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A 21st Century “Interstate Electric Highway System” – Connecting Consumers and Domestic Clean Power Supplies

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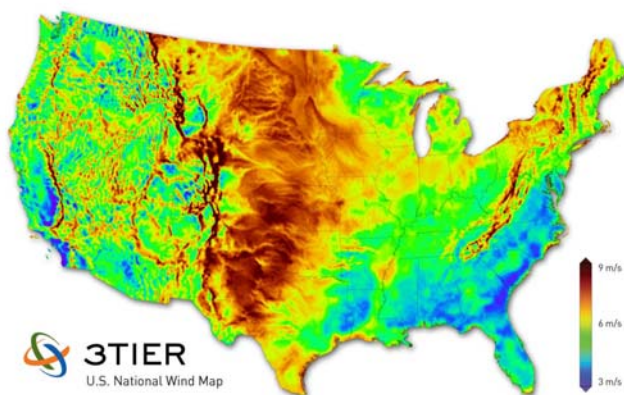
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EXECUTIVE SUMMARY

- Electricity is fundamental to our quality of life. Most Americans don't think twice about their electricity supply and how it gets to them. We expect it to be in the socket whenever we need it, no matter how many appliances we plug in, and at a reasonable cost.
- And yet, we still have our fathers' power system. The nation's electric system needs to keep pace with our modern requirements. We face new challenges in this century compared to the last: growing demand for advanced technology better suited to a digital economy; adequate supplies to keep pace with the economy; and global climate change, which will require significant reductions in greenhouse gas emissions from the power sector.
- These pressures are motivating substantial interest in producing more of our power supply from renewable energy. Renewables are a critical link in our ability to meet the nation's 21st Century energy needs.
- For example, wind on our prairies, mountains and off-shore waters provide us with a generous indigenous and renewable resource capable of providing significant electric energy with no carbon emissions and fuel costs delinked from global energy markets. We have seen significant increases in wind projects – in Texas, the Plains, the West, the upper Midwest, and the Northeast/MidAtlantic regions.

U.S. Wind Resources
(Meters per Second)

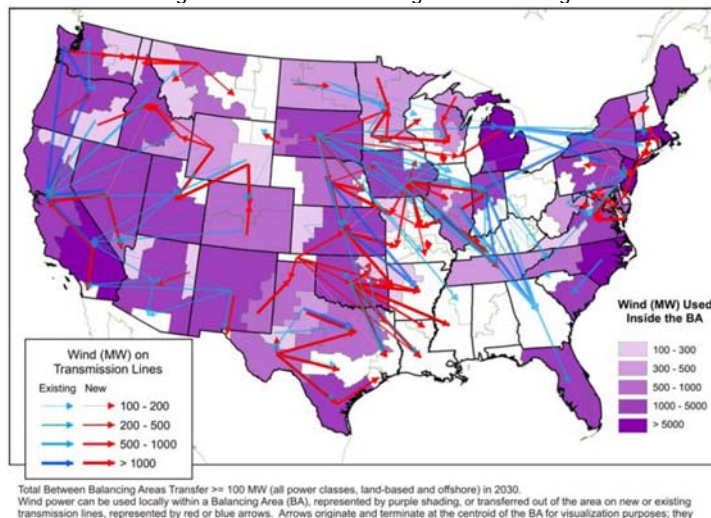


Source: http://www.gaccsouth.com/fileadmin/user_upload/Dokumente/Events_Houston/Sustainable_Energy_Strategies__Inc.__Richard_Walker.pdf

- But we cannot realistically expect to exploit fully our rich domestic renewable resources in the near term without strategic improvements to the electric transmission system. Wind projects must be located where the wind actually blows; once generated, their power can travel over power lines to customer locations. This means that wind power development is inextricably tied to electric transmission. The same is true for large scale solar projects, biomass-to-electricity, geothermal plants as well. They must be located near the resource, with power moved to consumers, most of whom live far away. Many recent studies have concluded that ensuring adequate transmission is built to deliver power from remote renewable projects to consumers in distant markets is just as important as developing the renewable resources themselves. Many groups from around the country, across the political spectrum and from a wide variety of constituencies agree.

- And yet transmission investment for wind often suffers from classic "chicken-and-egg" problems. It's hard to build renewable power plants in remote areas where there is inadequate transmission and few customers reside; and it's hard to build transmission in areas where there are no power plants or few customers to serve. Ironically, as the electric transmission system rises in importance in helping the nation develop its renewable resources, our transmission system has suffered from years of underinvestment. Continued inadequate attention to enhancing the nation's electric transmission system will undermine – if not prevent – our ability to satisfy our national goals for addressing climate change and our needs for energy independence.
- Strategic improvements to our nation's high-voltage transmission infrastructure are needed to meet our needs for clean, reliable and affordable power supplies in a carbon-constrained world. Transmission investments can help to modernize the system, facilitate clean power development, and improve power efficiency, while enhancing energy security and reliability.

Conceptual Illustration of Optimized Use of Wind Resources Locally and Transmitted to Distant High-Demand Centers Using New & Existing Transmission Facilities



Source: U.S. DOE, "20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply", 5-2008.

- We need a new vision for a 21st Century "Interstate Electric Highway System." Just as we adopted the National Interstate Highway System 50 years ago to usher in a new era of mobility, interstate commerce and economic development, it is time for a new era of electric transmission. This vision builds on current regional initiatives to plan transmission for renewables, takes into consideration the strategic benefits of private transmission investment, and relies on our traditional model of private funding for investment in transmission. Like the national highway system designed to connect parts of the country together, a national high-voltage transmission should build off of current regional planning efforts, with costs recovered from consumers in large electrical regions, through the portions of consumers' electricity bills that reflect interstate charges rather than local rates. A cost-support mechanism could take the form of a consolidated national "postage-stamp" rate available for strategic transmission projects and collected through the federal transmission tariff. Legislation may be required, and would benefit from further discussions on the design of technical issues – while still keeping with the goal of building national support for a national "interstate electric highway system."
- The complete Tierney White Paper ("21st Century 'Interstate Electric Highway System' ") is at <http://www.analysisgroup.com/analysisgroup/energy.aspx>

A 21st Century “Interstate Electric Highway System” – Connecting Consumers and Domestic Clean Power Supplies

**Susan F. Tierney,¹ Analysis Group
October 31, 2008²**

Introduction and Overview

Electricity is fundamental to our quality of life in America in the 21st Century (page 2). We continue to grow our demands on an electrical system that was built by our fathers – and in certain respects, our grandfathers. But it can't stay that way for long (page 2). Changes in the nation's electrical system need to keep pace with our modern requirements for clean, reliable and affordable electricity supply (page 3). This is especially true for utility-scale wind (page 5) and certain other large-scale renewable power projects (page 11).

We cannot realistically expect to exploit our rich domestic renewable energy resources without improvements to the electric transmission system (page 14). We need strategic improvements to the nation's transmission system (page 21). This includes transmission to support utility-scale wind and solar power project development. The interconnected, high-voltage transmission offers a wide range of well-known benefits (page 26).

Given 21st Century requirements for clean, reliable and affordable electricity supply in a carbon-constrained world, the nation's needs cannot be achieved without significant enhancements to our extra-high-voltage transmission system (page 29). This and other studies of extra-high-voltage systems show that they offer the ability to move power efficiently and reliably, by: modernizing the system (page 30); supplying capacity to transfer power (including wind) from one region to another at a relatively low cost (page 32); moving power with far lower line losses (page 34); reinforcing the reliability of an overall regional transmission system (page 34); producing economic dispatch savings (page 35); providing broad economic and reliability benefits through interconnecting electrical areas to enable them to better handle the operational issues associated with intermittent resources and to share reserves (page 37); and moving power with a relatively lower environmental footprint (page 37). A recent innovative approach used in the Southwest Power Pool offers useful lessons for the nation (page 32, and Appendix A – page 47).

Achieving the nation's requirements for clean, reliable and affordable electricity supplies requires a new vision for a 21st Century “Interstate Electric Highway System,” built on a new national extra-high-voltage transmission system overlay (page 39). There are useful and relevant lessons from the Interstate Highway System (page 40). Development of the vision requires several components: building off of current regional initiatives to plan transmission for renewables; broadening the analysis of benefits and costs to take into account strategic benefits of investment in transmission; and supporting a national extra-high-voltage overlay system by broadly allocating costs to consumers in large electrical regions

A starting point: Electricity is fundamental to our quality of life in America in the 21st Century.

Most Americans do not think twice about their electricity supply and how it gets to them. They expect electricity to be available at the socket, whenever they need it, no matter how many appliances they plug in, with near-perfect reliability, and at a reasonable cost.

Today, Americans use 13 times the electricity they used a half century ago, when the American population was roughly half its current size.³ In fact, in all but three of the past 25 years, Americans increased their use of electricity over the amount used in the previous year.⁴ Electricity use continues to rise domestically (as it does internationally), and it does so faster than overall energy use.⁵

Given the near ubiquitous availability of electricity in the U.S., and the role that electricity plays in energizing so much of our economic activities, this continued increasing demand for electricity creates strain on the electric system. Our electricity use per capita has been rising even Americans are using less electricity to produce goods and services in the economy.⁶

Not only is electricity the sole form of energy for many activities – from running our computers, to keeping the street lights lit, keeping our food refrigerated and our ATMs open, and so on – but it remains a relative value compared to many other types of energy. Certainly, electricity prices have risen – but less so than other kinds of energy prices: Compared to 1990 when oil was just under \$25 per barrel, the price of oil is now nearly six times that level (at a high of over \$145 per barrel during the summer of 2008).⁷ Since 1990, gasoline prices have nearly tripled and natural gas prices have risen nearly fourfold.⁸ By contrast, over that same period, the average price of electricity rose by approximately 40 percent (from 1990 through 2005). Some energy sources used to produce electricity offer even stronger price advantages: From 1990 to today, the price of fuel used to power wind turbines has remained the same – at zero cents per kilowatt-hour.

The snapshot today: This is your father's electric system – but it can't stay that way for long.

As Americans depend absolutely on a reliable electric supply, they also are tied to an electric system that is getting more antiquated. And while they are already struggling to pay high electricity costs, it is not likely that power will be much less expensive in the future. The industry is concerned about electricity prices ahead.⁹ An array of factors is likely to contribute to keeping electricity prices higher than what Americans would like. Besides the relatively high prices of the fossil fuels used to generate most of our power, electric companies face other costs in meeting consumers' electricity demand – whether in the form of expenditures on energy efficiency programs, or investment in power plants, pollution-control equipment, and transmission and distribution facilities.¹⁰

Among the more volatile costs in recent years have been the prices of fossil fuels used in the power sector: natural gas, oil, and – increasingly – coal. These high fossil fuel prices have led to growing interest among politicians and others to see the American power industry rely less on fossil fuels in the future. Often couched in terms of the need for greater energy security and independence, this goal stems from desires among many to mitigate the effects of high and volatile fossil fuel prices affected by global energy markets. It also rests on the objective of reducing U.S. emissions of greenhouse gases from the power sector – a goal held by an increasing share of Americans,¹¹ their leaders,¹² and members of the global community as well.

Americans thus face this dilemma of remaining dependent on reliable electricity to meet so many other needs, on the one hand, and a sobering outlook of continued high prices and the need to produce power from cleaner and more secure fuels in the future, on the other. In addition to maintaining the level of reliable supply that Americans take for granted and that our economy counts on, the industry faces new challenges in this century compared to the last: an increasingly aging electric infrastructure; growing demands for advanced technology better suited to a digital economy; and global climate change, which will require significant reductions in greenhouse gas emissions from the power sector.

These pressures are motivating substantial interest in producing more of the nation’s future electricity supply from renewable energy – indigenous and plentiful resources, like wind, solar, biomass, hydroelectric, and others. In combination, the pressure to decarbonize electricity, to mitigate the impact of high prices on consumers, and to retain a reliable supply of power so essential to the nation’s economy, hangs over the industry as a profoundly heavy mantle.

Looking ahead: Changes in the nation’s electrical system need to keep pace with our modern requirements for clean, reliable and affordable electricity supply.

To those actively engaged in electric industry issues, there are well-known challenges for the decade(s) ahead. Our nation’s electric system must continue to provide the level of reliable supply that Americans take for granted and that our economy counts on. It must do so while faced with this century’s new hurdles. These include an increasingly aging base of electrical infrastructure – power plants, transmission lines and local distribution facilities – largely built up in piecemeal fashion over the past half-century as the nation made electricity supply available to all Americans. There are also challenges associated with the growing demands for advanced power technologies better suited not only for a digital economy but also to customers’ needs to better manage their use of electricity. Perhaps most challenging of all these 21st Century challenges is the need to find ways to dramatically reduce greenhouse gas emissions from the power sector, and to do so as soon as practical.

Changes in our electricity system are needed to meet these multiple requirements. These changes need to occur in ways that respect the public’s views about balancing electricity prices and costs, energy security imperatives, and environmental requirements.¹³

Changes in all elements of the electric system – electricity production at power plants, the power delivery system, and devices on the customer end of the meter – all need to be part of the solution to providing clean, secure and affordable power.

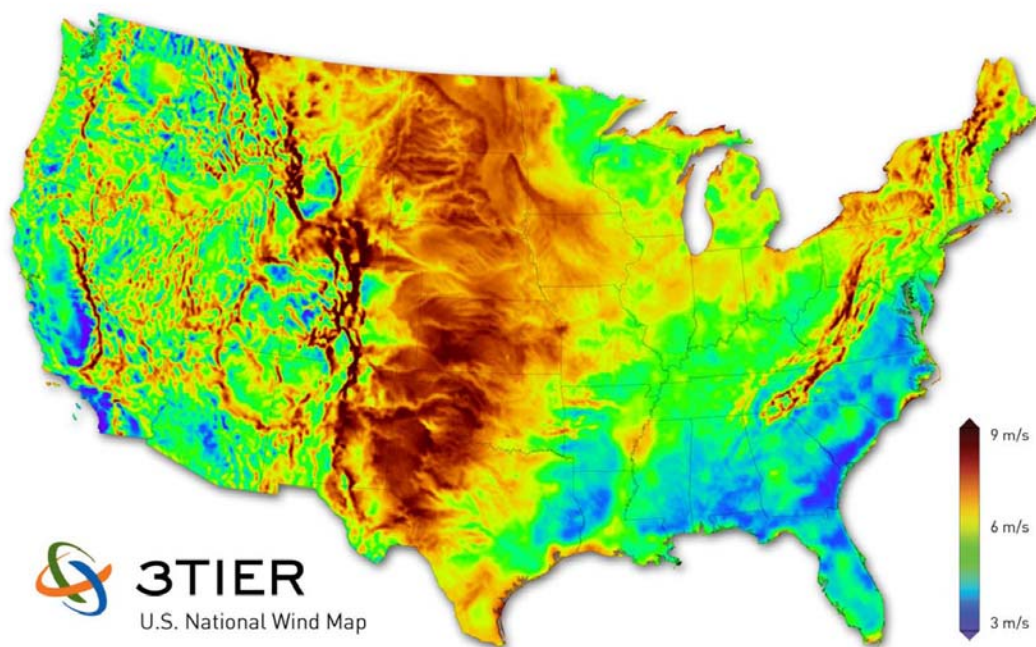
Let's start with the most obvious solution first: **energy efficiency and other demand-side measures**. These involve taking steps to make sure that we are using energy as efficiently as we can. While the nation as a whole has moved over time to use electricity more efficiently,¹⁴ there are significant opportunities to tap into plentiful domestic reservoirs where equipment, appliances, production processes, and buildings use more electricity than is needed or efficient. Countless recent studies have chronicled the amounts of electricity and larger energy savings available from economically and technically viable energy efficiency measures.¹⁵ Cost-effective energy efficiency and other demand-side strategies offer the multiple benefits of enabling customers to manage their rising energy use and electricity bills; to find local sources of power through deploying approaches that allow the customer to get the same energy value while using less electricity (and other forms of energy); to enable power companies to avoid producing and transmitting so much power and consuming so many fossil fuel in the process; and to avoid emissions of greenhouse gases. Certainly, today's high energy prices provide greater motivation for energy efficiency than in the past. But also, utilities, regulators, and a variety of other stakeholders are seeking to step up significantly our adoption of cost-effective demand-side measures. Any meaningful strategy to address simultaneously the challenges of energy security, lower carbon footprint, and enabling customers to control their electricity bills must include as its principal strategy a program to tap cost-effective energy efficiency as aggressively as possible.

Second, much attention has been devoted to examining the set of **power production technologies** that will be needed to produce low-emitting, efficient and reliable power supplies in the future. Countless groups in the industry¹⁶ are examining what combination of technologies – natural-gas power plants, advanced coal gasification technologies with or without carbon sequestration, advanced nuclear facilities, renewable projects, and others – will be added to the nation's existing fleet of generators in the future. Clearly, these decisions will be shaped by a mix of investors' expectations in markets and regulated industries about such things as fossil fuel prices and supply availability in the future; long-term security of fuel supply; construction costs for different types of power plant options; technical and commercial readiness of different advanced power generation technologies; the timing and shape of future environmental, tax and other policies affecting investments in one technology or another and, in particular, the stringency of future carbon controls; waste disposal challenges; regulatory rules for power procurement, investment recovery and power market structure and design; other financial incentives; permitting hurdles; public attitudes; and uncertainty about all of the above.

