competitive markets will be active in shaping the solutions.

Current U.S. House and Senate bills take different approaches to planning, and to siting in particular. The bottom-up approach of the House would keep the same entities involved at higher levels of planning, while the Senate supports interconnection-wide planning that is more top down. In fact, the Senate bill goes so far as to consider the benefit of joint ownership to reduce financial risk if the FERC is granted planning responsibility.

The FERC has been empowered with other ways to facilitate transmission planning and construction. Because transmission providers seek incentives to move power generated by others, government engagement can offer lower cost financing for system improvements. Siting assistance from FERC has developed in the form of pre-emptive authority that, although restricted by the courts, allows the Commission to overrule state decisions to object to new transmission along regional transmission routes of national interest. This authority to backstop interstate transmission needs will test the willingness of states to collaborate with regional planning efforts. States need to know how to consider broader benefits and cost causation as they define just and reasonable ratemaking. Some advocates believe FERC backstop authority will help reconcile legitimate state and federal interests. They claim state commissions will operate differently if they know federal intervention is foreseeable if their own resolutions are not achieved.

Regardless of the specific goals that are defined for the national electricity system, the FERC faces particular challenges in implementation. For example, pressure will remain to ensure that market driven planning works, even with national strategic goals. Linking the operations of RTOs and ISOs with municipal and public utilities must ensure participation by all stakeholders. This includes better integration of merchant transmission projects, which to date have not participated in regional processes for interconnection-wide planning.

Many system enhancements are encumbered by local transmission plans that provide no obligation to construct infrastructure for larger regional needs. A central authority could help direct right sized enhancements, although this entity would need to overcome concerns that such centralized planning would interfere with state requirements, native load service requirements and planning needs. Siting continues to pose the thorniest of problems. Statutory disregard for regional benefits results in opaque, costly assessments of project alternatives that incorporate such broader benefits. Even with backstop authority, the FERC can offer little support when siting issues inhibit transmission improvements.

Potential solutions are under evaluation:

1. Clarify and improve the FERC's siting process.

   Congress could improve siting processes by requiring cooperation among voluntary participants in a region. This would allow existing organizations, like RTOs and public service commissions, to maintain control but would foster common siting processes. Formally, state governments in New England already do this, and interstate compacts provide mechanisms as well. Pre-emptive authority could be avoided with new committees or through the FERC's regional offices.

2. Redefine backstop authority.

   To enable development of new assets, single states must be prevented from blocking regionally beneficial projects. Defining the FERC's role as a catalyst, it may be feasible for states that are net beneficiaries to compensate other states. This has been demonstrated to work in Wisconsin. The disadvantages to federal backstop authority lie in transferring massive amounts of regional detail to a federal agency for an inherently local siting process.

3. Allow the FERC to roll in rates over larger regions. RTO's and ISO's have provided easy-to-calculate ways to roll in rates and broadly allocate costs. The benefit to sub-regions aggregate over time and spread costs to many to get regional transmission built.

The Energy Policy Act of 2005 calls on the FERC to conduct "backstop" transmission siting if a state does not meet certain criteria. However, that authority to overrule state decisions denying applications has been limited by a U.S. court of appeals. The "Piedmont decision" regarding new transmission through the Adirondacks raises concern that interstate commerce could be blocked. The backstop authority helps to ensure the reliability of the national grid system. By designating a central authority on essential transmission corridors, the risk of single entities making isolated decisions that do not account for the full consequences can be avoided. Although even traditionally locally or regionally focused utilities support FERC backstop authority, this will remain a flashpoint for controversy until national goals for transmission infrastructure are defined.

Increasing the FERC's role in maximizing the benefits of the electricity system could open the sector to more than just increased use of renewable resources. Optimizing the grid for interconnection-wide transmission planning could allow for high priority transmission of 340KV or higher—the sort of electric backbone to move power from distant locations to power-short load centers. The federal government must define its goals. Efforts to ensure reliability while providing lowest cost electricity cannot survive unchanged along with goals to deploy low carbon resources.

Infrastructure investment in the face of transformational challenges

Interconnection of the national electricity system can be understood as fully connecting the East, West, and Texas, or just as strengthening the existing interconnections within regions. Both options can open new corridors for renewable sources of electricity and offer balanced portfolios in larger regions. In either case, an advanced transmission system will require planning that alleviates siting obstacles and fairly allocates costs. Restructuring brought efficiency to operations and dispatch. While these improvements did open the market to competition, however, they did not bring prices down in an era of rising fuel prices.

Market mechanisms have proven to go only so far in updating and advancing the country's existing transmission system. The remaining challenge arises from policy-related goals that could transform the electricity sector to operate in unexpected ways. Policies arising from environmental concerns, technology leaps, and national security goals each promise significant adjustments to how electricity is produced and delivered.

While the specifics of implementation are quite varied, certain goals require significant transformations to the electricity sector supply chain. These goals introduce new relationships between consumers and suppliers and create new markets for related products. Examples are:

1. Reducing demand and increasing energy efficiency;
2. Enabling green jobs and carbon-free generation through renewable resources; and
3. Empowering consumers through smart metering.

In each scenario, regulated and competitive markets alike will face choices regarding how to allocate costs, site facilities and establish planning guidelines.

1. Reducing demand and increasing energy efficiency

   Energy efficiency and demand reduction will reduce the load a utility is obligated to serve. This could reduce the need for an enhanced transmission grid. As a result, infrastructure investment may need to accommodate load balancing relative to decreasing loads. Additionally, distributed generation could reduce demand as consumers install generators at their points of use. If these generators are tied back to the grid, operators will also need to adjust their systems to accept additional supply. In each case, different roles for transmission will require different technology solutions and new financial arrangements. Long term supply contracts will have to be reevaluated and pricing regulation in regulated markets will require adjustment.

2. Enabling green jobs and carbon-free generation through renewable resources

   With the passage of legislation that puts a price on carbon, new job markets will rapidly emerge to meet increased demand for carbon-free generation. Manufacturers, renewable suppliers, and other low-carbon generators will benefit, and the coal industry and coal-dependent consumers will feel the cost. Thirty-one potential transmission projects designed to support renewable resources have been identified. This represents $21 billion of investment to transmit solar, wind, geothermal or biomass electricity.

   As renewable resources enter more markets through renewable portfolio standards or market demand, grid operators will have to face incumbent reliability problems in new ways. This will require strategic investment in infrastructure that had not previously been prioritized.