Third, **renewable resources** are a critical link in our ability to meet the nation’s 21st Century electric energy needs. Wind power, solar energy, biomass-to-electricity, hydroelectric power, geothermal, waste-to-energy gasification projects, and other renewable fuels offer the nation the means to help meet energy requirements through domestic, sustainable fuels with a low carbon footprint.

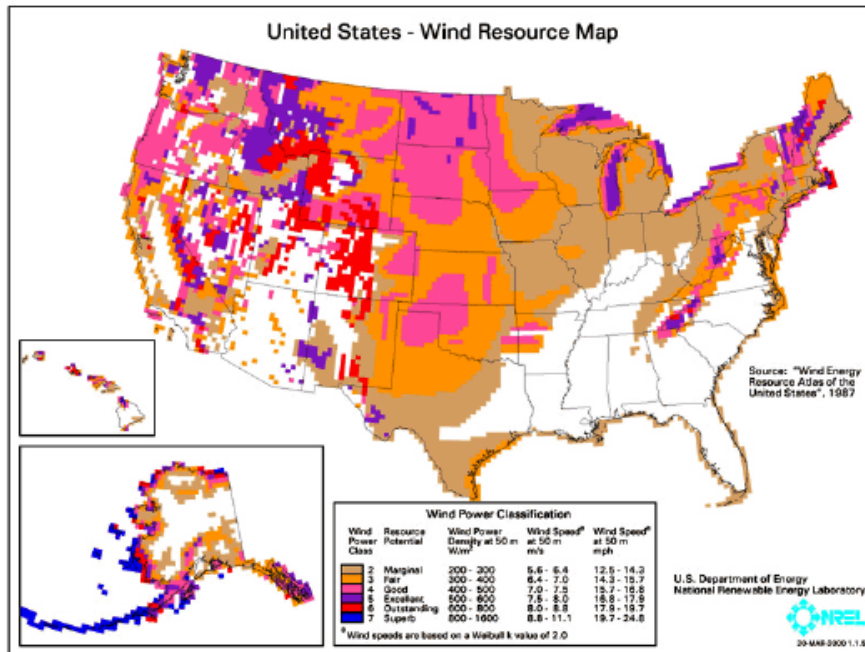
Spotlight on wind power: The U.S.’s wind resource is substantial, as shown in Figures 1 and 2. Together, these maps report what we know by common sense – that our prairie, mountain-top, and off-shore winds blow strong. Our wind resources provide the U.S. with a generous indigenous and renewable resource capable of providing significant electric energy with no carbon emissions, and at a fuel price (zero dollars per megawatt-hour (“MWh”)) that is both extremely low and beyond the control of foreign suppliers. Table 1 shows the classes of wind resources in various Western states.

Figure 1
U.S. Wind Resources
(Meters per Second)



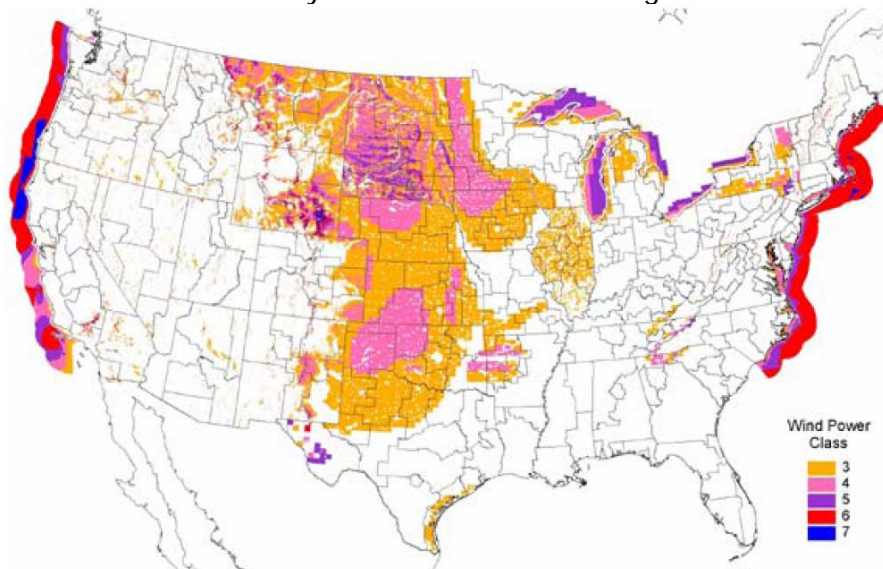
Source: http://www.gaccsouth.com/fileadmin/user_upload/Dokumente/Events_Houston/Sustainable_Energy_Strategies__Inc.__Richard_Walker.pdf

Figure 2a
 U.S. Wind Resources by Class of Wind



Source: NREL Wind Resource Map

Figure 2b
 U.S. Wind Resources by Class of Wind – Including Off-Shore Areas



Source: NREL Wind Resource Map

Table 1
 The Western U.S.
 Wind Power Production Potential by State
 and Class of Wind (in MW)

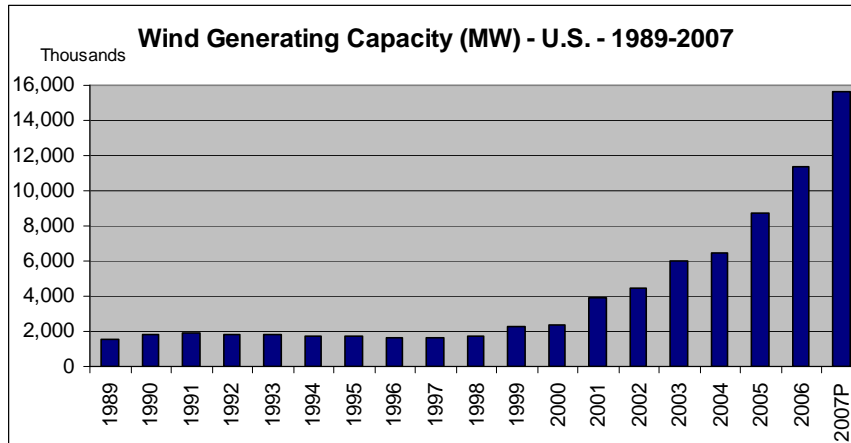
STATE	CLASS 4 GOOD	CLASS 5 BETTER	CLASS 6 & 7 BEST	TOTAL DEVELOPABLE POWER CLASS 4-7
AZ	1,670	440	200	2,310
CA	11,900	4,830	4,300	21,030
CO	65,560	3,510	4,060	73,130
ID	2,380	635	395	3,410
MT	237,030	38,860	15,620	291,510
NV	3,700	1,140	720	5,560
NM	62,260	8,980	1,800	73,040
OR	7,130	1,540	850	9,520
UT	2,310	770	410	3,490
WA	7,140	1,590	790	9,520
WY	140,980	59,630	57,040	257,650
TOTAL	542,060	121,925	86,185	750,170

[Source: National Renewable Energy Laboratory 2007]

Source: Data from the NREL (2007),
 cited by Western Resources Associates ("WRA"),
 "Smart Lines: Transmission for the New Renewable Energy Economy"
 (hereinafter "WRA Smart Lines Report"), 2008, page 2.

Wind turbines have turned a corner in terms of their commercial viability and promise. In the past few years, there has been an outpouring of new wind power projects, as indicated by the rise in installed wind power generating capacity since about a decade ago. Figure 3 shows the rapidly growing capacity additions in the U.S. "The U.S. wind power market surged by 46% in 2007, with 5,329 MW added and \$9 billion invested.... Wind installations in 2007 were not only the largest on record in the United States, but were more than twice the previous U.S. record, set in 2006."¹⁷ Forty percent of all generating capacity entering commercial operations in the first five months of 2008 was at wind projects, up from 35 percent of all capacity additions in 2007.¹⁸ In the second quarter of 2008, over 1,000 MW of new wind capacity was installed, bringing the total installed capacity to over 2,700 MW for 2008 and over 19,500 MW overall. The AWEA estimates that over 7,500 MW is likely to be installed in aggregate during 2008.¹⁹ By contrast, during the period from 2000 through 2004, nearly all of the generating capacity added in the U.S. was at power plants that use natural gas as the primary fuel.^{20, 21}

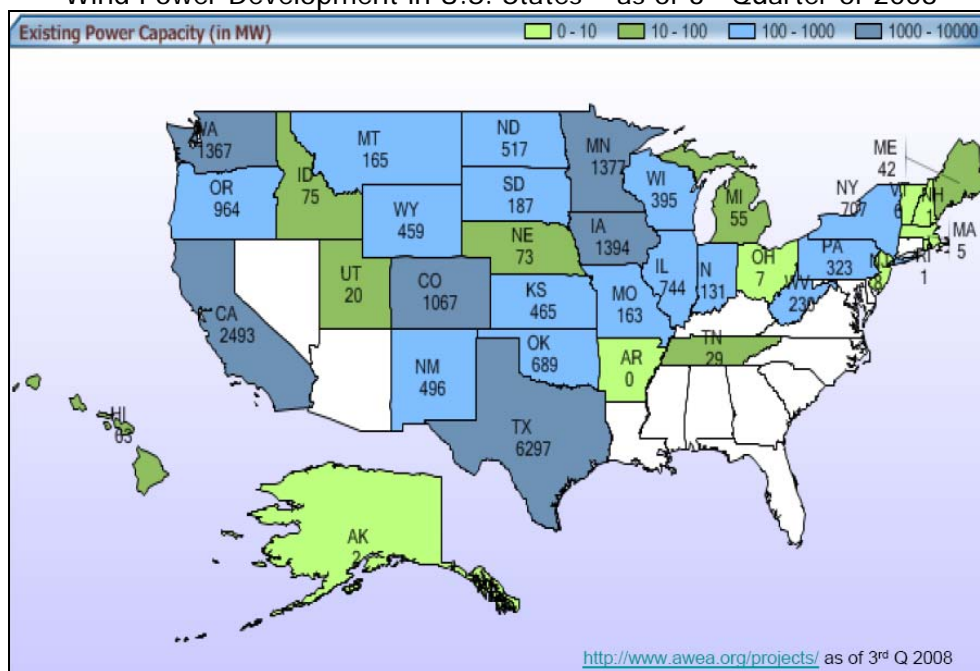
Figure 3
U.S. Wind Generating Capacity from 1989 through 2007



EIA, Annual Energy Review, 2007, Table 8.11a Electric Net Summer Capacity:
Total (All Sectors), 1949-2007, <http://www.eia.doe.gov/emeu/aer/txt/stb0811a.xls>

Wind turbines have been installed around the country. Figure 4 shows the location of the roughly 16,000 MW of wind projects now located in various parts of the U.S. The six states with the largest amount of installed wind capacity are Texas, Colorado, Illinois, Oregon, Minnesota, Washington, and Iowa (as shown in darkest green on Figure 4). "On a cumulative basis, after surpassing California in 2006, Texas continued to build on its lead in 2007, with a total of 4,446 MW of wind capacity installed by the end of the year. In fact, Texas has more installed wind capacity than all but five countries worldwide.... Although all wind projects in the United States to date have been sited on land, offshore development activities continued in 2007, though not without some tribulations." ²²

Figure 4
 Wind Power Development in U.S. States – as of 3rd Quarter of 2008



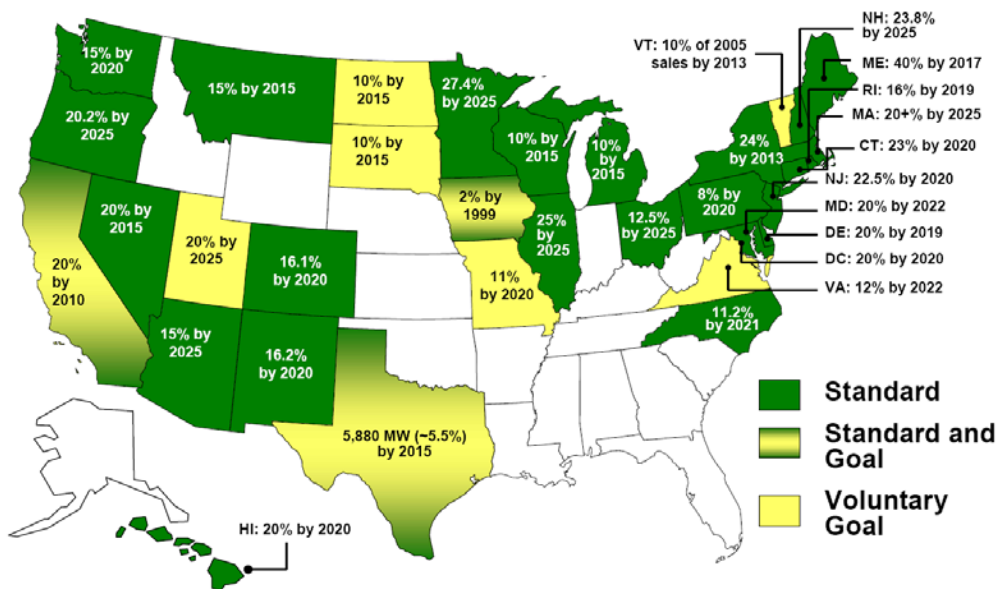
Source: AWEA, <http://www.awea.org/projects/>

There are many reasons (apart from the raw abundance of the wind resource itself) why wind project development has increased dramatically in recent years. Among the more important ones are:

- manufacturing and technological improvements that have generally lowered the dollar-per-megawatt (“MW”) installed cost of wind turbines;²³
- high energy prices that increase the economic attractiveness of generating projects (like wind turbines) that otherwise have high capital costs and low fuel costs;²⁴
- investment incentives (like the production tax credit in federal law);²⁵
- improvements in output (i.e., capacity factors) of wind turbines generally;²⁶
- the adoption of requirements (e.g., “renewable portfolio standard,” or “RPS”) in many states that create more demand for renewable power (see Figure 5, below, showing the states that have adopted an RPS requirement);
- the so-called “organized” wholesale power market designs in many regions (like Texas, parts of the Midwest, and the Northeast) that allow both transmission access with a single region-wide transmission rate, and a “single-clearing price” energy pricing structure that supports wind development;²⁷

- the public’s relative preferences for wind power projects as compared to many other approaches to clean power production;²⁸
- retail customer choice (e.g., selection of green electricity), along with , green tags and carbon offset programs; and
- the expectation that the nation’s requirements for electricity production with a lower carbon footprint cannot be accomplished without significantly greater reliance on wind energy.²⁹

Figure 5
 States with RPS Requirements (Including Non-Binding Policies)



Source: Union of Concerned Scientists, <http://www.ucsusa.org/assets/images/ce/res-states-map.gif>

Notably, estimates of the amount of renewables needed to meet the minimum RPS requirements suggest a continued demand for and interest in developing³⁰ additional capacity to generate power from the wind. For example, a Western Governors’ Association analysis of the implications of the Western states’ RPS requirements suggests that by 2017, there will be a minimum of 15,000 MW of renewables needed to be added; by 2025, the amount will be from 30,000 to 40,000 MW, with double that amount (70,000 to 80,000 MW) to meet the more aggressive targets for renewable energy set by the Western Governors’ Association “Clean and Diversified Energy Initiative”.³¹

More generally, these estimates of additional renewable energy resources that need to be developed are consistent with a future in which the electric sector must reduce its carbon footprint: “Without utility-scale wind, solar and geothermal facilities and adequate transmission access, we won’t be able to

meet future energy demand, much less reduce carbon emissions to levels needed to avoid the damaging effects of climate change."³²

Unlike other power plant technologies which tend to be located in relatively close proximity to customer demand centers and use various fuel-delivery systems to move fuels from production basins to the power plant, however, wind plants (and solar facilities, for that matter) must be located where the fuel – wind (or solar) – itself exists. Wind power must be produced on site where the wind blows. Once generated, the wind power can travel over power lines to customer locations.

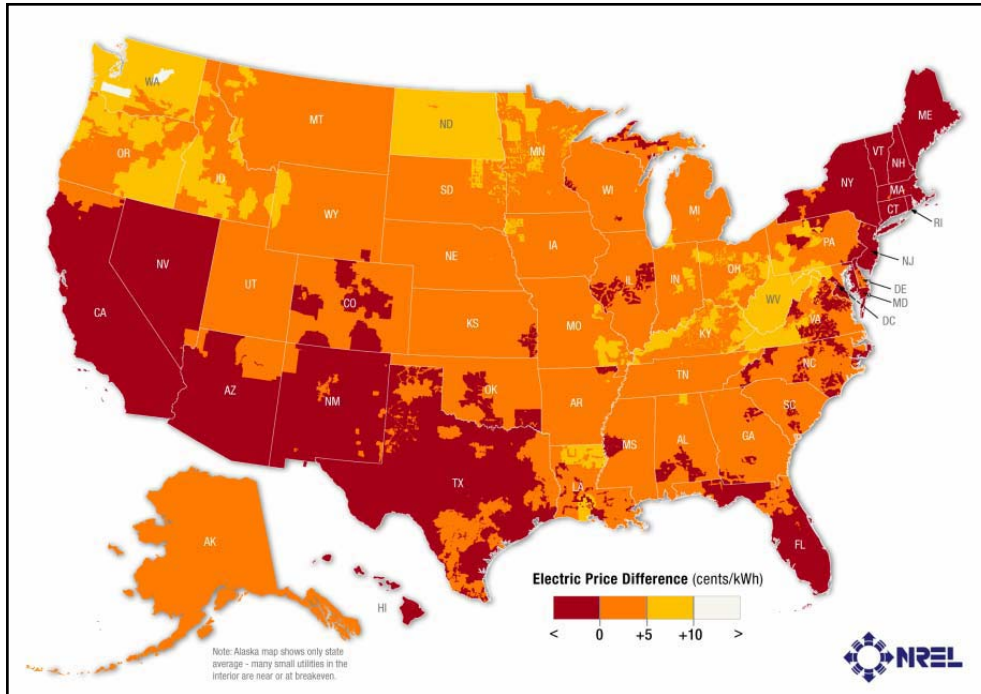
Typically, though, wind is located where people – i.e., electricity consumers – generally are not. This means that wind power development and deployment are inextricably tied to electric transmission. It also often means that transmission needs to be available in relatively remote and windy regions where there is less-than-robust transmission capacity (since previously, non-dense populations might not have warranted extensive transmission networks), in order to move the renewable power to distant customer demand centers.

Thus, there is significant near-term potential for wind power development. But to realize large wind penetration into the nation's power system – substantially greater than the percentages we now have – new transmission will be needed. (This is true for wind in the center of the nation, on mountain ridges and in off-shore areas.)

A brief comment about solar power: In addition to wind, solar energy also has zero fuel costs and no carbon emissions when used to generate electricity. Solar energy is principally used in two ways to produce power. First, it can be generated at relatively small photovoltaic ("PV") panels placed on the roofs of buildings, generating power for on-site uses and at times producing enough electricity to flow back into the grid. Second, solar power can produce electricity in more centralized "solar power stations," where clusters of PV arrays and/or a "concentrating solar power technology" is used to produce a significant amount of power to be shipped off site for consumption elsewhere.³³

Solar power equipment costs have been dropping in recent years, in large part a result of improvements in manufacturing – bringing solar closer to "grid parity" with costs comparable to what it costs to produce power from other sources.³⁴ Figure 6 depicts the parts of the country (shown in dark red) where the U.S. Department of Energy has projected that solar power installations will be as cost-effective or more cost-effective than power generated from other sources by 2015.³⁵ Revenues for the solar PV market have been projected to grow by approximately 30 percent a year from 2007 through 2014.³⁶

Figure 6
Differences between Retail Electricity Prices and
Price of Solar Installations in 2015

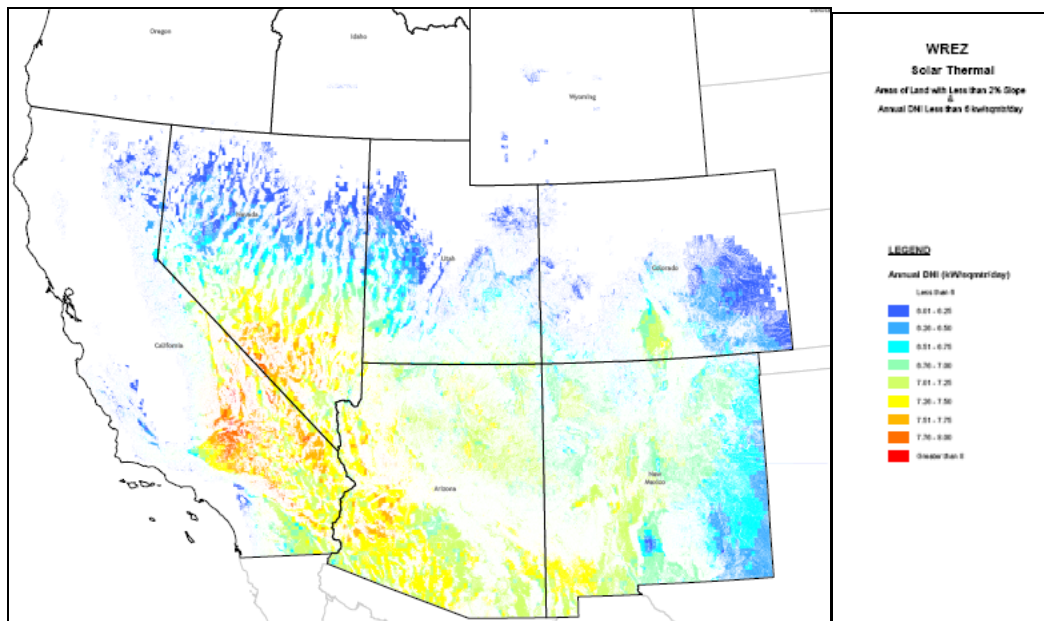


Source: "Solar Energy Industry Forecast: Perspectives on U.S. Solar Market Trajectory," Presentation by the U.S. Department of Energy Solar Energy Technologies Program, May 27, 2008.

Like wind projects, large-scale solar projects need to be located where there is strong solar radiation (and electricity prices at levels high enough to support solar installations), with the electricity produced at the solar site then transported to users via the grid. For example, Figure 7 shows the locations where there are relatively strong solar resources for utility-scale concentrating solar systems panels. While some of these resources are in densely populated areas, much of it is located in remote locales, far from customer electrical demand.

Figure 7

Solar Radiation Available to Concentrating Solar Systems



Source: Western Governors Association.

Other renewable projects – in brief: Another renewable fuel that offers economical, reliable and sustainable power production is biomass-to-electricity. Not a new technology, biomass-to-electricity in recent years has experienced fresh interest in the industry. The fuel for such facilities comes from a variety of sources, such as forest residues and wastes (including forest trimmings and cleared wood after forest fires), wastes from sawmills, certain agricultural and forestry wastes, and others. The energy in the organic materials can be converted to electricity by collecting the wastes, delivering them to a biomass-to-electricity facility, and burning it at such a facility to produce steam which in turn produces electricity. The biomass may be used in direct combustion, co-firing with other fuels, gasification, or other approaches. Typically, biomass-to-electricity facilities are considered to be (a) renewable energy facilities, because of the biomass fuel results from a sustainable life cycle of forests and agriculture, and (b) carbon neutral, because the carbon dioxide emissions produced by combusting the biomass material is offset by the CO₂ emissions consumed during the lifecycle of plant material.

Because of the weight and mass of the biomass fuel, along with the economics of materials delivery, most biomass facilities tend to be located close to their fuel sources – near forests or agricultural fields. Because biomass-to-electricity projects operate more commonly around the clock (thus avoiding the intermittency problems of wind and solar), they can sometimes support

investment in transmission, and often are sized better to fit with existing transmission. However, many larger scale biomass-to-electricity facilities still depend upon transmission to move power to distant consumers.

Finally, geothermal power projects are another renewable energy source quite often located distant to major metropolitan areas. Utility-scale geothermal resources are located in very few, specific regions in the Western states, often in areas with relatively spotty transmission coverage. They are baseload resources, however, and may support transmission investment more easily than intermittent wind and solar power projects.

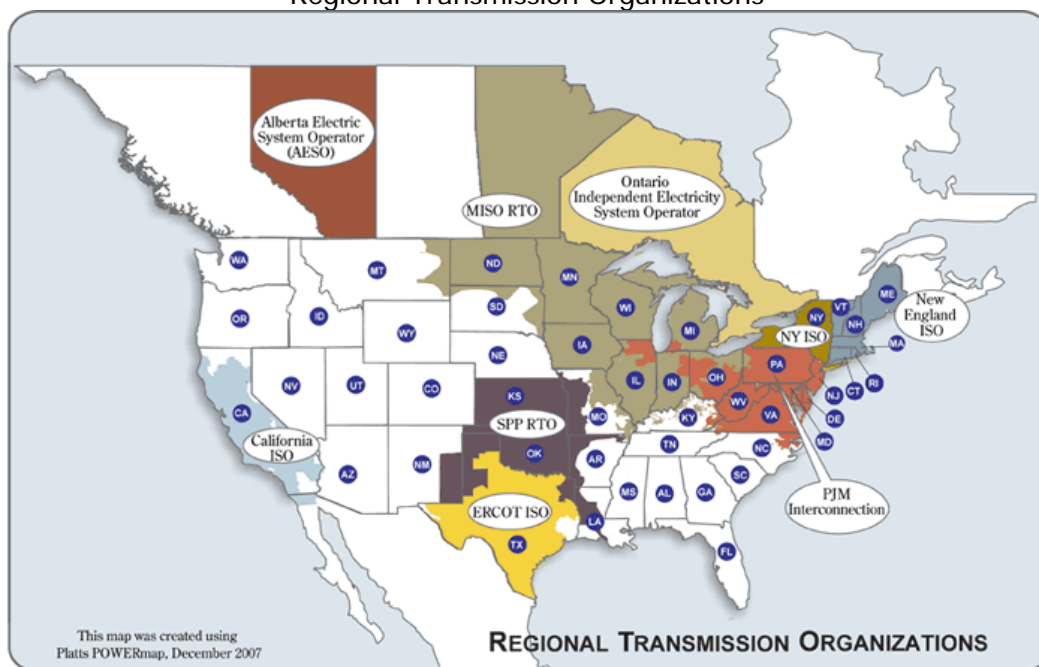
We cannot realistically expect to exploit our rich domestic renewable energy resources without strategic improvements to the electric transmission system.

The nexus between renewable power projects and electric transmission system adequacy has posed a hurdle to renewable project development and power production, in spite of the recent surge in new renewable energy projects (especially wind power projects) in the past few years. Examining the link between these renewable projects and transmission, industry observers have concluded that “Without utility-scale wind, solar and geothermal facilities and adequate transmission access, we won’t be able to meet future energy demand, much less reduce carbon emissions to levels needed to avoid the damaging effects of climate change.”³⁷

Wind power and transmission: The situation has been aptly characterized as a classic chicken-and-egg problem, as described in the following example relating to planning for wind power and transmission in parts of the Southwest Power Pool Regional Transmission Operator (“SPP RTO”).

The SPP RTO region (shown in Figure 8) includes Oklahoma, other plains and rural southwest areas with relatively strong wind development potential (shown in Figures 1, 2, and 4).

Figure 8
Regional Transmission Organizations



Source: <http://www.ferc.gov/industries/electric/indus-act/rto/rto-map.asp>

Planning for the future of electricity generation in Oklahoma is kind of like debating over which came first: the chicken or the egg. No one wants to build power plants in remote areas where there are few customers and no transmission infrastructure to get that power onto the grid. On the other hand, no one wants to build transmission infrastructure in areas where there are no power plants or few customers to serve. And no one wants to build anything until they have a plan in place for recouping their costs. 'So what, do you build it and they will come?' Jay Caspary, director of engineering for the Southwest Power Pool, asked members of the Oklahoma Electric Power Transmission Task Force on Friday. 'And how do you pay for that? It's a real chicken-and-egg thing here.'³⁸

Assuring that adequate transmission is available (and in some cases, newly built) for delivering power from remote renewable projects to the load centers where there is a market for renewable power is just as important as developing the wind resources themselves. The chicken-and-egg problem is, however, not the only challenge for renewable projects seeking to assure that adequate transmission is in place and accessible. A long array of recent studies have chronicled the impediments that "business-as-usual" transmission approaches pose for wind development and deployment, and the need to invent new

approaches to capture the full national benefits of clean, renewable, economical and secure wind power supplies. Several examples are as follows:

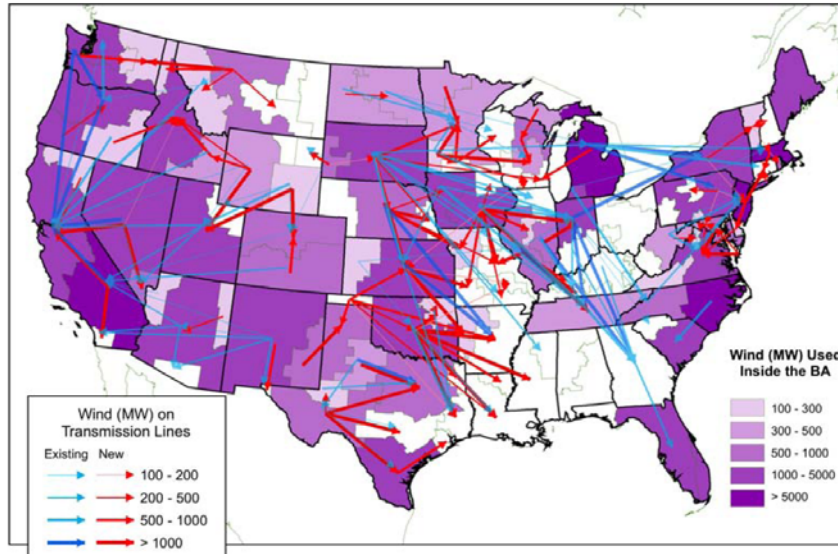
- "Expansive dreams about renewable energy, like Al Gore's hope of replacing all fossil fuels in a decade, are bumping up against the reality of a power grid that cannot handle the new demands. The dirty secret of clean energy is that while generating it is getting easier, moving it to market is not. The grid today, according to experts, is a system conceived 100 years ago to let utilities prop each other up, reducing blackouts and sharing power in small regions. It resembles a network of streets, avenues and country roads...'The windiest sites have not been built, because there is no way to move that electricity from there to the load centers,' he [Gabriel Alonso, chief development officer of Horizon Wind Energy] said. The basic problem is that many transmission lines, and the connections between them, are simply too small for the amount of power companies would like to squeeze through them. The difficulty is most acute for long-distance transmission, but shows up at times even over distances of a few hundred miles. Transmission lines carrying power away from the Maple Ridge [wind] farm, near Lowville, N.Y., have sometimes become so congested that the company's only choice is to shut down — or pay fees for the privilege of continuing to pump power into the lines."³⁹
- "One of the biggest constraints on the expanded growth of wind power in the United States will be the ability of the transmission grid to deliver large amounts of wind energy to customers. Why is transmission so important for wind energy development? Some of the best wind resources in the country are typically located in areas that are farthest away from the largest markets for electricity. By expanding and upgrading transmission systems, wind energy could be more easily moved from distant areas to population centers with the greatest need for electricity. By facilitating the expansion and geographical dispersion of wind power across a wide area, an upgraded transmission grid also increases the steadiness of wind supply on the grid. When the wind is not blowing at one location, it is usually blowing somewhere else. Dispersed wind power compensates for short-term fluctuations."⁴⁰
- "If the considerable wind resources of the United States are to be utilized, a significant amount of new transmission will be required. Transmission must be recognized as a critical infrastructure element needed to enable regional delivery and trade of energy resources, much as the interstate highway system does for the nation's transportation needs."⁴¹

- "Overlooked in most early power project finance deals, transmission issues (*e.g.*, the intermittent nature and distance from load) have become a focus as investors recognize the importance of transmission service to project completion and economics. The operational challenges facing competitive electricity suppliers (*e.g.*, available transmission, pancaked rates, and capacity value recognition) increase for wind generation. Wind generation is unable to maximize its use of reserved transmission capacity due to its intermittent nature. When purchasing firm transmission, a wind generator pays more for that transmission (on a per unit basis) when accounting for its low capacity factor. Also, because wind resources are only optimum in specific locations, wind generation does not have similar site selection flexibility as thermal resources and may incur multiple transmission charges when delivering to load. Finally, because wind generation is not recognized as having a capacity value in certain markets, wind generators lose value in those markets."⁴²
- "Over the past few years, wind power has been recognized as a significant emerging source of electricity. According to the American Wind Energy Association (AWEA), in the United States alone, during 2006, 2,454 MW of nameplate capacity was installed, bringing total capacity to 11,603 MW....Late last year, AWEA and the U.S. Department of Energy (DOE) introduced a 20% by 2030 Vision Scenario for Wind. One major obstacle for achieving that goal is the inadequacy of the national transmission system as it currently exists. Put simply: where wind is, transmission generally isn't. The chief contributor to this is the fact that the areas with the best wind resource are remotely located from load centers. Construction and/or expansion of transmission systems is a complicated and expensive undertaking, with costs running into the millions or billions of dollars and the process including siting, permitting, acquisition of right of way, environmental impact assessments, and numerous other steps. On top of all of this is the fact that there is a clear 'Not In My Backyard (NIMBY)' mindset when it comes to opposition to siting and construction of transmission lines."⁴³
- "Capacity on the existing grid is absent or minimal—the system under current electrical configurations is maxed out and needs extensive upgrades in many locations. As a result, *thousands of wind turbines in the United States are sitting idle or failing to meet their full generating capacity* because of a shortage of power lines able to transmit their electricity to the rest of the grid."⁴⁴
- "Development of 293 GW of new wind capacity would require expanding the U.S. transmission grid in a manner that not only

accesses the best wind resource regions of the country but also relieves current congestion on the grid including new transmission lines to deliver wind power to electricity consumers. Figure [9] conceptually illustrates the optimized use of wind resources within the local areas as well as the transmission of wind-generated electricity from high-resource areas to high-demand centers.... Figure [10] displays transmission needs in the form of one technically feasible transmission grid as a 765 kV overlay."^{45,46}