3. Empowering consumers through smart metering

   As discussed in more detail in the following chapter, smart metering can provide two-way communication between a grid operator and the consumer and can provide real time pricing at the point of use. This is a radically new relationship between consumers and their utilities. The quarterly visits from the "meter reader" will become a distant memory as new technology transforms how consumers consider their daily electricity usage. Smart metering opportunities will open new debates in addition to transmission siting and cost allocation. The proprietary or open architecture of information systems will present new issues regarding control and decision making authority. Also, the collection of consumer level data on electricity consumption will present new privacy concerns.

These three examples of transformative policy recommendations will be subject to great scrutiny over the next year. In smart metering, the opportunity exists for consumers to make more informed decisions about their energy use. As a result, in some competitive markets efforts are being made to empower consumers to choose renewables for themselves. Utilities are finding consumers will pay extra, and they want to give them access to it. In the Electric Reliability Council of Texas (ERCOT) region, planners recognize the need for an interconnected grid. With locales subject to hurricanes and ice storms, their web-like transmission system provides useful redundancy. They recognized their commodity risk due to the region's reliance on natural gas and took advantage of ample wind resources that could provide intervals of low prices in the spring to counterbalance the need to buy gas on the margin.

Recognizing that generators will participate if they can get their product to market, ERCOT determined to build where the wind blows, gaining support from the Public Utility Commission of Texas to complete transmission improvements sufficient to move over 18,000 MW of wind generation from west Texas. This decision is producing local economic development through the increased installation of wind turbines. The case demonstrates that transformative change is occurring in the electricity sector. But in this case, the motivation was price, not carbon reduction.

In regions where the mix of available resources may not justify the use of renewables, renewable resources can still offer additional value if stakeholders take a broader view. From this perspective, the jobs and economic development that the expansion of renewable energy will generate offer additional motivation for the integration of solar, wind and other variable resources. Future policy will help transform the transmission system by indicating to power providers that they need to include varied resources. Until that signal is clear, the most appropriate infrastructure investments are difficult to predict.

Transmission uniquely problematic

	Distribution	Transmission	Generation
Creates local jobs	✓		✓
Local tax revenue	✓		✓
Driven by local growth	✓		
Immediate benefits	✓		✓
Single siting jurisdiction	✓		✓
Aesthetically acceptable	✓		

Source: NERC

Unlike transmission, distribution and generation possess characteristics that overcome barriers to siting and local approval by creating local jobs and tax revenue.

Retail electricity sales amount to billions of dollars, and the cost of transmission enhancements is relatively small. Some industry observers argue that bickering over 50-70 cent increases in monthly utility bills should stop so the industry can begin solving larger national issues and implementing transformational solutions. They believe a national tax or fee could pay for the necessary transmission investment and spread costs evenly in a form of insurance that maintains the reliability of the country's electricity system.

The value of transmission in addressing climate change

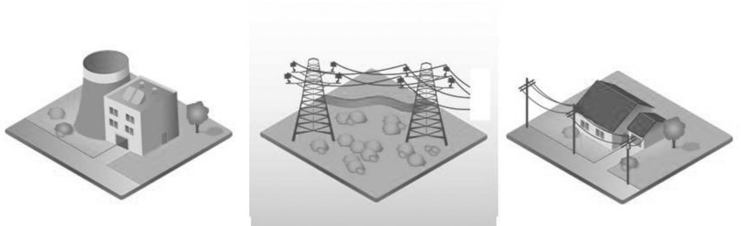
Power providers acknowledge that action on climate change opens up potential for significant and rapid changes to the electricity sector. Mitigation strategies to reduce carbon emissions have been under discussion for decades, but the United States is now moving closer to more specific restrictions that will affect prices. In addition to the increased use of renewables, two policies in particular would engage the electricity system in innovative ways to help achieve carbon reduction: advancing technology for the grid and moving to electric vehicles. These two climate change strategies pose great challenges and opportunities for the 21st century transmission grid.

Grid technology enhancements

The promise of the advanced technology for the transmission system has captured the attention of technology fans and mainstream media in recent years from the *Wall Street Journal* to *Wired* magazine. With the introduction of smart appliances and smart meters at the distribution level, efforts are underway by Google, Intel, Microsoft and other companies to introduce innovations in two-way communications and time-of-use pricing. These extensions of the smart grid concept inspire space age stories of nearly magical programmable appliances that signal to each other and their users, minimizing carbon footprints and maximizing leisure time.

With so little recent transmission investment, some advocates see an opportunity to abandon obsolete 1950's technology in a leap that introduces entirely new ways to think about the transmission and distribution systems. The possibilities are many. For example, advanced communications across the system could optimize capacity and enable variable sources like wind and solar on larger scales. Load balancing across regions could be simplified and the results of new, more finely tuned pricing structures could be measured. If carbon reduction is the ultimate goal, advanced technology offers a range of solutions to achieve higher reductions, faster.

Inherent characteristics of system components



Generation	Transmission	Distribution
5,000 plants	160,000 miles	Over 1,000,000 miles
65% of monthly bill	5% of average customer monthly bill	30% of average customer monthly bill
Employs approx. 120,000 people nationwide	Employs approx. 15,000 people nationwide	Employs approx. 400,000 people nationwide

Source: NERC

Transmission provides fewer jobs and accounts for a much smaller portion of customers' electricity bills than generation or distribution.

However, for electricity providers, transmission upgrades pose less attractive investments because of the risks inherent in siting and regulatory new lines. Although transmission is only five percent of the total cost of electricity to consumers, an undertaking as massive as replacing or extending existing transmission systems presents enormous costs. Commitment to national goals could provide the urgency needed to abandon incremental changes and revolutionize the grid.

The transportation sector

Electrification of the transportation sector is a transformation that will take place largely outside the jurisdiction of the principal electricity stakeholders but requires their participation to succeed. The automotive industry would take the lead, under federal guidance or in response to market demand. The transition from combustion engine vehicles would likely be slow as technology improves, costs come down, and consumer interest grows. Until market penetration of electric vehicles reaches some threshold level, the impact on climate change would be small. Long term it could provide meaningful reductions in carbon emissions, however, as one third of all emissions is now attributed to the transportation sector. To contribute to desired climate change mitigation goals, electric vehicles would need to "refuel" from a transmission grid that moves electricity from reliable low carbon generators. These topics are addressed in greater detail in Chapter 3.

Costs for any new transmission will be high. Developers face uncertainty that can alter net present value dramatically. The notion of who benefits is critical to the proper allocation of costs. Only if the definition of benefits is expanded to include environmental and security goals will all participants have reasons to more broadly share the costs.