- More than 50 percent of the renewable generation poised to satisfy California's Renewable Portfolio Standard in the next few years has identified transmission as a risk factor (second only to availability of the production tax credit/investment tax credit).⁴⁷ As of July 2008 in California, "361 [transmission] interconnection requests totaling more than 105,000 megawatts (MWs) are pending in the interconnection study process. Of these, more than 68,000 MWs are from renewable resources. These requests far exceed the California ISO historic peak demand of 50,270 MWs and also exceed the ability of the current interconnection procedures to efficiently process the requests." In response to this flood of requests, the California ISO adopted a new process in an attempt to "accelerate the development of generation needed to meet California's Renewables Portfolio Standard and greenhouse gas (GHG) reduction goals."⁴⁸

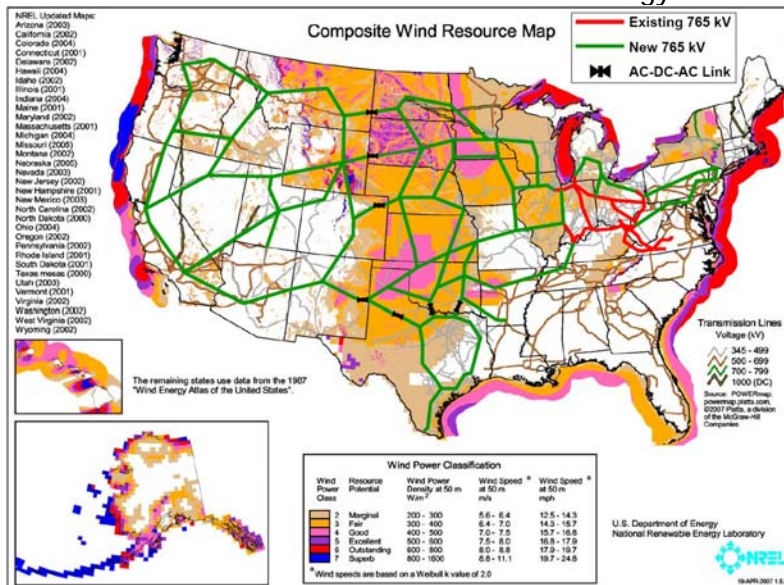
Figure 9
 Conceptual Illustration of Optimized Use of Wind Resources
 Locally and Transmitted to Distant High-Demand Centers
 Using New and Existing Transmission Facilities



Total Between Balancing Areas Transfer ≥ 100 MW (all power classes, land-based and offshore) in 2030. Wind power can be used locally within a Balancing Area (BA), represented by purple shading, or transferred out of the area on new or existing transmission lines, represented by red or blue arrows. Arrows originate and terminate at the centroid of the BA for visualization purposes; they

Source: U.S. DOE, "20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply" (hereinafter "U.S. DOE 20% Wind Report"), May 2008, page 11.

Figure 10
 Technically Feasible, Conceptual Extra High-Voltage Transmission Plan
 to Accommodate 400 GW of Wind Energy

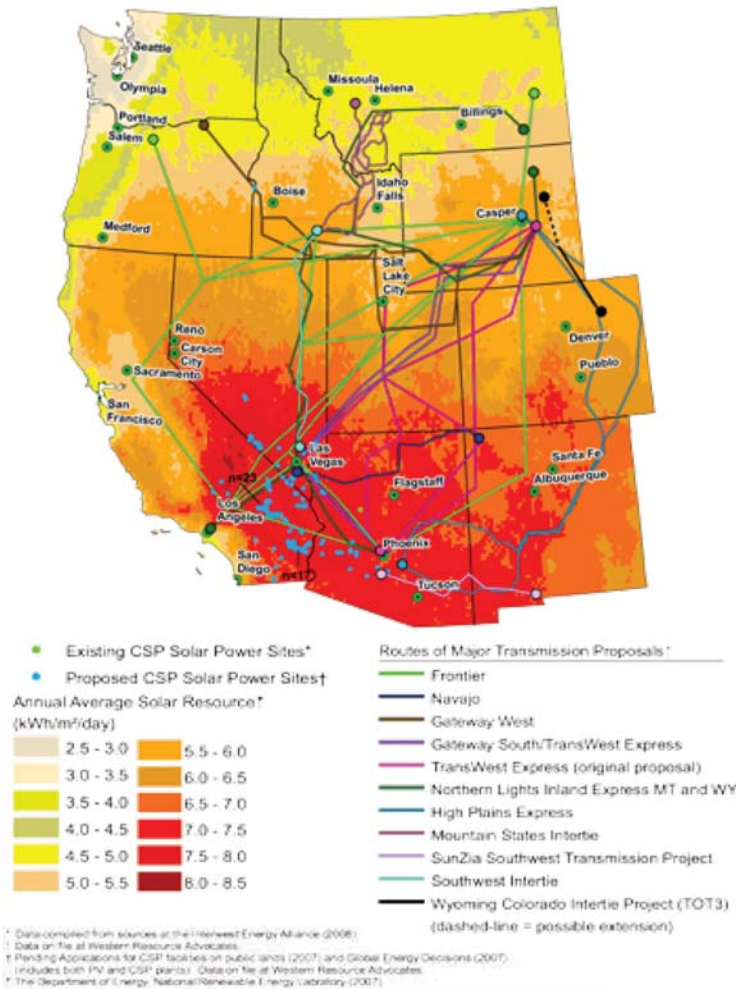


Source: U.S. DOE 20% Wind Report, May 2008, page 12, showing conceptual transmission plan prepared by AEP Transmission and AWEA.

These days, it is well understood that tapping the nation’s abundant wind resources will require a robust transmission grid – one that is much more robust than our “fathers’ system” that we have today.

Solar power and transmission: Of the two technological approaches to solar power, the centralized “solar power stations” require transmission to connect the power plant to customer load centers. Like large-scale wind development, large-scale solar power plants are well-suited to development in remote locations with rich solar resources and plentiful land. Looking at the Western areas as an example, Figure 11 maps the location of intense solar radiation against several recent transmission proposals, suggesting that solar generated electricity will need to be moved over the same transmission lines that carry not only fossil-fueled generation but also wind-generated power as well.

Figure 11
 Solar Resources and Recent Transmission Proposals in the Western U.S.



Source: WRA Smart Lines Report, 2008, page 2.

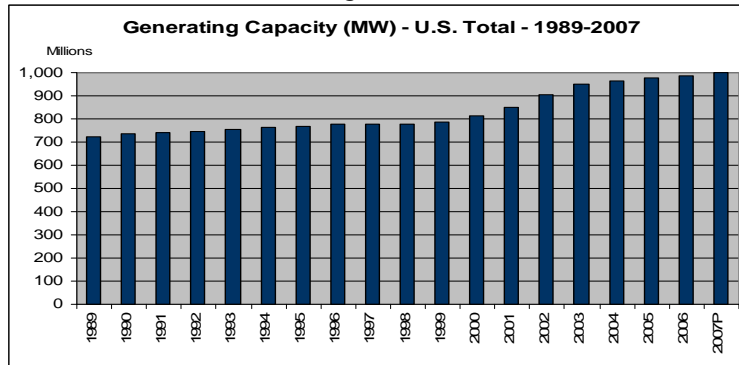
Carbon reductions and transmission: This discussion of transmission and renewables highlights the fact that today’s transmission system is not configured to move power from remote locations to metropolitan load centers. The current grid was built for 20th century power needs, linking individual utility systems (or “control areas”) over time and as needed. The needs of the system have evolved over time. Many regions have become interconnected, in part for reliability and power trading purposes, but there are still large parts of the country with significant transmission system constraints. While there are many reasons to look for more investment in the grid, there are several that are important for addressing the nation’s 21st Century requirements: (1) to increase the ability to transfer power between regions, increasing competition, allowing the electric infrastructure to be used more efficiently and to keep prices lower than they otherwise would be; (2) to reinforce parts of the system that are aging and require upgrades; and – most importantly for the purpose of this discussion – (3) to facilitate massive carbon reductions in our nation’s energy system through delivery of zero-carbon power. That final point is worth emphasizing: the nation will not be able to reach targeted and significant reductions in greenhouse gas emissions without significant changes in the transmission grid.

Therefore, we need strategic improvements in our nation’s electric transmission system.

Thus, many recent studies have concluded that ensuring adequate transmission is built to deliver power from remote renewable projects to consumers in distant markets is just as important as developing the wind resources themselves. Ironically, as the transmission system rises in importance in helping the nation to realize full development of its renewable resources, it has become increasingly clear that our transmission system has experienced significant underinvestment for many years (until quite recently, at least).

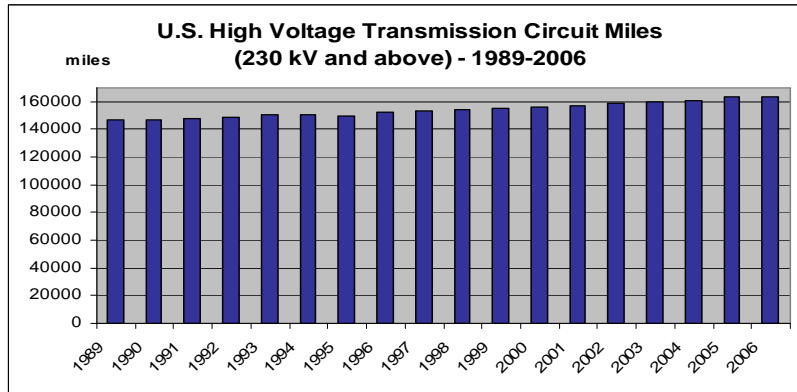
The transmission system’s role in solving these national challenges has too often been overlooked as the focus has shined on power plant investment in recent years. As demand for electricity has grown steadily over the past three decades,⁴⁹ the nation’s installed generating capacity has nearly doubled (see Figure 12). But investment in transmission has lagged (as shown in Figure 13) with many years of year-to-year declines in annual investment (Figure 14).

Figure 12



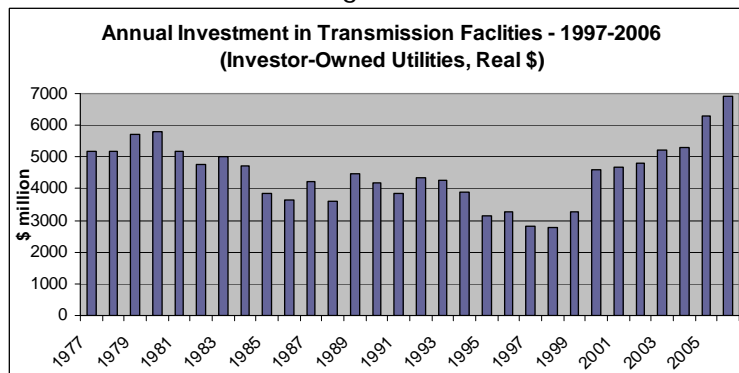
Source: EIA, Annual Energy Review, 2007, Table 8.11a, Electric Net Summer Capacity: Total (All Sectors), 1949-2007, <http://www.eia.doe.gov/emeu/aer/txt/stb0811a.xls>

Figure 13



<http://www.nerc.com/files/MilesByVoltage.doc> (accessed 8-23-08); http://www.nerc.com/files/High-Voltage_Transmission_Circuit_Miles_2005.doc; http://www.nerc.com/files/HistoricTotalMiles_95-04.doc; http://www.nerc.com/files/HistoricTotalMiles_89-94.doc

Figure 14



EI Statistical Yearbook, Table 9.1: Construction Expenditures for Transmission and Distribution, Shareholder-Owned Electric Utilities, http://eei.org/industry_issues/energy_infrastructure/transmission/Transmission-Investment-Expenditures.pdf

Continued inadequate attention to enhancing the nation's electric transmission system will undermine – if not prevent – our ability to satisfy our national economic goals while also addressing climate change and our needs for energy independence. This problem has recently been described in congressional testimony by a senior official from the U.S. DOE:

We have seen only a 6.8 percent growth in total transmission line miles in that same period [since 1996], and only 12 percent over the last two decades. While there has been an uptick in the development of new transmission infrastructure since 2005, these have typically been small upgrades needed for reliability, not components of the large, high-voltage, multistate, and inter-regional transmission network needed to deliver reliable and clean energy from remote locations to population centers.⁵⁰

Many groups from around the country, across the political spectrum and from a wide variety of constituencies have also recognized the importance of greater investment in the years ahead, especially in order to deliver power from new renewable energy projects located in remote areas to load centers located far away from the power facilities. Among those calling for much-greater attention to and investment in electric transmission are: state regulators; governors; environmental advocates; investor-owned electric utilities; public power; the wind industry; and a variety of other diverse stakeholders. A sample of statements from these groups includes:

Public power: "It is widely recognized that our current transmission system is insufficient and, in many regions, highly constrained. The weaknesses of the transmission grid not only threaten reliability, they undermine the ability of all types of generation, including renewable generation, to be developed and brought to market...If new electric generation resources, especially renewable resources, are going to be brought to market to meet increasing demand and to address climate-related concerns, substantial new transmission facilities are going to be required. Both the public and Congress must understand the need to balance the concerns of states, landowners and other groups opposing specific transmission projects against the larger public good. As some in the industry have quipped, 'if you are going to love renewables, you can't hate transmission.'"⁵¹

State utility regulators: "A robust regional electric transmission system is an essential prerequisite to support a) reliability and b) the market function allowing more generators to reach loads and compete directly for wholesale sales to such loads in order to increase competition among generation suppliers and meet national goals for renewable generation and energy independence. A new rate design is needed that will facilitate the

construction of the strong transmission backbone required to support the nation's wholesale electric markets, future increases in renewable generation capacity, and reliability." ⁵²

Western Governors: "The Western Governors' Association and U.S. Department of Energy launched the Western Renewable Energy Zones Project [WREZ] in May 2008. Utilizing those areas in the West with vast renewable resources to expedite the development and delivery of clean and renewable energy is the central goal of the WREZ project. Participating in the project are 11 states, two Canadian provinces, and areas in Mexico that are part of the Western Interconnection. The WREZ project will generate: [1] reliable information for use by decision-makers that supports the cost-effective and environmentally sensitive development of renewable energy in specified zones, and [2] conceptual transmission plans for delivering that energy to load centers within the Western Interconnection [with the goal of adding 30,000 MW of "Clean and Diversified" energy by 2015]." ⁵³

Environmental advocates: "To build a clean energy economy and seriously combat climate change, the West needs to develop large-scale renewable energy projects in renewable rich areas. A major obstacle to getting these sources on the grid and powering western homes and businesses is the availability of transmission. In fact, the U.S. Department of Energy has concluded that establishing a reliable interstate electricity-transmission superhighway is the critical requirement for achieving a 20 percent wind-power goal...Current proposals call for at least 9,000 linear miles of new or upgraded power lines and associated rights-of-way in the West. Not all of these proposals will materialize, but it is clear the region needs a significant expansion of its aging power grid to accommodate renewable energy development. Creating this clean energy transmission grid won't require new technical breakthroughs. But it will entail new impacts to federal lands because the best renewable resources have inadequate or no access to transmission. That means the active participation and cooperation of Westerners is necessary to ensure acceptable projects are developed in a timely manner." ⁵⁴

Electric utility executive: "We at Xcel Energy applaud the DOE, NREL, and AWEA's combined efforts and complex analytics in developing the 20% Wind Vision Report. As the nation's number one retail provider of wind energy, we agree that reliable integration of large amounts of wind power, especially in areas with concentrations above the 20% level, will require geographic dispersion, larger balancing areas, improved bulk transmission system transfer capability and improved forecasting and grid

control technologies to effectively control for the variability in wind generation output. We would add to the integration discussion the need for responsive gas and hydro generation and new energy storage technologies. We look forward to working with AWEA, our fellow utilities, and technology vendors to meet these challenges as the U.S. advances along an aggressive renewable energy path."⁵⁵

North American electric reliability organization: "Significant investment in transmission is still required in many areas of North America as projected transmission additions lag behind demand growth and new resource additions in most areas.Though investment is increasing in some areas, lagging investment in transmission resources has been an ongoing concern for a number of years. More investment is required, as each peak season puts more and more strain on the transmission system, especially in constrained areas such as the Northeast, California, and southwestern U.S., as well as parts of Ontario, Canada."⁵⁶

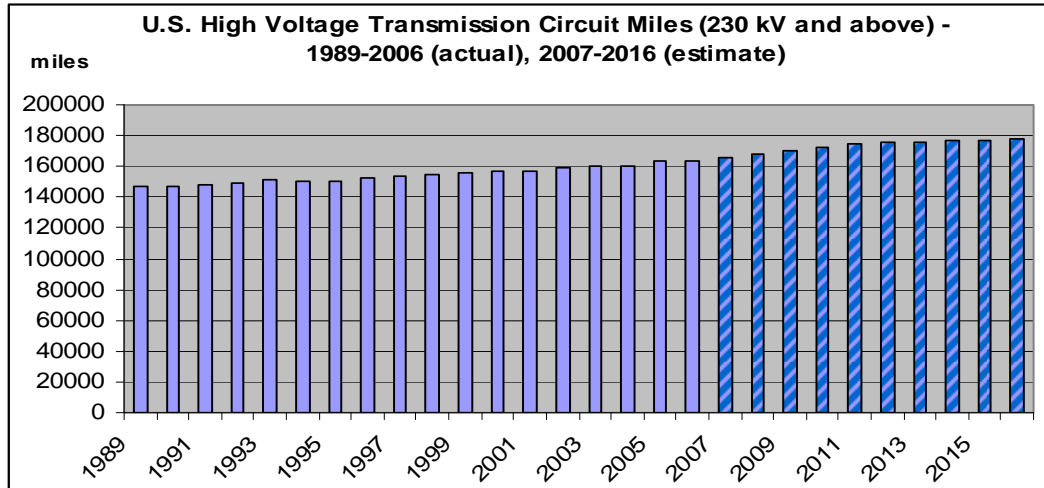
Diverse stakeholders in the electric industry: "Expansion of the physical transmission infrastructure is critical to ensuring a reliable and economical electricity system, as are increasing demand-side resources, adding generation capacity, improving operating procedures, and developing new transmission technologies."⁵⁷

U.S. DOE: "...[L]ack of transmission availability remains a primary barrier to wind development. New transmission facilities are particularly important for wind power because wind projects are constrained to areas with adequate wind speeds, which are often located at a distance from load centers. In addition, there is a mismatch between the short lead time needed to develop a wind project and the lengthier time often needed to develop new transmission lines. Moreover, the relatively low capacity factor of wind can lead to underutilization of new transmission lines that are intended to only serve this resource. The allocation of costs for new transmission investment is also of critical importance for wind development, as are issues of transmission rate 'pancaking' when power is wheeled across multiple utility systems, charges imposed for inaccurate scheduling of wind generation, and interconnection queuing procedures."⁵⁸

While many electric utilities and other transmission companies have plans to invest in new transmission capacity and miles on the transmission system (See Figure 15), these plans are broadly viewed as insufficient at present to address the 21st Century requirements of moving significant quantities of electricity

produced by renewable energy in remote locations to customers located far away.