III. Integrating Renewables and Electric Vehicles

The national policy goals assign new functions to the transmission grid that focus on the greater use of renewable energy resources. Renewable Portfolio Standards (RPS) and Plug-in Hybrid Electric Vehicles (PHEV) present two popular initiatives that require creative upgrades to the transmission system. In the future, the system will deal with greater use of wind, solar and geothermal in general. A smart grid can enable the expanded use of intermittent and inconveniently located renewable resources to meet the power needs of an increasingly electrified transportation sector. Nonetheless, to reach these goals, technological, regulatory and financial obstacles must first be overcome.

This chapter outlines:

- The outlook for wind energy
- The path to 20 percent RPS
- The impact of electric cars
- Data integration concerns

The outlook for wind energy

Wind power projects represented 35 percent of all new generation capacity added to the U.S. electricity grid in 2007. The outlook for wind remains strong in terms of new capacity and technology features to improve its utilization. Of the 110GW of renewables capacity that will be added, 80-90 percent is expected to be wind. Nonetheless, many power providers remain skeptical about the long-term potential of wind as a major contributor in the overall energy mix. Few systems in the world have achieved wind penetration levels greater than five percent. Policy and regulatory changes could address some of the concerns and improve wind's outlook by addressing the how the grid can be optimized for its use.

Changes would be needed to address local systems that cannot affordably integrate wind resources in the existing regulatory regime. In rural markets, weak distribution grids with less line capacity, long transmission distances and single phase operations challenge the integration of wind resources. Enhanced or new transmission is not affordable with small rate bases. However, policy changes tying wind deployment to goals beyond reliable and affordable electricity would motivate broader regional planning.

In addition to the distances involved in moving power from remote, windy places to customers, integration of this resource is complicated by its intermittent nature. However, renewable advocates contend that wind's variability is overplayed. Power providers can ramp up output from other generation sources on the system, which creates significant impact on some parts of the grid. Operators actively dispatch electricity throughout interconnections in response not only to variable sources but also to changing customer demand. In this sense, wind behaves like load on the grid. Not only does it rise and fall within hourly and daily time periods, but it is also non-dispatchable. These variables were managed with planning reserves for other generation forms before load forecasting became as precise as it is today. The operating and uncertainty costs of this type amount to less than 10 percent of the value of wind energy.

Although the variable nature of wind deters many small utilities and rural electric cooperatives, its potential to produce carbon-free electricity motivates new infrastructure investment. Expansion efforts to integrate renewable resources will require greater connectivity. By connecting load centers and aggregating generators, power system operators can manage variable resources and conventional generation plants over a wider area. Larger areas for load balancing can enable higher levels of variable resources in utilities' generation portfolios. This is accomplished by maintaining a large and diverse portfolio of generation options and a robust transmission system to bring them to market.

The cost and low capacity factor of wind as compared to nuclear or coal requires that utilities maintain adequate ramping ability and load following capabilities. Capacity factor measures the actual amount of electricity produced over time against the power that would have been produced with the generator running at its maximum capacity, 100 percent of the time. Requirements for ramping ability and load following are factored into all generation costs. However, wind energy's unique characteristics for transmission and production costs make it difficult to price. With adjustments to fix the market prices where wind is generated, long term capacity and locational markets will reflect adequate pricing. This is easier to do in RTO's and ISO's; however, the pricing models for wind must be improved for competitive bidding.

The Southwest Power Pool (SPP) demonstrates that wind energy can be attractive in competitive markets. Their new integrated planning process focused on demand for harnessing domestic resources that were isolated from load centers. As a result, they are building a grid that will benefit customers throughout their region for the long term. That effort will include planning for an extra high voltage overlay that will serve as a backbone to their system not only in Texas but reaching into the Eastern and Western Interconnections. This highway-byway approach is a major departure from traditional grid design.

Transmission planning will continue to evolve. Federal proposals for a national electricity backbone seek to provide a policy foundation for efforts to move large scale wind generation from the central U.S. to the load centers along the coasts. FERC backstop authority on large capacity transmission could help move these proposals forward. Advances on storage technology can also bring down costs and better utilize wind resources. The National Renewable Energy Laboratory's flexibility supply curve outlines additional options in terms of responsiveness and cost to improve strategies for wind integration.

In order to benefit from the use of wind energy, interconnection improvements are essential to bring about long-distance movement of the electricity from rural areas to load centers. High voltage lines are necessary to bring wind from remote locations, and congestion must be reduced to allow renewable generation to move to some markets. Beneficiaries along the route can be defined in many ways. In the SPP, proposals call for extra high voltage to be paid for by regional rates, while lower voltage lines would be funded with local rates. This bypasses the contradictory cost allocation methods that can vary from region to region. Without an equitable and affordable way to pay for it on a broader base, extra high voltage cannot be achieved and wind expansion plans can only succeed in isolated places.

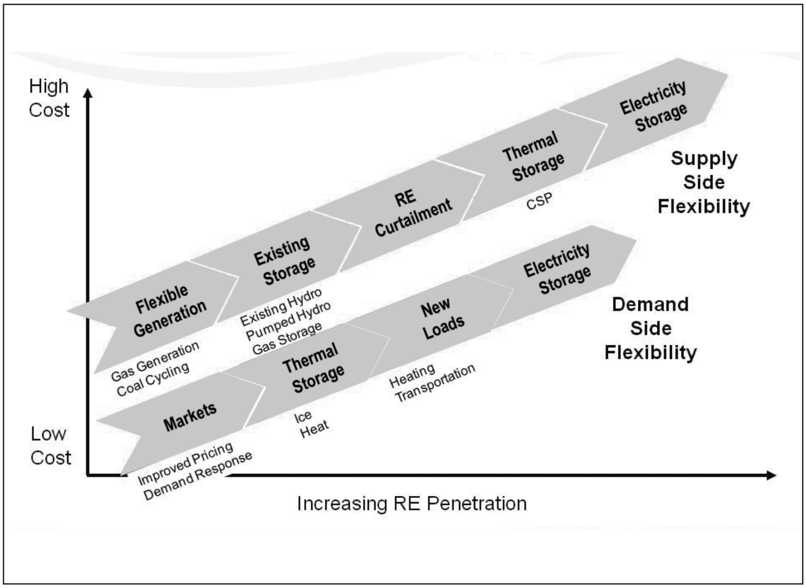
The path to 20 percent RPS

Currently 27 states plus the District of Columbia have voluntary or mandatory RPS policies. In most of these states, the policy sets a target percentage of renewable generation for the local delivery utility to provide, regardless of whether they generate it or purchase the renewable energy from others. Policy makers are also increasing the emphasis on energy efficiency, and some legislative proposals allow demand reduction to count toward part of the required renewables portfolio. Some legislators argue for inclusion of new hydropower capacity, and others for all non-carbon sources. The goal can be achieved faster with agreement on the purpose of the effort.