Figure 15



NERC Transmission Circuit Miles, <http://www.nerc.com/files/MilesByVoltage.doc> (accessed 8-23-08), http://www.nerc.com/files/High-Voltage_Transmission_Circuit_Miles_2005.doc, http://www.nerc.com/files/HistoricTotalMiles_95-04.doc, http://www.nerc.com/files/HistoricTotalMiles_95-04.doc.

The interconnected, high voltage transmission system offers a wide range of well-known benefits.

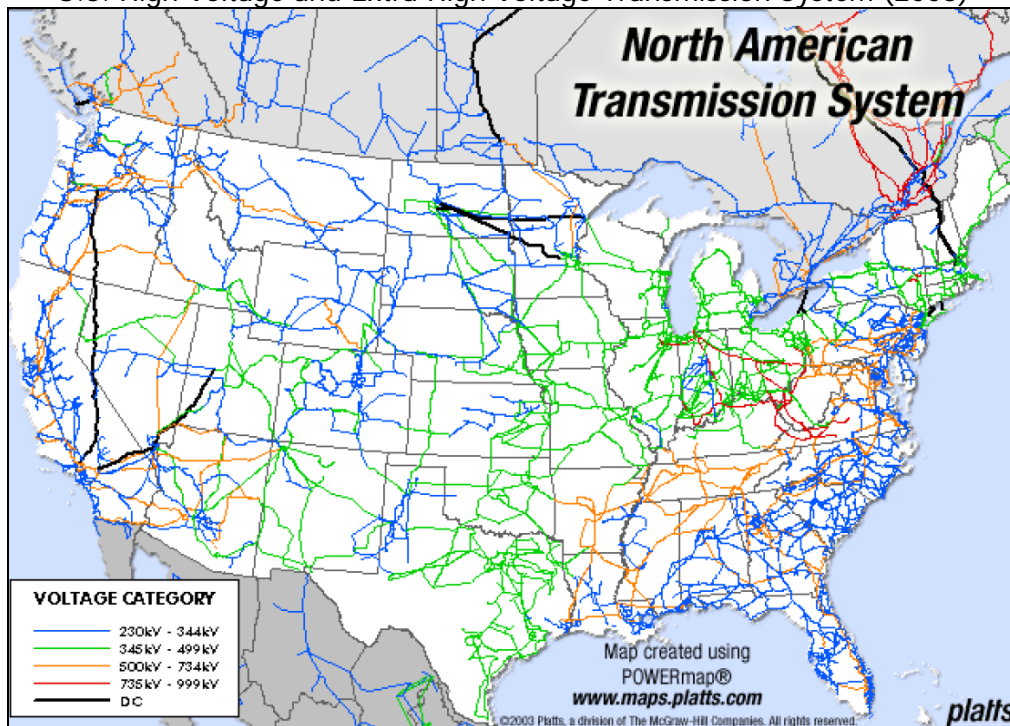
The nation's transmission grid has gradually evolved over the last half-century, growing in size, complexity and scope. Early on, electric systems were made up of small power plants connected to local distribution systems that fed power to customers along low-voltage, local power lines. Over time, small systems owned by one utility connected to one another and power began to flow across longer distances; these changes gradually warranted increases in line voltage in order to avoid inefficiencies in the form of losses on the distribution and transmission system. Longer distances meant a larger circle of customers feeding off the system; these larger customer demands began to justify the economics of constructing and operating larger power plants, some of which exhibited economies of scale. Eventually, the nation's collection of small, local electric systems evolved into the present series of interconnected systems.

Figure 16 shows a snapshot of the complex network of high-voltage transmission lines crisscrossing the country. As shown, there is a complex network of lines. Except for a few large "direct current" ("DC") lines, the rest of the system uses alternating current ("AC"). At the lower end of "high voltage" ("HV") lines are 115 kV (not shown on this map), 230 kV and even 345 kV lines; at the "extra high voltage" ("EHV") end are lines of 500 kV and above (e.g., 765 kV).

As shown on Figure 16, there are few EHV lines today in the middle of the country, in part a result of the more historically rural character of the Plains

states with lower density of population and lower overall electricity loads. In fact, in some parts of the country, 230 kV lines provide the backbone of the transmission system. The higher voltage lines in other areas reflect the combination of larger power plants, concentrations of populations around metropolitan loads centers, and historical investment patterns for transmission systems that led to larger and higher voltage transmission lines. At various points along these HV and EHV systems, there are substations where transformers change voltage levels up or down. Most of these facilities outside of the most densely developed urban areas are above ground.

Figure 16
U.S. High Voltage and Extra High Voltage Transmission System (2003)



Source: Platts

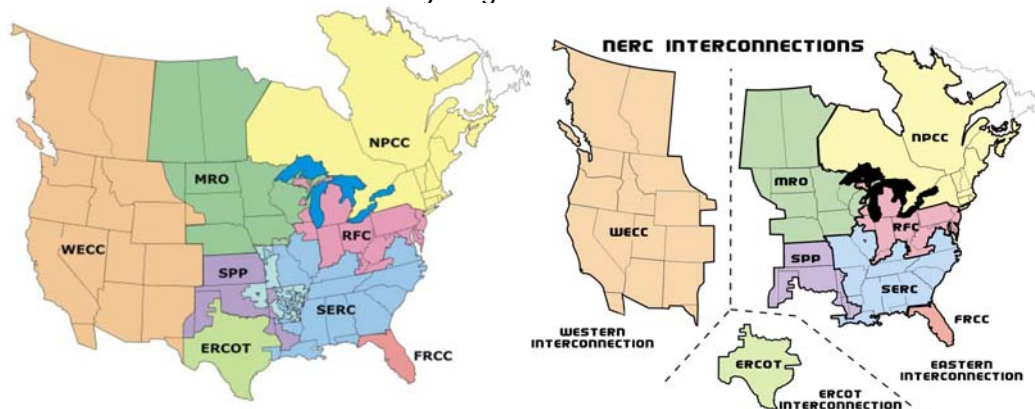
Like the highway system, with ownership of lines by states, the federal government and others, the different components of the electric transmission system – power lines, substations, and other facilities – are owned by hundreds of entities, including publicly owned federal utilities, many large and small investor-owned utilities, federal power authorities, some other publicly owned utilities, and some merchant transmission companies.

These entities developed elements of their systems in a piecemeal fashion, largely to serve the needs of relatively small areas served by individual utilities. In recent decades, as groups of utilities banded together in "power pools," as utilities merged and consolidated in some areas, and as some regions instituted "regional transmission organizations" serving relatively large electrical areas (as

shown in Figure 8), transmission system elements have been planned for larger areas. This has led over time to investment in higher-voltage transmission infrastructure. Their networks of facilities are interconnected to one another, making up the grid shown in Figure 16. Power flows over the interconnected networks according to the laws of physics, rather than according to ownership of the facilities or state boundaries.

There are three, fully interconnected electrical networks spanning the lower 48 states: the “Western Interconnection,” connecting the Rockies and Western states; the “Eastern Interconnection,” linking the states of the Plains and the East; and the “Electric Reliability Council of Texas” (“ERCOT”), serving most of Texas. As shown in the maps in Figure 17 which indicates the different electric reliability regions (on the left) and interconnections (on the right), the Western Interconnection is the same area as the “WECC” reliability region (the Western Electricity Coordinating Council); ERCOT is the same area on both maps and serves most of Texas; and the other reliability regions together make up the Eastern Interconnection.⁵⁹

Figure 17
Electric Reliability Regions and Interconnections



Source: NERC, 2008 Summer Reliability Assessment, May 2008, page 5.

The benefits of high-voltage transmission have been understood for decades and contribute to the overall reliability and economic efficiency of the power system. Although it is sometimes hard to distinguish a bright line between reliability and economic functions, high voltage lines allow for: power production systems to assist one another as system conditions change over time; the grid to remain flexible as conditions on the system change from moment to moment; various regional systems to install less power plant capacity locally, because they share reserves through transmission interconnections; movement of electricity produced in one area to another; and other benefits.

Moving power from one place to another allows power to be delivered to customers in homes, offices and factories located far away from the power plants that produce their power. High voltage systems provide utilities and their customers with access to lower-cost, diverse power supplies available at different

times in different regions. These interconnected networks allow for inter-regional trading which can help drive down overall power production costs. They reduce a system's vulnerability to extreme conditions and catastrophic events (including long-term power plant outages or extreme weather conditions causing high use of electricity). They allow regions with plentiful energy supplies to develop them for distant markets, gaining economic development, tax revenues, and jobs. They also move power from resource-rich basins (e.g., hydroelectric power, wind resource areas) to consumers in other regions.

Decisions about what level of voltage is appropriate in certain circumstances are driven by many factors. The most important tend to be tied to technical and non-technical trade-offs in: desired degree of carrying capacity (e.g., rated electrical capacity of the lines); construction costs (e.g., dollar-per-mile of construction); siting issues (e.g., width of the right-of-way, height of the transmission towers); land and environmental issues (e.g., availability of corridors for development of new and/or expanded lines); fit with the configuration of existing facilities (e.g., power loadings and flows across the new and existing parts of the system); permitting issues (e.g., ability to demonstrate need for a particular facility in order to obtain any necessary approvals from regulators); percentage of power that is lost as a result of transmission; the geographic size of the utility's service territory; the institutional arrangements that exist for joint planning and cost support for transmission lines; perceptions relating to the degree of regulatory certainty over investment recovery; limits and conflicts among state and federal entities with authority over construction, cost-recovery and other issues; chicken-and-egg problems relating to whether transmission or generation should proceed in tandem or serially; and attitudes of decision makers (e.g., utilities, their regulators, abutters, elected officials) about the value of and risks relating to investing in and building transmission facilities for the benefit of others.⁶⁰

With this array of trade-offs, it is no wonder that the nation's transmission system is composed of elements that have gradually been added in incremental pieces over time. And it is no wonder that the litany of features have been so strongly and widely identified as serving to inhibit full development of cost-effective and needed electricity projects using the nation's abundant but geographically remote renewable resources.

Given the 21st Century requirements for clean, reliable and affordable electric supplies in a carbon-constrained world, significant enhancements can be provided by extra-high-voltage transmission.

A robust EHV transmission system connecting regional electrical systems could dramatically enhance the nation's power system and the services it provides to electricity users, while also providing access to valuable renewable resources. It could serve to modernize the nation's electrical grid. It could strengthen electric reliability and clean power development by linking systems and regions. It could

move power efficiently, with lower line losses as power moves from one place to another, and with improved operational flexibility. And it could move power in environmentally acceptable ways by using limited transmission corridors and land resources efficiently.

Electric system modernization: When done in parallel with other enhancements to the system, EHV is part of the 21st Century electrical system. These enhancements would improve both the customer end of the system, the sources of power supply, and the links between the two.

Collectively, examples of needed electric system enhancements for the 21st Century include:

- Aggressive development of demand-side measures and distributed generation to make our electricity use more efficient and resilient with resources located physically close to customers. As discussed previously, there are large amounts of energy savings available through cost-effective energy efficiency measures and active discussions are underway on how to implement what's needed in a "national action plan for energy efficiency."⁶¹
- Investment in smart meters and other energy management systems to give customers greater control over their energy use. There are parallel, active discussions on how to advance such technologies.⁶²
- Investment in advanced power generation technologies with low greenhouse gas emissions. Significant attention to this topic is being developed in policy, technology and investment circles, as described at the beginning of this paper.⁶³
- EHV transmission, connecting regions rich in resources with customer markets. This element of the framework needs newly focused attention and a new vision for the nation's transmission system, aimed more at interregional benefits and opportunities as compared to the historical focus on transmission as local infrastructure supported in local electricity rates.

Facilitating clean power development while enhancing both energy security and reliability: An EHV overlay system would allow renewable resources to be developed and brought to market.. It could enable regions that are rich in indigenous clean energy, like those in the Plains states, the Southwest, the Rockies, and in offshore areas, to develop economically and supply power to areas in need of cleaner power supplies.

While the last-decade's discussions about the need to enhance inter-regional power markets focused on reaping benefits from greater competition (through power trading), this decade's focus must be on how to tap our nation's domestic energy supplies in ways that support energy security, economic development, efficient energy supplies, and significant greenhouse gas reductions.

In many segments of our economy – agriculture, banking, tourism, ports, and high-tech industries, to name a few – the regions of our country depend upon each other for producing goods and services for both local and distant American consumers. This is true in our energy markets generally, with the Gulf States producing much of the nation's domestic oil and gas supplies; oil refineries located in states as diverse as California, Illinois, Texas, New Jersey, and Pennsylvania, providing gasoline and other petroleum products; the Rockies and Appalachian areas providing coal to supply half of the nation's electricity; fields in the Midwest providing grain for biofuels; rivers in the Pacific Northwest providing hydroelectric power for use by Western electricity consumers; ports in Massachusetts and Maryland providing access to global liquefied natural gas supplies for consumers in the Northeast; and wind resources in the Plains, Texas and other parts of the Southwest providing electricity to the local regions. No region of the country is self-sufficient today from an energy point of view, or in terms of providing for itself the array of goods and services needed for our standard of living.

Like its domestic supply of fossil fuels, the nation's endowment of clean and indigenous energy resources is not spread evenly across the states. Wind, biomass, solar, hydroelectric, geothermal, and cost-effective energy efficiency improvements are located in different regions of the country. While some (e.g., end-use efficiency improvements) can be produced and consumed locally, others (e.g., wind, biomass, solar) offer potential resource development more plentiful than the amounts local residents can use. The opportunities for clean power development often exist in areas of the country with relatively low populations and a small share of the nation's electrical demand. Based on data from the American Wind Energy Association and the U.S. Census Bureau, AEP estimates that, excluding Texas, only seven percent of the nation's population lives in the ten states with the most wind potential.⁶⁴ Furthermore, most of the population lives in metropolitan areas that lack the kind of strong winds needed for power production; as noted by David Garman, then U.S. Assistant Secretary of Energy for Energy Efficiency and Renewable Energy, "...where the wind blows tends to be where people don't want to live, and the population and load centers are often quite distance from the best wind resource sites."⁶⁵

Many constituencies recognize today's realities – that (a) there are important economic, environmental and national security values that deploying renewable resources can provide for the nation; and (b) our "business as usual" approach to transmission (both planning and investment) is impeding our ability to tap fully the nation's rich, indigenous reserve of renewable resources, especially wind. As so eloquently stated by an environmental advocacy group with regard to these issues in the West:

In a very fundamental way, the nation's renewable energy transformation hinges on the ability to bring these resources to the market. Two key facts underscore the important role transmission will play in the region's new energy economy. First,

many of the region’s best renewable energy resources—Wyoming’s impressive wind resources are a perfect example—are far from major population or ‘load’ centers. Renewable energy generation is place-dependent—wind farms need to be built where it’s windy; solar plants where it’s sunny. Wind, solar and geothermal potential cannot be shipped via rail or pipeline to a power plant for energy production. Generation must take place on-site. Sufficient transmission must be brought to these places in order to bring clean energy resources to market. Second, the existing power grid in the West is inadequate, both in terms of physical location and overall carrying capacity, to accept large quantities of renewable energy. New and upgraded power lines will be the missing link that brings the West to a new and prosperous energy economy befitting the 21st century....Given the vast scale of this development, it will be essential to site and configure new energy infrastructure to minimize environmental impacts.⁶⁶

Using EHV transmission to link regions of producers and consumers offers important opportunities to tap our local energy supplies, develop local jobs, and allow access to cleaner power production in an efficient and reliable way.