If the goal of RPS is to reduce carbon emissions and increase air quality, the answers will be different than if the goal is to create green jobs, jump start a new industry, or expand U.S. based manufacturing of energy equipment. Even a goal of increasing our reliance on domestic energy sources would inform actions in the near term that will have long term implications, although only significant electrification of the auto sector will have a major impact on oil imports.

As generators and distributors seek to address these questions, they pay close attention to characteristics of renewable generation that will require adaptations to their operations and cost structures. Challenges to effective integration of renewable sources include how to accommodate larger amounts of variable generation, how to price it, and how to move it affordably.

NREL's Flexibility Supply Curve



Source: NREL

As penetration of renewable energy increases, costs will rise. Thermal and electricity storage have the potential to influence both supply and demand for renewable resources.

Accommodating variability

The intermittency of wind and solar is not the only factor that adds variability to renewable resources. Consumer demand is problematic. First, it normally peaks when renewable resources are not as reliable. For example, March, April and May are the most productive months for solar, wind and hydro power, but highest consumer demand comes in July or August. Similarly, time of day offers variability as solar is often available on high demand summer afternoons, but wind isn't. Second, distributed renewable generation at the consumer level, such as small wind turbines, solar collectors and photovoltaic, contributes to additional load balancing the utility must accommodate.

Storage opportunities can relieve this problem, but that technology is not ready to deploy. Demand-side management and reservoir hydro or pumped storage systems offer currently available mechanisms that can alleviate the variability problem.

Pricing

Market structures have offered solutions to integrating renewables efficiently, such as short scheduling intervals that offer system flexibility. Large RTO's accommodate renewables with five-minute and ancillary-service markets. In discussions of mitigating climate change, renewable resources look like an attractive solution. However, a carbon price alone may not drive additional deployment. If natural gas and possibly nuclear turn out to be cheaper, carbon reductions may be possible without large scale implementation of variable resources. Nonetheless, advocates for the expanded use of renewables also argue that RPS can enable other policy goals. Manufacturing for new wind and solar products or the construction of high voltage transmission offers new jobs and domestic industrial growth.

Transmission of renewables

The remote locations of most renewable resources pose difficulties in mandating federal standards. States lacking their own indigenous resources tend to approach RPS cautiously. Meanwhile, solar and wind resources in the West and Midwest are left undeveloped until the plans are defined for the transmission required to move power to load centers.

Congestion and interconnection in the eastern U.S. present challenges to energy distributors that need to monitor and account for the sources of their electricity. When demand shifts from one area to the next, grid operators may shift the mix of electricity to favor a local generator. In interstate commerce, this situation raises questions regarding enforcement if a utility dips below the mandated RPS.

The key challenges outlined here reflect the reality that electricity flows according to physical laws, not legislative directives. Bringing renewables to market requires providing the transmission capacity to maintain the movement of electricity from source to sink and sending the market signals to incentivize competitive markets to do so.

RPS should be considered in context with other actions underway. For example, the proposed federal ban on once-through cool-

Towards RPS—Green Energy, the capacity element

	Wind	Solar PV (non-DG)	Solar Thermal	Geothermal
Capacity Value	15-30% prior CPUC Approx. 3-8% new CPUC	65%	71-80%	80-90%
Capacity Factors	18-20% historical <30% new turbines	18-24%	20-28%	80-90%

Source: California ISO; California PUC

Renewable Portfolio Standards take into account the large differences among various renewable resources. Capacity values estimate the contribution of resources to meet peak load and sustain reliability, and capacity factors estimate the output of resources over time. Different methodologies can result in different estimates.

ing technology in all coastal plants presents a challenge for power providers. The amount of operating generation that would be affected could be high, and some capacity in coastal states could be under threat. In light of such a ban, generators may have to consider alternative generation options located elsewhere that would cause significant rebalancing of the grid system.

The impact of electric cars

The increased use of renewables and the introduction of new electric cars could present a radical transformation to the electricity system. While consideration of the future electrification of the transportation sector is necessary for near-term electricity infrastructure development, it is likely to be at least another decade before the U.S. achieves a significant shift away from combustion engines. First, there is a need for adequate charging technology for vehicles. While electric cars have existed for many years, commercialization has not been achieved largely because of battery prices and performance. Second, the possible penetration rate for these vehicles must be assessed based on the manufacturer's outlook, customer demand and feasibility. Third, evaluation and assessment of what impact these cars will have on the transmission system will be essential to informing required transmission upgrades. However, if one considers the history of technology achievements in a compressed period of time, it is possible that major changes could take place as soon as the transmission system can handle the new variable load of electric cars.

Technology

There are a variety of ways that electric cars could gain momentum in the marketplace. There is a small existing market of electric vehicle drivers that could be expanded, and a breakthrough in battery technology that increases range and battery life would inspire new interest. Manufacturing developments that improve price and scalability of production also present opportunities for growth. Industry advocates see that today's electric cars are not competing with the old cars consumers own today. Instead, today's electric cars compete with the newest technology.

New technology includes different types of electric vehicles and five options for charging. Arguably, Nissan has the most promising program in the near term, with the largest estimate for consumer use and a retooled plant in Tennessee capable of meeting demand. GM and Ford have programs as well, and Chrysler has worked with five utilities to explore deployment options.

New technologies are being introduced in pilot projects around the country. Battery electric vehicles (BEVs), also known as electric vehicles, such as the model by Nissan, run exclusively on electricity. Plug-in hybrid electric vehicles (PHEV) feature an internal combustion engine that directly powers an "on-board generator" for electric drive.

In addition to the types of electric energy systems for vehicles being introduced, battery technology enabling these systems is also evolving. Currently, standards work is being done on four types of vehicle charging options including:

- Level 1 - 110/120V AC
- Level 2 - 220/240V AC
- Level 3 - 440V AC and higher
- Direct Charging – High Voltage using DC

Opportunities may emerge to improve how electric cars interface with the transmission system. High speed chargers on the street or in parking garages could prevent load balancing challenges when drivers return home and expect to charge their vehicle at peak hours. Additional options include incentives or technologies to have people recharge in the middle of the night instead of when they arrive home.

Markets

As estimates of the size and timing of consumer markets for electric vehicles become more precise, companies can invest more in reducing costs. Until technology advances are achieved, size of the market will be limited. Currently, some of the research and development money being put toward electric cars is to evaluate the business case. Businesses and governments are looking for ways to facilitate the required infrastructure to promote technology adoption. Who will install that infrastructure has not yet been determined. Some believe it will be utilities; others see opportunities for new businesses to do it. Whether government intervention is required and whether it should be done federally or at the state or local level remain to be seen.