The Southwest Power Pool, the grid operator in parts of the south central U.S., recently began a planning initiative to explore the long-term development of an EHV overlay transmission system. As detailed further in Appendix A, the SPP includes Oklahoma, other plains, and rural southwest areas with relatively strong wind development potential, but the region’s current transmission grid is composed primarily of relatively low voltage lines. SPP’s initial analysis of a potential EHV overlay recommended the development of a \$4.9 billion, 765 kV loop and extensive 500 kV upgrades to interconnect the RTO with nearby electric systems. SPP sponsored a second analysis in 2008 which estimated the required investment at more than \$6 billion by 2026, but found that the many benefits of such an EHV overlay would exceed the costs.

Moving power efficiently and reliably: The SPP case study presents many of the features of an EHV approach to transmission planning – including moving power efficiently and reliably while minimizing environmental impacts. These types of benefits have also been identified in a number of studies and evaluations in other regions of the country.

First, EHV systems provide **capacity to transfer power (including wind) from one region to another at a relatively low cost.** As described by the U.S. DOE in its study of what it would take to meet a 20 percent renewable power target:

Wind energy development requires two types of transmission. Trunk-line transmission runs from areas with high-quality wind resources and often carries a high proportion of energy from wind

and other renewable sources. The second type is backbone high-voltage transmission across long distances to deliver energy from production areas to load centers. These superhighways mix power from many generating areas, sources, and shippers—just as a highway carries all types of vehicles traveling a range of distances.When determining whether it is more efficient to site wind projects close to load or in higher quality wind resources areas that are remote from load and require transmission, the WinDS optimization model finds that it is often more efficient to site wind projects remotely. In fact, the model finds that it would be cost-effective to build more than 12,000 miles of additional transmission, at a cost of approximately \$20 billion in net present-value terms.”⁶⁷

EHV systems can enable the addition of more transmission capacity to transport large quantities of power at a lower cost than an equivalent amount of transmission using lower voltage facilities. According to AEP Transmission, which has extensive experience in constructing and operating EHV systems,⁶⁸ there are inherent cost advantages of EHV lines in certain conditions. In fact, for 2,400 MW of transmission capacity, EHV (765 kV) lines can cost less than one-third of what it would cost to install a lower voltage (356 kV) line per mile, as summarized in Table 1 below.

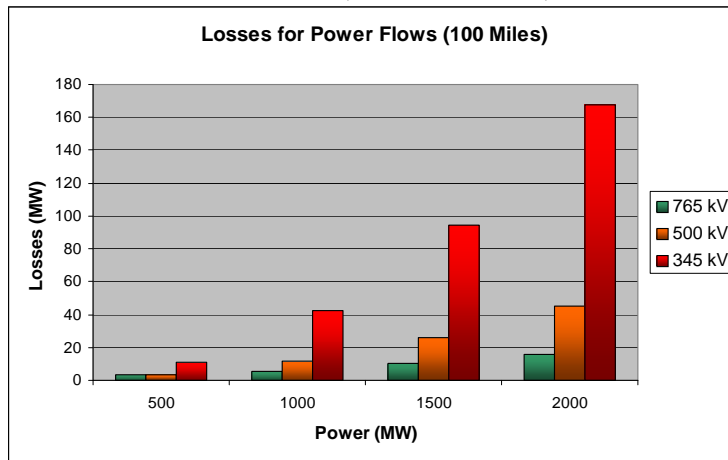
Table 1 Transmission Needed to Deliver 2,400MW over 100 Miles			
	765 kV	500 kV	345 kV
Conductors per phase	6-bundle	3-bundle	2-bundle
SIL* per line	2400 MW	910 MW	390 MW
Lines required for 2,400 MW capacity	1	3	6
Width required	200 Ft.	600 Ft.	900 Ft.
Average cost per mile for 2,400 MW capacity**	\$2.6 million	\$6.9 million	\$9.0 million
<p>* “SIL” = surge impedance loading, which is a measure of relative line loadability at the reactive power balance point without voltage support. Thermal capacities vary; e.g., 765-kV can carry well over 4,000 MW; 500-kV can carry over 2,000 MW.</p> <p>** Average single-circuit construction costs in 2006\$; rural terrain with rolling hills; includes siting and right of way costs; excludes station costs.</p> <p>Source: Heyeck, Michael, “The Next Interstate System: 765-kV Transmission – AEP advocates a 765-kV transmission overlay for the entire United States,” Electric Light and Power, 2007, http://uaelp.pennnet.com/display_article/284510/34/ARTCL/none/none/1/The-Next-Interstate-System:-765-kV-Transmission/ http://uaelp.pennnet.com/articles/enlarge_image.cfm?IMAGE_ID=238225&SITE_ID=ELP</p>			

SPP found similar cost advantages to EHV systems in its own analyses. It found that the cost per mile of a single-circuit 765 kV line is \$2.2 million per mile, while the cost for an equivalent amount of capacity was \$4.2 million per mile using

three 345 kV double-circuit lines, and \$6.0 million per mile using six 345 kV single-circuit lines.⁶⁹

Additionally, EHV transmission systems move power with **far lower line losses** and other impacts over long distances.⁷⁰ All else equal, lower line losses mean that less electricity needs to be generated at power stations to meet a given amount of electric demand – with less fuel consumption, lower cost, and lower environmental emissions. When transmitting power over long distances, relative losses decrease with higher voltages, especially as loading increases – meaning that the more power is moved on the line, the more an EHV provides savings (in avoided losses) as compared to a lower-voltage system. Figure 18 compares the line losses of various voltage systems for power flows over 100 miles.

Figure 18
Comparing Line Losses of 345 kV, 500 kV and 765 kV Line
for Power Flows (Over 100 miles)



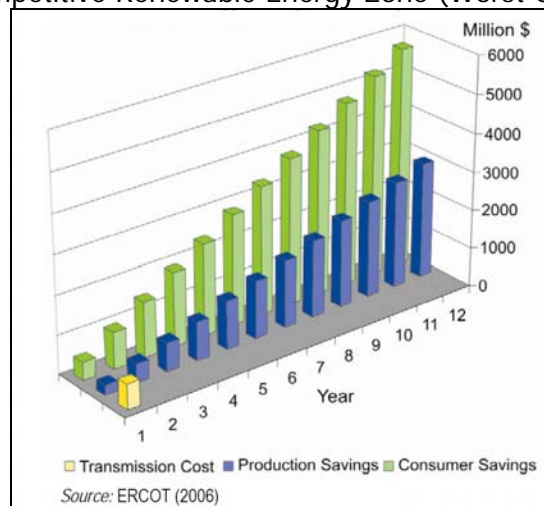
Source: Evan Wilcox, “765 kV Transmission System Facts For the Southwest Power Pool (SPP) Cost Allocation Working Group,” May 28, 2008, page 17.

EHV facilities can **reinforce the reliability of an overall regional transmission system**. According to one study that examined the causes, conduct and impacts of the large electrical blackout that occurred in the Northeast U.S. in August 2003, “[h]igher voltage lines and more densely networked lines, such as the 500-kV system in PJM and the 765-kV system in AEP, are better able to absorb voltage and current swings and thus serve as a barrier to the spread of a cascade.”⁷¹ Additional reliability reinforcements were found in New York State during the same blackout, in light of New York’s own 765 kV system elements.⁷² More generally, AEP has described these reliability benefits as follows: “[t]ransmission at 765-kV also offers greater reliability due to its line design. With only one line outage per 100-mile year, 765-kV reliability surpasses all other voltage classes.”⁷³

By providing greater ability to transport power across a wider electrical – and market – region, EHV facilities can also provide **significant dispatch savings**. This occurs as a result of relieving congestion and allowing wind energy (with zero fuel costs) to displace energy produced at more expensive power production facilities (that use fossil fuels).

The U.S. DOE study analyzing the implications of meeting a 20 percent renewable power target found that there were potentially large economic savings from enhancing the grid to deliver power from fuels with low fuel and production costs. For example, the study reported the results of analyses examining the cumulative production and consumer savings relative to transmission costs that would be associated with developing the “worst case” Competitive Renewable Energy Zones in Texas. As shown in Figure 19, even for this worst case (i.e., highest-cost transmission option), the cumulative production savings exceeded the total transmission costs, producing significant savings for consumers over the study period.

Figure 19
Cumulative Production Cost Savings, Consumer Savings and Transmission Costs: Competitive Renewable Energy Zone (Worst Case Option)



Source: U.S. DOE 20% Wind Report, May 2008.

There have been a wide range of economic studies of transmission system enhancements for moving power from areas rich in renewable resources. The U.S. DOE 20% Wind Report reviewed and summarized a number of these studies, observing that “[d]eveloping any major new generation sources in remote or semi remote locations will require new transmission to deliver the energy to loads. As long as load continues to grow, investment in transmission will be needed as well. Most high-voltage transmission additions serve multiple generation resources, not just wind. Once the marginal transmission cost for wind is balanced against its low energy cost and environmental impacts, the net

costs might turn out to be not much greater in the portfolio context than the transmission costs of traditional fossil fuel resources."⁷⁴

Among the studies reported by the U.S. DOE 20% Wind Report were:

- Studies for the Mid-Atlantic region: In the PJM system, "where several 765-kV projects have been proposed, 900 miles of new transmission would cost approximately \$3.5 billion, or 0.1 cent/kWh in amortized rates for consumers in the PJM system, a high-cost area for new transmission construction [fn]. Under optimistic assumptions, the rate impact of the transmission portion of the 20% Wind Scenario could be as low as \$1.30 per residential customer per month. But this cost would be partially offset by the benefits of access to lower cost resources and enhanced reliability. The cost of new transmission, then, might not be excessive or prohibitive for customers. In any case, and as long as electricity demands grow, new transmission will be required to serve any new generation developed, and incremental transmission costs will be unavoidable."⁷⁵
- Studies for the Western Region: In 2006, the Energy Advisory Committee of the Western Governors' Association's Clean and Diversified Initiative ("CDEAC") "evaluated a 'high renewables' case and found that it would require an additional 3,578 line miles of transmission at a total cost of \$15.2 billion [fn]. This transmission investment would access 68.4 GW of renewable generation (predominantly wind) and 84.6 GW of new fossil fuel generation. Under the CDEAC analysis, if half of the transmission cost is assigned to wind, the resulting cost would be approximately \$120 per new kilowatt of wind developed. This represents about a 7% increase in the capital cost of wind development (based on capital costs for a wind energy facility of about \$1,800/kW)."⁷⁶
- Studies for the Midwest area: "The Midwest ISO compared the benefits and costs of bringing 8,640 MW of new wind energy online. Using a natural gas price of \$5 per million British thermal units (MMBtu; well below 2007 prices), the annual benefits of reduced natural gas costs from new transmission and development of wind generation were between \$444 and \$478 million [fn]. The Midwest ISO recently studied the costs of developing 16,000 MW of wind within its system, along with 5,000 miles of new 765-kV transmission lines to deliver the wind from the Dakotas to the New York City area. Although the overall generation and transmission costs reached an estimated investment of \$13 billion, the project produced annual savings of \$600 million over its costs. These savings are in the form of lower wholesale power costs and prices in the eastern part of the Midwest ISO footprint—such as Ohio and Indiana—resulting from greater access to lower cost generation in the western states such as Iowa and the Dakotas."⁷⁷
- In Texas: ERCOT recently "evaluated 12 options to build transmission for additions of 1,000 MW to 4,600 MW of wind energy. ERCOT found that the transmission addition would cost between \$15 million and \$1.5 billion,

depending on the distance required. The transmission cost averages \$180/kW of wind energy, or about 10% of the \$1,800/kW capital cost [fn]. The benefits available from such transmission are often reported in terms of annual savings to consumers and the reduced cost of energy production...It should be noted that wind transmission cost estimates remain highly uncertain. For example, ERCOT recently updated their earlier study and found that for additions of 5,150 MW to 18,000 MW of wind energy, the transmission addition would cost between \$2.95 billion and \$6.38 billion, or in the range of \$350/kW to \$570/kW [fn]."⁷⁸

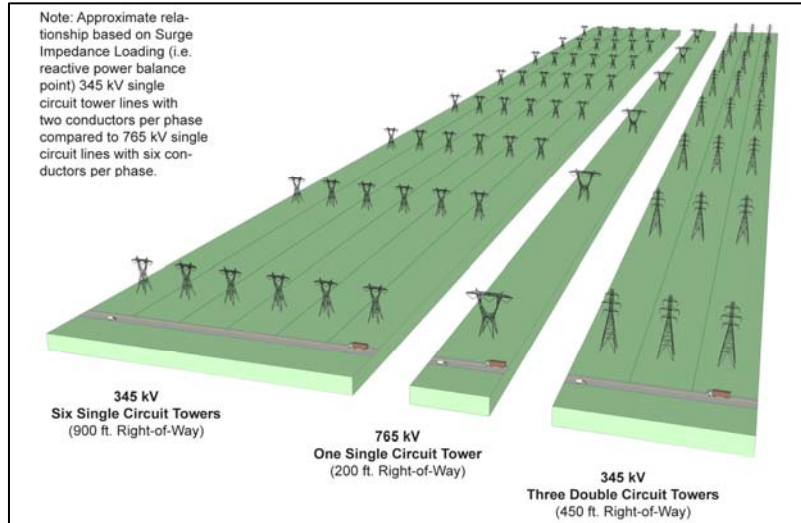
Additionally, EHV systems can provide **economic and reliability benefits because they interconnect larger electrical areas which are better able to handle the operational issues associated with intermittent resources** like wind. As described by the U.S. DOE, larger electrical regions improve the important "balancing function" for regions with wind power resources. "To maintain stable operation of the electric system, the amount of generation supplied must balance with the load instantaneously. If the generation and load are not in balance, the system could potentially suffer a loss of either or lose stability and collapse...Wind units operate in a parallel situation across multiple balancing areas. As indicated previously, geographically dispersed wind units produce electricity more consistently and predictably. Similarly, when a system is operating across a larger area, more wind generators are available to offset customer demands, making the resulting load net of wind less variable and more predictable."⁷⁹

In addition, all else equal, the **ability of regions to share reserves** and to back up each other's systems can lead to a reduction in the amount of installed generation capacity needed to maintain high-performing, economical and reliable electrical systems.

EHV systems can also offer benefits by **moving power in environmentally acceptable ways**. EHV systems do this by being able to move more power over a given right-of-way, thereby enabling fewer lower capacity lines to be built. A 765-kV line requires less land used for right-of-way as compared to the multiple, lower voltage lines that would be needed to carry an equivalent amount of power from one region to another.

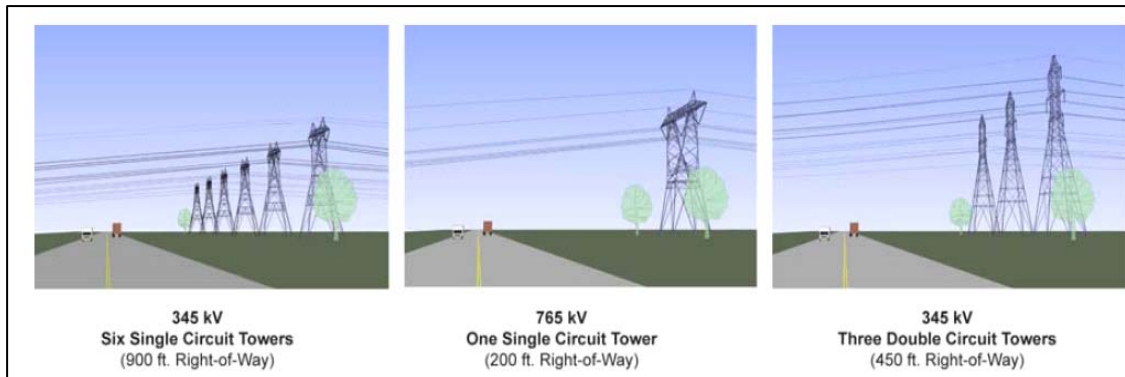
AEP Transmission has shared its experience in constructing EHV transmission, in comparison to lower-voltage transmission systems. Figures 20 through 22 illustrate the lower environmental "footprint" of EHV facilities. Figures 20 and 21 show the ways in which EHV can utilize land in a transmission corridor relatively more efficiently than lower voltage lines. Figure 22 shows the comparative heights of towers of transmission lines of different voltage levels and demonstrates that the towers of EHV and lower voltage systems are similar in stature and visual impact.

Figure 20
765 kV Transmission Facilities:
Higher Utilization of Right-of-Way Minimizes Landscape Footprint:



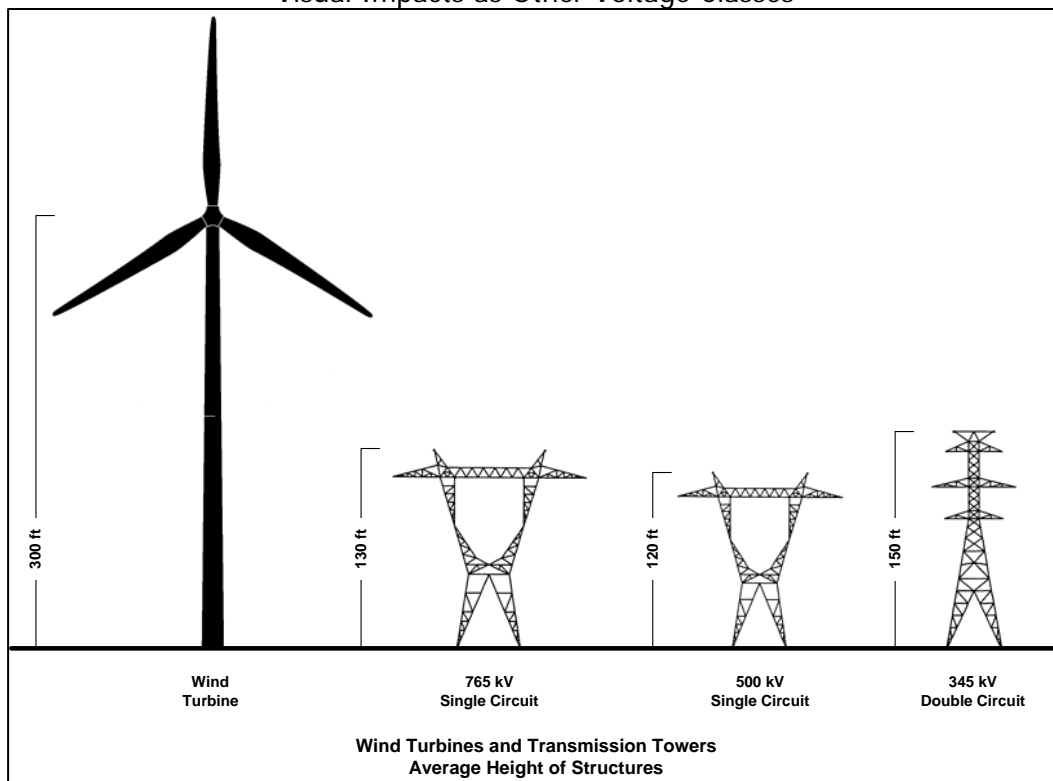
Source: Evan Wilcox, "765 kV Transmission System Facts For the Southwest Power Pool (SPP) Cost Allocation Working Group," May 28, 2008, page 13.

Figure 21
765 kV: More Lower-Voltage Lines are Needed for Equivalent Capacity



Source: Evan Wilcox, "765 kV Transmission System Facts For the Southwest Power Pool (SPP) Cost Allocation Working Group," May 28, 2008, page 15.

Figure 22
765 kV Transmission Facilities: Towers are Similar in Stature and
Visual Impacts as Other Voltage Classes



Source: Evan Wilcox, "765 kV Transmission System Facts For the Southwest Power Pool (SPP) Cost Allocation Working Group," May 28, 2008, page 14.

Of course, environmentally friendly power transmission doesn't occur automatically, whether for lower voltage or EHV systems. Developing transmission capacity – even to carry renewables – still has environmental impacts and requires care to assure that these impacts are minimized, to the extent possible. Minimizing siting, construction and operational impacts, along with using existing rights of way as efficiently as possible, are important objectives as regions consider the other economic, reliability, security and environmental benefits of using EHV systems for transmitting renewable power.⁸⁰

Achieving the nation's requirements for clean, reliable and affordable supplies requires a new vision for a 21st Century "Interstate Electric Highway System."

As recently as 2005, Congress articulated the national interest in ensuring a reliable and modern electric grid. Many of the changes introduced by the Energy Policy Act of 2005 ("EPACT") and implemented since then have pointed to the

importance of transmission in assuring a secure, robust and reliable electric system.⁸¹

Those recent changes were necessary but not sufficient to focus attention on the transmission-related resources and investment we need. Just as the nation adopted the National Interstate Highway system over 50 years ago to usher in a new era of mobility, interstate commerce and economic development, it is time to usher in a new era of electric transmission.

Lessons from the Interstate Highway System: A half century ago, leaders in America launched a program to connect the cities and countryside of the United States in a national, interstate highway system. The vision was to unite the states through a web of highways, providing a foundation for national security, commerce, recreation, and development.⁸² The system has sometimes been called the largest public works project in U.S. history.

Americans funded the interstate highway system primarily through federal dollars,⁸³ and it now links major U.S. cities, connects workers to their jobs, and carries most of the goods and services in our country at some point along their way. People and commerce move across state lines, without regard to the origins of the products or the trips, or their destinations in one state or another. It is hard to imagine the shape of commerce and recreation in America in the absence of this national, interstate transportation system. And it is easy to believe that the original estimates of the system’s value barely scratched the surface of the actual returns we have realized from the nation’s investment in our interstate highway system.⁸⁴

A parallel “interstate system” is now needed to build another critical plank in the infrastructure required for 21st Century American national security, prosperity and environmental progress. This one – built primarily through private investment – stems from a different vision of creating stronger connections to enhance the nation’s electric grid and to give Americans access to the domestic energy resources vital to our national security and energy independence.

Like the national highway system that began with initial legs in the middle of the country,⁸⁵ a national EHV overlay built to connect the nation’s heartland – with its wind, biomass, and solar resources – will help to produce economic development, strengthen energy independence, and satisfy customer demand in markets throughout the country. (The SPP’s initiative to support wind power development and deployment exemplifies the type of interstate EHV transmission system that could be designed in conjunction with many parts of the country to enhance today’s lower-voltage transmission infrastructure.)

Like the national highway system that benefited from interstate planning and whose value was difficult to estimate at the time, a national EHV overlay should build on inter-regional transmission planning efforts aimed at establishing a modern system whose benefits may be realized over time and in ways not imagined by today’s planners and analysts.

Long-standing and new regional transmission planning efforts, together with evolving federal policy, have shifted attention toward **regional planning for transmission systems for renewables**. One example is the “Joint Coordinated System Plan,” being prepared by various regional transmission organizations in the Eastern Interconnection. This joint planning process is examining the implications for transmission of a 20 percent renewables mandate by 2024.⁸⁶ State-specific efforts include the California “Renewable Energy Transmission Initiative” (“RETI”)⁸⁷ and the Texas “Competitive Renewable Energy Zone” (“CREZ”).⁸⁸ Other regional and state-level planning initiatives⁸⁹ are actively underway in various parts of the country and focus on assisting wind power development and delivery. These initiatives can serve as the platform for planning this new electrical interstate highway system.

While these initiatives are directionally supportive, we still need to move farther towards inter-regional planning for the transmission grid. Line-by-line, piecemeal investment will not support the advanced EHV interstate system we need. Like the interstate highway system, electrical transmission systems are best designed as a spider web, with strength from loops and connections, rather than in small piecemeal additions. Strengthening the system requires looking at the system as a whole.⁹⁰ As illustrated in Figure 16, the middle of the country has many low-voltage and relatively fragile systems, for example, yet very large wind resources. Opening up those markets for clean power through EHV interstate “highways” will provide benefits to both the sending and receiving regions of the clean power.

Given the strategic benefits afforded by renewable power development, transmission planning tied to encouraging renewable resources such as wind projects, utility-scale solar installations and other renewable power projects should take care to **analyze the full array of benefits and costs afforded by strategic investment in transmission**.

Currently, economic studies of transmission facilities attempt to quantify the costs and benefits to the electric system (and those who pay for it) by comparing a “base case” generation/transmission/demand scenario, with alternative cases involving transmission enhancements (and/or generation, and/or load-reduction strategies). These tend to simulate how the electric system would perform with and without the investment under consideration. The studies typically compare the overall costs to produce electricity in the different cases against the cost to build new transmission.

But historically, these types of transmission benefit/cost studies do not anticipate fully the array of direct and indirect benefits associated with the economic performance of long-lived infrastructure investments such as EVH systems. There are dynamic changes that occur in the system over its life and the benefit/cost studies of the electrical system capture some, but certainly not all, of the internal and external benefits and costs of such additions.

A recent analysis⁹¹ characterizes these studies in terms of their ability to quantify appropriately the strategic benefits of transmission projects. The analysis was prepared by a team at Lawrence Berkeley National Laboratory ("LBNL")⁹² for the Public Interest Energy Research ("PIER") program of the California Energy Commission, and conducted with the input of a technical advisory committee of industry and academic experts.⁹³ This study observed,⁹⁴ among other things, that:

Transmission benefits can be grouped into the following categories.

1. Primary Benefits: Improve network reliability – meet reliability standards and guidelines; Lower cost of energy and capacity adjusted for transmission losses as a result of reduced congestion, access to lower cost resources, and increased inter-regional power trading.
2. Strategic Benefits: Renewable resource development and integration; Fuel Diversity – lower natural gas consumption, gas prices; Emissions reduction/environmental; Market Power Mitigation; Insurance against contingencies; Development of new capacity and inter-regional trading.
3. Extreme Event Benefits: Reliability -- improve network load carrying capacity and ability to reduce or mitigate impact of extreme events resulting from multiple contingencies; Market volatility – societal benefit of reduced vulnerability to extreme price volatility due to long term outages and catastrophic events;

In addition, there are secondary benefits related to infrastructure development, economic development, tax base, use of right-of-way, and new investment. However, the research did not address quantification of secondary benefits....

Models understate benefits of long life assets (50+years) by discounting future benefits using high interest rate based on cost of capital – essentially reducing the impact of benefits beyond the first 10-years; Models utilize expected value approach that tends to minimize impact of high impact but low probability events; Models are data intensive – require assumptions about future generation mix, fuel prices, and transmission network; Models are static with no feedback – assume no change in investment for new generation resulting in a zero sum benefit distribution game....Extreme market volatility and multiple contingency system events which can be very costly and risky to society are not captured in current

models: The 2001 California market dysfunction -- \$20-40 billion; the 2003 Northeast Blackout -- \$5-10 billion.⁹⁵

A similar perspective was expressed by the members of the Transmission Task Force of the Western Governors' Association's *Clean and Diversified Energy Advisory Committee*, although not necessarily in reference to the particular study described above:

Determining the adequacy of transmission must be the product of an on-going process that regularly reassesses uncertainties such as the economics of alternative generation technologies, fuel costs, the preferred location for generation, changes in demand and energy growth rates, and new transmission technologies. The further into the future one attempts to look, the greater these uncertainties....Typically long-term transmission planning looks at most 10 years into the future because that provides sufficient time to construct needed transmission.

The Task Force observes that transmission investments typically continue to provide value even as network conditions change. For example, transmission originally built to the site of a now obsolete power plant continues to be used since a new power plant is often constructed at the same location.

The Task Force also believes it is important to identify and preserve transmission corridors in advance of urban development. Adding transmission in developed urban and suburban areas is extremely difficult and costly. Similarly, preservation of corridors to energy rich geographic areas with location constrained resources, such as areas with good wind or geothermal resources, is important to assuring future transmission adequacy.

Finally, the Task Force observes that transmission costs are less than 10 percent of the delivered cost of energy and thus the economic penalty of making poor transmission investments is small relative to costs of uneconomic generation investments. However, the environmental and social cost of transmission lines needs to be considered when evaluating the cost of potentially over building transmission.⁹⁶

These observations provide insights into how we might improve the economic analysis of proposed strategic transmission infrastructure. In addition, the actual plans for adding new transmission must incorporate **sound environmental and siting principles**. Plans to configure new additions to a national EHV overlay system should include, for example, use of existing transmission towers and corridors as efficiently as possible, avoidance of critical habitats and scenic

vistas,⁹⁷ and siting approaches designed cooperatively with local communities where possible.

Finally, like the national highway system designed to connect parts of the country together, a **national EHV overlay system should be funded by consumers in large electrical regions**. That is, funding should be grounded in the portions of consumers’ electricity bills that reflect interstate charges rather than local rates.

In designing funding support for, and terms of access to, our national interstate highway system, we have deliberately recognized that the interstate is open to all users on a non-discriminatory basis, whether those users’ trips are entirely within a single state or end up crossing state lines. In the interstate highway system, all drivers pay a common cents-per-gallon charge into the Interstate Highway Fund, regardless of whether they ever actually set a tire on the interstate highway. The fundamental cost-support principle is that the interstate highway *system* enables untold economic, national security, social, recreational, and other benefits to the nation that need to be broadly supported by users of the roads.

Similarly, our national policy has embraced the importance of open access to electrical transmission, and its critical role in assuring efficient supplies of electricity in interstate commerce. Our funding mechanisms for a modern interstate electrical highway should align with these principles as well.

State and utility-service-territory boundaries have no more meaning for the transmission grid than they do for the transportation highway system, since electrons flow across boundaries according to the laws of physics rather than the laws of states, and since our electric systems rely on resources in large interconnected regions in order to provide reliable, economic, secure supply and to reduce dramatically our power sector’s emissions over time.

The new EHV system should be designed to encourage interstate support for moving renewable power in part through the design of the cost-support mechanism. Ideally, this should occur by moving transmission investment recovery into the federal electricity tariff, which will facilitate broad-based geographic support for investment in transmission spanning large regions.

This could take the form of a consolidated national “postage-stamp” rate available for strategic transmission projects. Qualifying regional projects that make up the interstate EHV system would be supported through customer payments collected through the federal transmission tariff. Such a tariff could be subject to review by federal regulators (Federal Energy Regulatory Commission), as now done today for investment carried out by private transmission companies.⁹⁸

Since the benefits of these strategic projects are inherently broad in nature – providing reliability, economic, security and environmental benefits for the

nation, not just for the particular users of the system at any point in time – all users in the interconnected region would support the EHV system through their electricity bills. Transmission companies making the investment in these strategic facilities would be compensated for their investment through cost-recovery mechanisms in the federal transmission tariff.

(There may be various ways to establish mechanisms to create incentives for investment, allow cost recovery in tariffs, and allocate investment costs to users in large regions. Some approaches might require new legislative authority. Whether investment occurs through actions of private utility companies, independent merchant transmission companies, publicly owned utilities, or any combination of the above, qualifying investment in strategic pieces of the transmission system could be recovered in transmission tariffs charged by transmission entities, with costs spread across many systems. In turn, the revenues could be collected by transmission entities, and redistributed through repayment formulae that track the source of underlying investments. Issues associated with needed changes in statutory authority, investment recovery and cost-allocation mechanisms, and associated transmission access rights should be the topic of lively discussion, further technical studies, and policy mechanisms, with the goal of finding investment recovery and cost-allocation pathways that support an "interstate electric highway system" paid for by users of electricity service, and presumptively not by taxpayers.)

A broad-based cost-allocation approach for strategic transmission system is akin to what we have long viewed as an appropriate mechanism to support the interstate highway system. All users pay fees that support investment in highways by providing a stream of revenues into the Highway Trust Fund.

Building off of this same type of logic, then, an EHV interstate transmission system built to support the nation's investment in clean, reliable and affordable power supplies would provide tangible and intangible benefits to the nation. This approach is premised on an understanding that the benefits of this strategic investment will be hard to quantify and monetize, and harder still to assign to particular constituencies of users. It presumes, appropriately, that the beneficiaries of these strategic investments would change in unexpected and unpredictable ways over the life of the system. It is part of a large vision for clean energy, supported by advanced power generation technology, and shaped by a program that caps emissions of carbon from electricity production and use. This vision for a 21st Century "Interstate Electric Highway System" thus aligns with a new vision of cost support from the nation's electricity users and a new vision for an American clean energy economy.

While such an approach is different that what is normally used today in many regions of the country, it might nonetheless be capable of addressing many of the problems that have kept us locked in a "chicken-and-egg" cycle that inhibits adequate transmission investment that in turn stalls the much-needed deployment of our nation's rich renewable resources.⁹⁹

Conclusion

Unlike the national highway system whose funding approach was criticized as having undermined the nation's support for mass transit, the development, planning, funding and siting of a national EHV overlay must occur in parallel with the other electrical improvements necessary to assure a clean, reliable, secure and economical energy supply for the country. This explicitly must include aggressive demand-side measures, investment in advanced metering and energy management systems, and clean power production technology. Cost-effective demand-side measures must be part of the 21st Century electric system, but not in a way that causes planning for and expansion of transmission for renewables to wait until all cost-effective energy efficiency is adopted and in place; doing so would take too long, and it will delay renewable power development and the strategic benefits it can provide.