Some new electric vehicle purchasers have been surprised when their first electric bill arrived. A typical car in the current fleet draws an additional 730kW hours, about the same drain as a home air conditioner. As a result, the electric car's operating costs can serve as a deterrent. Some utilities are considering tiered payments such as those used in Italy and other ways to charge that will incentivize use of these vehicles. As this market expands, the distribution design system will also be important to prevent local transformers from maxing out.

Transmission impacts

Standards for electric vehicles are among the first order of concern for power distributors. Utilities need to know that infrastructure technology can allow drivers to move their vehicles and always have charging capabilities within range. Currently, some electric vehicles require large installed systems, a sort of home base, where they can plug into the requisite equipment to recharge. To expand recharging options requires industry-wide codes and standards, including electric codes on charging systems and interconnection codes for utilities, cars and suppliers. A uniform approach will be essential to long-term success. Already too many utilities are unprepared and cannot answer consumer questions about their new electric vehicle when they arrive home ready to plug it in for the night.

When consumer demand increases for electric vehicles, grid operators and utilities must be prepared to optimize grid utilization. Some utilities have looked at the impact of the cars on their system. One determined that even in the highest penetration scenario of 1.6 million vehicles, they would account for only 11 percent of their total load. However, they have confirmed that these vehicles cannot charge on peak. Drivers who want to drive to work and plug in during the day could collapse the system. Consumer education and incentives will have to be priorities.

The Pacific Northwest National Laboratory issued a study that suggested electric vehicles could be a new resource to the grid, not just new load. Anticipating an ambitious 16 million electric vehicles on the road by 2030, the scenario suggests that the power of those batteries could offer terawatts of battery cranking capacity. Theoretically, this capacity could offer additional electricity that could be dispatched quickly, similar to the fast action of today's peaking plants. In effect, electric vehicles could help meet the peak demand instead of threatening it. However, this two-way functionality of electric cars is far from commercialization. Nonetheless, the scenario does raise important questions about energy storage—should it remain at the source or move to the consumer? Storage at the generation source makes the most sense today.

In the context of a cap-and-trade system, industry observers question who will get the carbon credit for the plug-in hybrid. It could be the consumer, the auto manufacturer or the power company. From a broad economic standpoint, the uncertainty of cap and trade does not make the market system for reducing carbon attractive. Those who view climate change as an urgent issue to be addressed with rapid carbon reductions observe that inattentive electrification of the transportation sector could simply move carbon emission from the urban tail pipe to the rural smoke stack.

Data integration concerns

Transmission and distribution already rely on extensive data integration. An advanced transmission system will better integrate communication technologies to improve information exchanges across the system. The use of modern communication software and internet applications in the electricity sector will present new ways of managing information in such areas as load balancing and long distance transmission. At the generation level, it will improve efficiencies of variable resources.

For example, the North American SynchroPhasor Initiative introduced monitors that could take precise grid measurements. These high speed monitors produce time-stamped data that can be shared with different utilities to give a comprehensive overview of what is happening throughout an entire interconnection at a specific point in time. These measurements can indicate where the system is stressed or how the system can integrate new resources. The technology allows the grid to give feedback to operators that can trigger corrective maintenance, allow for automation of certain controls, or increase system throughputs.

Smart meters exist at the consumer level and offer another example of how communication will become an important part of the future transmission system. They allow customers to monitor real-time pricing and provide data to the utility on usage patterns that suggest potential efficiency gains. To implement them effectively, power producers and distributors are working to determine what electric vehicles and smart appliances need from the grid. Industry leaders agree that taking a smart meter and retrofitting the transmission system to use it will not work—the technology needs to be designed for the system.

Using the transmission system to empower national environmental, economic or security goals will become more feasible as advanced technology becomes available. The key is to imagine the world the infrastructure will make possible and then figure out how to get there.

The business models under evaluation for advanced transmission-communications technologies emphasize two models for two-way communications. The first requires interoperability standards that would engage multiple organizations and facilitate dynamic pricing. In this assessment, remote monitoring doesn't count. Others suggest it does not matter what protocol or architecture is used as long as it provides a two-way look at electricity use and pricing. These advocates use the ISO experience to illustrate that as long as it is two way, they can set up a multi-node network that connects many-to-many, without an open architecture.

IV. Distribution and Demand-side Management

The transmission system cannot reach its full potential without attention to distribution. The interrelatedness of long-distance transmission and local distribution requires right-sized, right-located investments in the energy system. That means evaluating the potential impact of "behind the meter" efforts that can improve reliability, create green jobs and meet environmental objectives.

This chapter explores:

- Efficiency re-envisioned
- Necessity-inspired innovation
- The technology of a smart grid
- Securing an advanced transmission system

Efficiency re-envisioned

As utilities re-envision what the industry looks like, they are aware they must meet energy demand affordably while reducing carbon emissions. Conventional answers have emphasized clean generation options, but these solutions do not address today's challenges completely. As decision makers evaluate the role and responsibilities of the 21st century grid, they must also take into account the use patterns at the end points for electricity distribution.

Effective transmission planning requires consideration of electricity use from source to sink. The interrelatedness of consumer consumption and generation requirements offers tremendous potential to improve grid reliability and enable national goals. As a result, many power providers have begun to consider options to influence aspects of the transmission system that extend “behind the meter,” directly into the homes and businesses of consumers.

When the United States faced shortages of oil products in the 1970’s, new attitudes about energy use emerged. From conserving resources by using them more carefully to extending resources by maximizing their useful outputs, energy efficiency has become a daily part of American lives. New approaches to transmission and distribution infrastructure present additional ways these principles will inform the future of the electricity sector.

The varied tactics to improve the outputs of long distance transmission and local distribution can be grouped into two categories:

- Energy efficiency and demand reduction
- Resource utilization

In both instances, actions can be taken anywhere along the electricity supply chain to improve outcomes. All stakeholders—generators, operators, owners, regulators and consumers—can participate in promoting system improvements for energy efficiency, demand reduction and resource utilization or revolutionize how the transmission system works. Consumers in particular play an essential role in this approach. In order to use their assets more effectively, power providers must engage end users to make consumption more efficient and transparent.

Energy efficiency

Energy efficiency can be achieved in many ways; consumers may reduce energy use at peak, purchase energy efficient appliances and windows and install compact florescent bulbs. Studies show that consumer behavior has been difficult to motivate. Utilities seeking better ways to influence demand have given rise to demand response and reduction programs.

Demand response and reduction differ from energy conservation. At the consumer level, measurable energy efficient actions include technological solutions such as programmable thermostats, compact fluorescent lightbulbs, light emitting diodes (LEDs), high efficiency Energy Star appliances, thermal energy storage, and insulation. Power providers seek to better understand their customers' actions to improve forecasting on other available efficiency gains. Surveys and focus groups by industry leaders confirm that consumers are not motivated by calls for energy efficiency. They expect electricity to be available as long as they are willing to pay for it, and they are not willing to pay too much. Behavioral economics underscores the difficulties of utilities in determining how to motivate consumer behavior. Programs to reduce demand have been deployed to help manage peak loads.

In markets where transmission is congested or stressed during periods of high demand, power providers have educated consumers on options to reduce demand in order to help maintain the system's reliability. The inconsistent participation of consumers when crises are forecast has generated creative ways for power providers to send more compelling signals. "Price responsive demand" relates to how electricity pricing can influence consumer behavior. From peak load shifting to smart metering, options to inform customers of real-time prices for their electricity are expanding. But the subtleties of consumer price responsiveness are great. One municipal utility learned that giving feedback to customers on their overall electricity usage resulted in increased demand. Initially they added information to each monthly bill that indicated whether the household's consumption was above or below average. After a few months of receiving this information, below average households began using more electricity. The utility responded by adding emoticons to the bills—happy faces for below average consumption and frowns for above average—and the intended demand response was achieved.

Consumer decisions impacting energy use are largely incidental to system-wide efficiency. Economic analysis of initial energy efficiency programs in Ohio demonstrated that consumers were not participating. Consumers opted to pay higher prices rather than change their behaviors. They preferred to conduct daily activities normally at a higher price than shift electricity intensive tasks, like running dishwashers and washing machines, to off-peak demand periods. In California, PUC-approved efforts to improve customer communication helped to engage 30-40 percent of Southern California Edison's consumers in pilot programs. However, when a heat wave called for customer participation, only 6 percent responded. The difficulties of forecasting consumer behavior threaten the stability of grid operations, and industry planners are reluctant to use capital in ways that cannot reliably achieve demand reduction goals.

Across the country, regulatory requirements and market realities pose additional challenges. Additional available capacity resulting from demand reduction drives down spot prices that would otherwise evoke a demand response. Energy efficiency can drive down overall energy demand while utilities remain obligated to maintain higher levels of reserve capacity than necessary. The transmission system today is built on the assumption of inelastic demand with prices set by generation. In addition to addressing individual power providers' needs as a result of changing consumer behavior, coordination of wholesale and retail markets also has to be addressed.

The Public Utility Commission of Ohio is working to implement aggressive new energy efficiency standards to reduce consumption 22 percent by 2025, to a level lower than 2007 consumption. Their phased approach characterizes the host of energy efficient tactics available throughout the industry. The program looks at ways to reduce peak demand both with and without technology interventions. It depends on being able to broadcast price signals to consumers and, in the long term, employing smart devices from producers like Whirlpool and GE that can respond intelligently. It introduces three generations of consumer behavior reforms and adds increasing levels of commitment and investment as they proceed:

- 1st generation: Introduces water heater controls to enable consumers to reduce demand and respond to dynamic pricing.

- 2nd generation: Removes RTO barriers to price responsive demand such as requirements for carrying capacity and planning reserves for demand that would not exist at higher energy prices.

- 3rd generation: Provides capabilities to interoperate complex systems and accommodate new controls over various transactions, creates an open architecture for third party innovation and facilitates the development of distributed intelligence in the grid.

Each step of this process introduces actions to the retail level that bring consumers into this market place. The plan transitions to decentralized coordination that utilizes smart devices at the point of use and allows for assigned actors to affect the system at every point of electricity distribution. The implications of this rollout plan are that aggregated actions by consumers, providers and generators will create a more efficient and reliable transmission system.

According to EPRI, energy efficiency has the potential to reduce 22 percent of the forecast demand growth by 2030. Other studies show even greater gains, although many of these gains are not achieved at the point of end use. While they are an important factor in the equation, aggregated household demand reductions are not equivalent to the opportunities presented earlier in the supply chain to improve the efficiency of the system.

Asset utilization

Capacity utilization measures the rate at which potential output levels are achieved. In terms of the 21st century transmission system, that factor relates to not only the generator's ability to maximize output of power production, but also to the grid operator's ability to optimize the movement of electricity from available sources to existing demand. The greatest stresses on the grid come at times when peak consumer demand cannot be met either through increased transmission or production. Therefore, some industry leaders believe the best solution is to rely on consumers only to flatten peak demand while more significant investment is made in improving the efficiency of the system higher in the supply chain.

How to make it happen:

- Smart meters: Installing meters at the customer level that allow them to monitor and respond to real time pricing.

- Smart grid: Improvements in distribution at the local level, such as advanced fiber optics, offer promising ways to replace aging infrastructure and integrate new technology.

- Interoperability: Companies like IBM, Cisco, Microsoft and Google have plans to help energy providers pass data back and forth across the electricity supply chain.

- Back office system: Utility systems currently gather data once a month and send it to customers, but many are looking at ways to collect on hourly or 15 minute intervals. Data manipulation and security updates will be essential to this more transformational change that is underway.

With each of these options, the total transmission system increases its capacity utilization, enhancing its ability to shift load and control distribution.

Necessity-inspired innovation

If the United States is going to reduce carbon by 80 percent by 2050, an increasing price on carbon must be imposed to spur investment and innovation. Power providers cannot change the infrastructure overnight, and today's grid already reflects generations of necessity-inspired invention. However, the electricity sector has not optimized to the degree other industries have, providing greater opportunities for improvement. Other industries face much higher costs to revise their operations as they have already optimized their processes. The oil refining industry has a capacity utilization of 93 percent and the airlines industry 73 percent. Utilizing only 44 percent of its current capacity, the electricity sector has more opportunity to reduce emissions at lower cost. As a result, electric utilities may be able to reduce greenhouse gas emissions more cheaply than other industries and sell credits to industries with fewer opportunities.

Utilities are investing for the long term by working with consumers now to achieve interesting results. For example, California heat storms stressed local distribution systems in 2006 and 2007 as consecutive days of temperatures over 100 degrees Fahrenheit had air conditioners on full blast. The local operator prevented circuits from shutting down by cycling air conditioners. The program engaged consumers and shared the burden across the system, allowing the operator to control demand. Energy efficiency and demand reduction are considered low-hanging fruit in terms of necessity-inspired innovation. But getting usage patterns to change is not easy.

Even in commercial settings where businesses could achieve significant cost savings, room settings are maintained at 66 degrees. If the profit-oriented business sector is not ready to make simple changes, industry observers question what real impact these programs can have. One successful program offered consumers an efficiency program they could opt into. Participants shave peak demand for the system, moving their consumption and saving 10 percent on their bills. But while their costs went down, their demand remained—they just bought electricity at different times. If the goal is to achieve carbon reductions, different efforts are required.

The National Rural Electric Cooperative Association explains that their members control 6 percent of their peak load. The innovations allowing for this level of control were the result of unique characteristics of co-ops. With relatively small utilities with small staffs and a diverse mix of suburban and rural markets, co-ops serve 42 million people in 47 states and control 42 percent of the nation's distribution lines. Despite these large numbers, co-ops serve an average of 7 consumers per line mile. The ownership by their customers presents unique opportunities for these utilities, and large scale investments in innovations are taking place. For example, Basin Electric Power in North Dakota is exploring carbon capture and sequestration. In Indiana, the Wabash Valley Power Association is investing in integrated gasification combined cycle technology. PowerSouth Energy in Alabama is using innovative compressed air energy storage, and the Golden Valley Electric Association will demonstrate nickel cadmium batteries on the utility-scale.

Utility scale energy storage is an innovative way to improve the efficiency of the overall transmission system. Storage supports overloaded substations and helps meet the peaks in demand by making electricity available to the grid even when generation cannot bear the full load. It also improves the potential for integrating solar and wind generation by making them dispatchable at all times.

Whether to fulfill the need to reduce peak demand or reduce carbon impacts, energy efficiency programs will likely play a lesser role than these other innovations in meeting goals set out for the 21st century transmission grid. As shown in Ohio and California, energy efficiency has not inspired highly motivated behavior. In fact, market research shows that energy efficiency and conservation are perceived to be sacrifices. Nonetheless, consumers do respond positively to messages about not wasting resources. Consumers will make efforts to save money and not waste energy; however, electricity will continue to enable their essential activities and maintain the standards of comfort they expect.

Acknowledging this distinction between efficient use and waste reduction, many power providers strive for solutions that make energy efficiency a back-of-the-mind issue. Rather than requiring consumers to think continually about demand reduction or energy efficiency decisions, electricity providers are finding technology that allows consumers choice while keeping responsibility for system-wide goals within the industry's control.

The technology of a smart grid

Terms to define an advanced transmission system do not always reflect the variety of alternative solutions facing decision makers today. To some, a "smart grid" refers to an advanced transmission and distribution system that integrates power systems with advanced communication infrastructure. It enables two-way communication and supports applications that allow for new forms of interaction between stages of the electricity supply chain.

The benefits of such a smart grid are numerous:

- Defer generation investment decisions
- Empower consumers to control their energy bills
- Receive timely feedback on energy costs
- Reduce often regressive cross-subsidies in flat rates
- Mitigate potential market power
- Enhance system reliability: price responsive demand creates beneficial feedback as price increases cause demand reduction
- Improve predictability of demand and power flows for operations
- Improve distribution system reliability
- Reduce outage time and condition-based maintenance
- Reduce emissions through lower energy requirements
- Substitute demand response for generators providing ancillary services

- Account for transmission line losses
- Create a platform for innovation

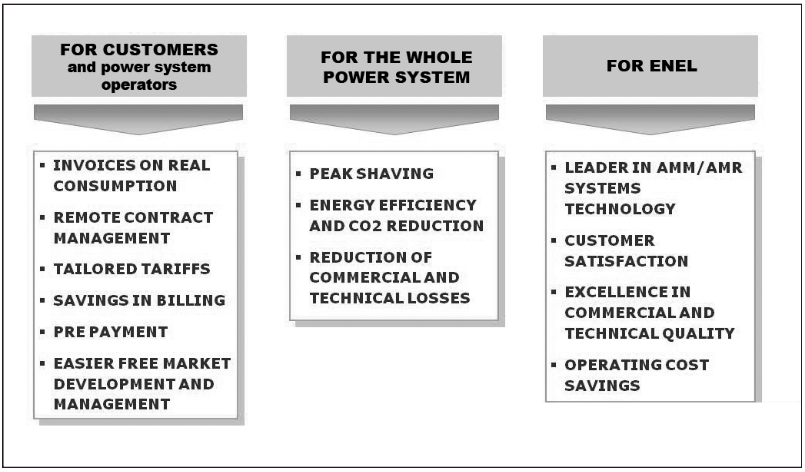
Even when consumers see opportunities to reduce their bills, they need options from their power providers to meet their needs. Electricity is a necessity that enables too many other consumer behaviors for usage decisions to be based on price alone. As a result, some providers are using a smarter grid to transition to "smart rates." Sometimes this simply refers to the use of smart meters; however, new technologies are improving what can be communicated and using smart meters for more than demand reduction. One pricing strategy divides generation prices into component parts and designs hedges and price structures that can accommodate different consumer needs.

A precursor to today's smart meter technology, the low bandwidth "turtle meter," named for the shape of the meter, developed out of the necessity for co-ops to reduce the number of truck trips to service their territories. The Automated Meter Reading (AMR) provides two-way communications for improved operations and has introduced Advanced Metering Infrastructure (AMI) to half of all co-ops. The experiences of these power providers in implementing this technology illustrate the compromises needed nationally to avoid costly software interfaces.

Italy is far ahead of the United States in fully digitalizing their grid. Their experience began with efforts to design a smart meter that would cut costs in field operations. Like American power providers, Enel recognized they would need an efficient machine that would deliver returns on their investment. The initial program was targeted only on reducing costs of remote management operations: activations, contract management and contract termination. This soft introduction was not controversial and easy to implement among consumers. As new technology became available, the program could use the load profiles of all its customers to conceptualize further advances to a smart grid system for the country.

The smart meters gave consumers a tool to increase their awareness. They could see their consumption at home and see their consumption cost at peak times. This first step was enabled by web applications that would allow the community of users to show different applications and consumption modes. Integration of information about home appliances will be the next step.

Benefits from Enel Smart Meter Program



Source: Enel

Enel's introduction of smart meters in Italy is far ahead of the United States. Consumers, the system, and the company all benefit.

Smart meters have the potential to inform consumers with exceptionally precise data such as what replacing an old refrigerator might do to their monthly bill. The question of industry leaders today is where to make the best investment. Future innovators are looking at ways an advanced transmission system may allow the system to function as a large battery, balancing electricity among generators, consumers and utility scale storage. While some see the future in capacity gains at the system level, others see viability in a more distributed system. In this case, efficiency gains would be made with a more radical redefinition of the electricity business that moves away from the centralized spoke-and-hub model used today.

Securing an advanced transmission system

Companies like Google and Intel see smart grid communications as part of their future. The futuristic scenario has been played out in television commercials: a consumer's phone triggers a response from the home cooling system as she is returning to the neighborhood. An interoperable grid system would allow for transparent forecasting of demand. It would impact wholesale and retail standards by allowing real-time transactions across the entire supply chain. Furthermore, it could potentially accommodate transactional control of the millions of potential devices and consumers that would otherwise overwhelm a dispatch operator. Such interactivity would engage consumers of electricity in new ways. As a result, the existing radial system would become cellular. The interrelatedness of systems and the volume of customer-specific data points would grow exponentially. With new variables influenced instantaneously at the touch of a button, however, the role of cyber security becomes increasingly important.

Electricity's role as an enabler of business and daily life requires a resilient and redundant system. As an advanced transmission system develops, finding ways to mitigate increased interdependencies is essential. The platform for integrating a broad range of sensing, measurement, transactional, control and other applications will open multiple systems to new vulnerabilities. There are two areas of electric sector interoperability that require cyber security attention: physical security and privacy.

Physical security

Protocols that drive automation on the grid will open critical vulnerabilities that power providers will need to address. That will entail creating redundant systems at critical nodes and determining who decides where those are and how costs are allocated to support them. Within a smart grid, no system will be immune. Software that drives interoperability throughout the supply chain will require attention.

In forming security policy for the future, it will be important to distinguish physical asset attacks from cyber security. Sustaining a secure and resilient smart grid cannot be accomplished solely on a physical basis. The nature of cyber threats will require system-wide assessments. However, physical assets have been successfully secured for decades. The security culture and procedures are well accepted and maintained by individual owner-operators. The complexity of the future system continues to take shape, presenting yet unknown and untested cyber security issues. As a result, an interoperable transmission system will require new approaches to security. For many stakeholders, this presents a valid reason for federal authority; however, that rationale is less popular when security is related to physical assets. The challenge will be maintaining the proven physical security methods while expanding into procedures to protect cyber-communications concerns.

Some policy makers recommend that security improvements could be made by extending FERC authority to local distribution lines. As smart appliances are integrated into homes and interoperability becomes the rule, there must also be ways to hold vendors accountable for the reliability of their equipment. Questions also take shape on the cyber security of local distribution lines, expanding the controversy over the balance of power between federal and state interests that already confront the larger transmission system.

As an advanced transmission system is being negotiated, it is clear that multiple players are involved. In addition to the FERC, the Department of Defense and the Department of Homeland Security have an interest in protecting the critical infrastructure of the country. Private owners have full reason to protect their own assets as well. Some industry leaders call for greater coordination within the sector to educate policy makers before standards are defined without their input.

Privacy

While consumers and policy makers may find concerns over the security of market data in an increasingly interconnected system, industry leaders express less concern. From their perspective, this market data related to customers, privacy and anti-trust considerations is already regulated and well managed. Privacy rules regarding customer data already exist. In the existing system, customer information cannot be passed to the generation side.

As a result, future systems will be built upon this foundation of secured private information. Cyber security for usage information will be “built in” to the software that enables a smart grid. It will drive data sharing protocols, and software developers will bear the burden of developing adequate solutions in order to compete for market share among utilities. Nonetheless, to maximize the potential of a smart grid system, some reform may be necessary.

Appendices

Agenda

An Electricity Grid for the 21st Century

Co-Chairs:
Susan Tomasky, President, AEP Transmission
Linda Stuntz, Partner, Stuntz, Davis & Staffier

Wednesday, July 8

8:30 – noon

Pre-session Roundtable: Renewables and Clean Tech

This session will explore the challenges, opportunities, and key drivers of renewables and related clean technology, including solar, wind, and other renewables as well as transportation and energy storage.

Co-chairs:	**Daniel Weiss,** Managing Partner, Angeleno Group LLC
	Jack D. Hidary, Chairman, Global Solar Center
Guest expert:	**Andy Karsner,** Managing Director, ManifestEnergy LLC

Thursday, July 9

8:30 – noon

SESSION I: The Goals

Calls for enhancing electricity transmission in the U.S. encompass a variety of goals. What are they? How do they intersect with national economic, environmental, and security goals? What technical and regulatory challenges do they pose? .

Chair:	**Susan Tomasky**
Speakers:	**William W. Hogan,** Raymond Plank Professor of Global Energy Policy, Harvard Kennedy School
	Richard P. Sergel, President and CEO, North American Electric Reliability Corporation
	Susan F. Tierney, Managing Principal, Analysis Group

1:30—5:00 pm

SESSION II: Who Decides? Who Pays?

Planning for, siting, and allocating the costs of transmission enhancements are crucial to the ability to achieve our goals. They raise issues of the need for additional capacity, the role of markets vs. planning, the locus of any strengthened planning authority, the question of allocating the costs of enhancements, and state-federal regulatory authorities.

Chair:	**Linda Stuntz**
Speakers:	**Nicholas A. Brown,** President and CEO, Southwest Power Pool
	Barry Smitherman, Chairman, Public Utility Commission of Texas
	Susan N. Kelly, Vice President of Policy Analysis and General Counsel, American Public Power Association
	Suedeen Kelly, Commissioner, Federal Energy Regulatory Commission

Friday, July 10

8:30 – noon

SESSION III: Integrating Renewables and Electric Vehicles

Among the challenges our national goals pose for the transmission grid are how to expand the use of intermittent and inconveniently located renewable resources and meet the power needs of an increasingly electrified transportation sector. What technological, regulatory and financial obstacles must be overcome?

Chair:	**Phil Sharp,** President, Resources for the Future
Speakers:	**David K. Owens,** Executive Vice President, Business Operations, Edison Electric Institute
	Yakout Mansour, President and CEO, California Independent System Operator Corporation
	Patrick Lee, Vice President, Powerlink Project San Diego Gas & Electric
	Robert Gramlich, Senior Vice President of Public Policy, American Wind Energy Association

Saturday, July 11

8:30 – 11:30 am

SESSION IV: Distribution and Demand-side Management

Much of the potential for improving reliability, security, and environmental objectives is in the distribution sector and "behind the meter." The greatest potential for green jobs may also be here. What can be achieved and when, and what is necessary for it to happen?

Chair:	**John Bryson,** Senior Advisor, KKR, and former CEO, Edison International
Speakers:	**Paul A. Centolella,** Commissioner, Public Utility Commission of Ohio

Lynda Ziegler, Senior Vice President for Customer Service, Southern California Edison

Francesco Starace, Managing Director, Renewable Energies Division, Enel SpA, and Chairman, Enel Green Power

Edward Torrero, Executive Director
NRECA Cooperative Research Network

Respondent: **John Jimison,** Senior Counsel - Energy
Energy and Commerce Committee
U.S. House of Representatives

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