We cannot realistically expect to exploit our rich domestic renewable energy resources without improvements to the electric transmission system. This includes transmission to support utility-scale wind and solar power project development.

Achieving the nation's requirements for clean, reliable and affordable electricity supplies requires a new vision for a 21st Century "Interstate Electric Highway System," built on a new national EHV transmission system overlay. There are useful and relevant lessons from the Interstate Highway System. Development of the vision requires several components: building off of current regional initiatives to plan transmission for renewables; broadening the analysis of benefits and costs to take into account strategic benefits of investment in transmission; and supporting a national EHV overlay system by broadly allocating costs to consumers in large electrical regions.

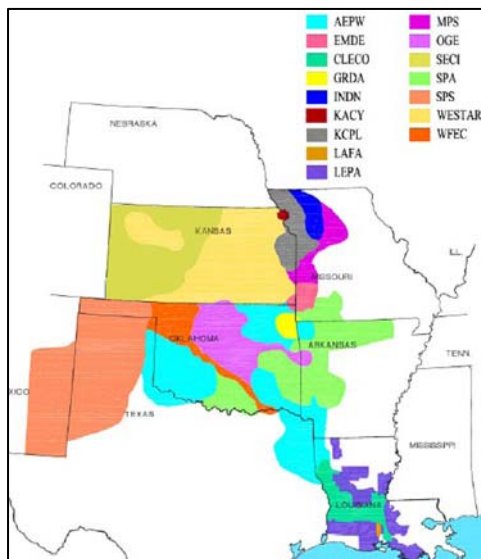
Appendix A

Case Study: The Southwest Power Pool's planning for an EHV overlay for transmitting wind power

SPP is a region that has recently explored the benefits and costs of installing an EHV overlay transmission system to help stimulate further economic development of its abundant wind resource and to facilitate movement of renewable power to market. Several years ago, SPP began a planning initiative to explore options for enhancing the transmission grid to support wind development.

As shown in Figures 8 and 17, above, SPP is the grid operator in parts of the south central U.S. (This area is also shown in Figure 23, depicting SPP's footprint (all of the colored areas) along with the locations of the individual "balancing authorities" which retain certain responsibilities in the SPP market and operations.) SPP is a relatively rural area with 4.5 million customers and a 2008 summer peak electric demand of 43,129 MW. SPP's members include 20 utility systems (public and private), 11 generation and transmission cooperatives, 2 state authorities, 4 independent power producers, 11 power marketers, and 2 independent transmission companies. The SPP region (especially parts of Kansas, Oklahoma, New Mexico, and the northern part of Texas) has a strong wind resource with significant potential for renewable power development. (This can be seen by comparing the footprint of the SPP territory against the wind resource maps in Figures 1 and 2.) According to SPP, "there is enough high-capacity wind to potentially add over 40,000 MW to the electric grid. By comparison, our record demand for electricity set in 2007 was just over 43,000 MW. SPP has 1,800 MW of wind in service, with approximately 30,000 MW proposed and under study."¹⁰⁰

Figure 23
SPP Footprint Including Individual Balancing Authorities



Source: http://www.spp.org/publications/SPP_Footprints.pdf

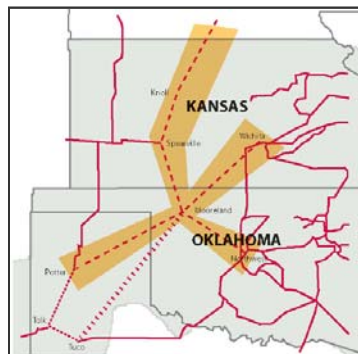
As a regional transmission organization, SPP has operating and planning responsibilities for ensuring the reliability of the grid. SPP's transmission planning involves multiple approaches. For example, in addition to its annual transmission planning process to address relatively near-term reliability issues, in recent years SPP has also conducted a longer-term transmission planning process. During the past few years, this latter process sponsored an EHV study, with initial results published in 2007 and updated in 2008 (the "2007 EHV Overlay Study" and the "2008 Update").

According to SPP's Vice President for Regulation in 2007, "An SPP extra-high voltage overlay would enhance reliability with a stronger transmission system for the communities within SPP's footprint. It would provide greater access to abundant, environmentally friendly, renewable energy from existing and potential wind farms in the South Central portion of the United States. It also would enable SPP to become an even more integral part of an enhanced transmission system extending across the Eastern Interconnection as well as the Electric Reliability Council of Texas and Western Electricity Coordinating Council markets, increasing access to a variety of generation resources...The extra-high voltage study will do much to meet the long-term planning needs of SPP's system, but the scope of such a project stretches far beyond SPP's borders. We recognize the need to work with neighboring entities to plan for and build transmission on a continental scale."¹⁰¹

The EHV study suggested the construction of a 500-kV and 765-kV transmission system on top of and integrated with the existing transmission grid in the SPP region, composed primarily of lower voltage lines (as shown in Figure 16). The 2007 EHV Overlay Study recommended a \$4.9 billion 765 kV loop, to be interconnected with the Midwest ISO ("MISO") and PJM areas (where other 765-kV facilities are located), and extensive 500 kV upgrades to interface with the neighboring systems in Missouri, Arkansas, Texas, and Louisiana.

Included in this longer-term plan was the development of an "X Plan." The "X Plan" is designed to develop an efficient transmission expansion system to deliver wind from the Central and South Plains to the rest of the grid, and would be built in the shape of an 'X', as depicted in Figure 24. The SPP Board of Directors approved this "X Plan" in January 2007.¹⁰² As one of the SPP project leaders said, "'Keep in mind that to do nothing has a cost,'... 'We need a 20-year outlook, because now we're just doing incremental, reactive stuff.' SPP officials are trying to envision what they would like the region to look like in 10 or 20 years, and build a plan to make that vision a reality...The plan anticipates that Oklahoma will lead the nation in wind generation by the year 2024."¹⁰³

Figure 24
SPP "X Plan"



Source: http://www.spp.org/publications/SPP_Wind_Integration_QA.pdf

The 2008 Update of the 2007 EHV Overlay Study further supported reinforcements of the SPP grid with EHV lines. Its analyses found that constructing the EHV overlay will require an estimated investment of more than \$6 billion by 2026, but according to industry observers, is expected to allow the system to "handle a dramatic increase in wind power production without weakening grid reliability."¹⁰⁴ The 2008 Update analyzed four EHV overlay designs,¹⁰⁵ in conjunction with about "20,000 MW of proposed wind generation projects in SPP's [transmission interconnection] queue. Up to 20% of wind exports could be sent to the Western Interconnection through asynchronous ties, the report found. The rest could be exported to the Eastern Interconnection, with equal portions flowing north and south."¹⁰⁶

In July 2008, state regulators in the SPP region who sit together as the SPP Regional State Committee ("RSC") and have responsibilities for determining cost-allocation policies for SPP transmission investments, considered the recommendations relating to the EHV overlay. In summarizing the recommendations of the EHV overlay studies, SPP Staff noted that the EHV system was driven largely by demand for thousands of MWs of wind capacity located in the SPP region by customers outside of the region. Paraphrasing the comments of the staff, "The last study showed that the EHV overlay could be economic even if there is only 4,600 MW of wind. Currently, SPP has 1,600 MW of installed wind capacity. 4,600 MW is easy to imagine." Staff noted that the EHV plan offered strategic opportunities to develop the region's wind resource, and that these strategic objectives warranted a new cost-support approach to fund the EHV overlay. The strategic benefits included not just electric system reliability and economies associated with reduced congestion and fewer line losses, but also other types of benefits not typically taken into account in transmission planning studies. Among the other benefits were access to lower cost resources, and increased inter-regional power trading, renewable resource development and integration, fuel diversity (e.g., less reliance on natural gas-fired generation with its volatile and high fuel prices), air emissions reduction, insurance against contingencies (e.g., long-term and simultaneous outages of multiple large power plants), and reduction in vulnerability to extreme events on the grid.¹⁰⁷

The SPP's RSC indicated its intention to entertain a new type of rate structure – a "postage stamp" rate – for SPP EHV enhancements in light of these strategic benefits. Underlying this approach was the notion that all customers benefit from the EHV upgrades, so that all should pay. At their July 2008 meeting, the RSC members and SPP expressed their interest in working with neighboring regions to spread the costs of the upgrades across a wider range of electricity users, all of whom would have positive strategic benefits from the grid enhancements. But rather than wait for those other support agreements to be in place, the RSC decided that this was an opportunity for this region to lead in developing its wind resources and supporting EHV system enhancements to facilitate them. As one member expressed the common sentiment of the group at the meeting, "This creates a positive step for us to lead, without asking someone else to pick up the tab."¹⁰⁸

Nevertheless, energy producers and others have already made commitments to help bring the X Plan to fruition. Oklahoma Gas and Electric Co. has offered to build the western half of the X Plan into the Texas Panhandle, and Public Service Company of Oklahoma's parent company, AEP, has indicated interest in building a huge portion of the national overlay project. ITC Great Plains has offered to build transmission for specific portions of the project in Kansas, Oklahoma and Texas.¹⁰⁹

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Endnotes

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² Dr. Tierney was commissioned by American Electric Power - Transmission to provide this assessment of the nation's energy needs. She prepared a brief statement, "Vision for a 21st Century Interstate Electric Highway System," in July 2008; this white paper expands on the ideas presented in that July statement.

³ U.S. Population was 151.3 million in 1950, and 299.4 million in 2006. In 1950, American retail electricity sales totaled 291 billion kilowatt-hours ("kwh"); in 2006, total consumption of electricity by retail customers (and direct electricity use by end use consumers) was 3,908 billion kwh. Energy Information Administration ("EIA"), Annual Energy Review 2007 (June 2008), Table 8.1 Electricity Overview, Selected Years, 1949-2007 (billions of kwh). <http://www.census.gov/compendia/statab/tables/08s0001.xls>; <http://www.census.gov/compendia/statab/tables/08s0012.xls>.

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⁹ "Utilities across the USA are raising power prices up to 29%, mostly to pay for soaring fuel costs, but also to build new plants and refurbish an aging power grid. Even more dramatic rate increases are ahead. The mounting electric bills will further squeeze households struggling with spiraling gasoline prices. 'Consumers now face a tough reality on electricity,' says Mark Cooper of Consumer Federation of America. The increases come after rising fuel prices already have driven up utility bills nearly 30% in the past five years, the sharpest jump since the 1970s energy crisis. Fuel costs are again the main culprit." Paul Davidson, "Price jolt: Electricity bills going up, up, up," *USA Today*, 6/20/2008. http://www.usatoday.com/money/industries/energy/2008-06-15-power-prices-rising_N.htm

¹⁰ As I described in a 2007 paper, "the nation's electric system is growing, and new investment has been required to keep the lights on. Peak electrical demand in the U.S. grew nearly 12 percent from 2000 to summer of 2007 (an increase of approximately 80,000 MW). [fn] To put that in context, Texas' peak demand in the summer of 2006 was over 62,339 MW [fn] so from 2000 to 2007, the U.S. added more than a Texas-sized amount of new demand. During that same time period, more than 210,000 MW of new power production capacity was put into operation, which is roughly equivalent to the addition of one large power plant a week

over the entire period. [fn] Using a conservative, back-of-the-envelope estimate of capital costs, this represents an investment of roughly \$99 billion.[fn] In addition, power plants in many regions (e.g., California, Texas, and the Northeast/ Mid-Atlantic states) have had to install air-pollution control equipment and use cleaner (and more expensive) fuels in the past decade to address various clean-air requirements. The electric power sector spent more than \$21 billion to come into compliance with air- and water-pollution laws from 2002 through 2005 [fn] and these costs have already begun to show up in electricity prices in these regions....Further, cost of construction materials is up — sharply. Recent reports indicate significant cost increases in the materials and components associated with power projects, after a decline in such costs for decades.[fn] "Prices for iron and steel, cement, and concrete — commodities used heavily in the construction of new energy projects — rose sharply from 2004 to 2006.... [I]ron and steel prices have increased by 9 percent from 2002 to 2003, 9 percent from 2003 to 2004, and 31 percent from 2004 to 2005." [fn] Growing demand in other global markets, including China, exacerbates these conditions. The indications are that the price effects of these combined factors are not likely to abate any time soon.[fn] Investment requirements are also expected to remain high. The U.S. government estimates that 258,000 MW of new capacity is needed between 2006 and 2030, equivalent to four new "Texan" size electrical additions and a total investment of \$412 billion (2005 dollars) — or even higher, if today's high construction-related cost increases continue. [fn] These estimates may overstate investment requirements if Americans spend more on energy efficiency technologies than in the past, but in any case, future costs for electricity supply (and demand reduction) loom large. Further, grid operators see significant new investment requirements to expand and upgrade regional power service. [fn] Installing more advanced metering technologies to enable consumers to see — and better manage — their electrical use would be in addition to those other costs. Meeting existing clean-air regulations affecting power plants will cost the industry an additional \$2.7 billion a year in 2010, and \$4.4 billion in 2015, according to federal regulators.[fn] Consumers in states relying on significant amounts of coal-fired generation will be most affected by these costs. Also, any costs related to the adoption of new laws to regulate greenhouse gas emissions from the power sector in the future will further affect cost of production at such plants. Some states (e.g., the Northeast and California) have already adopted caps on carbon emissions from power plants, and it appears increasingly likely that Congress will adopt a national program before too long. Estimates of such costs vary considerably, in part because of the uncertainty about what eventual carbon-control programs and laws will look like. For example, one study that modeled the impact of a national carbon policy imposing a price of \$10/ton of CO₂ suggests increases in electricity rates in the Midwest and South would be approximately twice the size of such increases in New England and New York, in large part due to the Midwest's and the South's higher dependence on coal-fired generation. Even so, estimated electricity prices would still likely be lower in the South and Midwest than in New England and New York even taking these carbon-control-costs into account.[fn] Susan Tierney, "Decoding Developments in Today's Electric Industry — Ten Points in the Prism," October 2007, pages 4-6.

¹¹ "[S]even in 10 Americans want more federal action on global warming, and about half of those surveyed think the government should do "much more" than it is doing now....Sixty-two percent of those surveyed say the government should require power plants to reduce emissions of greenhouse gases." Juliet Eilperin and Jon Cohen, "Growing Number of Americans See Warming as Leading Threat: Most Want U.S. to Act, but There Is No Consensus on How," *The Washington Post*, April 20, 2007, page A20. Public opinion surveys that traced public awareness of and attitudes about global warming, along with views as to what technologies to use to address emissions from energy production and use, have found that: "A sizable majority now recognizes global warming as a problem; and the willingness to pay for remedies has risen 50 percent [since 2003]...Between 2003 and 2006, there was a dramatic shift in public concern about global warming. The percent of the American public ranking global warming as the top environmental problem tripled over the last three years. In 2003, global warming ranked sixth on a list of ten environmental problems. In 2006, global warming was the number one environmental concern. More than one in three chose global warming as the nation's top environmental priority from a list of ten key environmental problems. In 2003, about 10 percent of the public felt that global warming was the primary environmental problem facing the country. It lagged behind water pollution, destruction of ecosystems, toxic waste, overpopulation, and ozone depletion." Thomas Curry, Stephen Ansolabehere & Howard Herzog, "A Survey of Public Attitudes towards Climate Change and Climate Change Mitigation Technologies in the United States: Analyses of 2006 Results," April 2007, MIT Laboratory for Energy and the Environment, MIT LFEE 2007-01 WP, pages 3, 8.

¹² For example, both of the 2008 Democratic and Republic nominees for President of the United States favor adoption of national mandatory controls on carbon emissions in the United States. Barack Obama supports an economy-wide cap-and-trade program to reduce greenhouse gases by 80 percent by 2050. John McCain supports a cap-and-trade program (for power, transportation, large commercial & industrial sources) to reduce greenhouse gases by 60 percent by 2050. <http://my.barackobama.com/page/content/newenergy>; <http://www.johnmccain.com/Informing/Issues/da151a1c-733a-4dc1-9cd3-f9ca5caba1de.htm>.

¹³ I note the results of recent public opinion polling on issues relating to economic and environmental trade-offs: "A series of poll items taken in 1990, 1992, and 1997 asked respondents whether the United States should

take actions to prevent the greenhouse effect even if it resulted in increased unemployment. With this economic impact in mind, in 1990 and 1992, 45 percent and 42 percent of respondents favored taking action ...Relative to other economic impacts, in 2001, Harris asked whether the public would prefer ‘tough government actions’ even if they resulted in inflation (54 percent supported, 39 percent opposed), or if utility bills went up (47 percent supported, 49 percent opposed).” Matthew Nisbet and Teresa Myers, “The Polls – Trends: Twenty Years of Public Opinion About Global Warming,” *Public Opinion Quarterly*, Vol. 71, No. 3, Fall 2007, page 463. “Environmental issues are often framed as being a tradeoff between the economy and the environment. ...It appears the economy holds an edge on the environment. In both surveys [conducted by MIT in 2003 and 2006], a greater percentage of Americans ranked the economy among the top three problems facing the U.S. than ranked the environment among the top three problems. The economy remained a higher concern in 2006 even though the percentage choosing the economy dropped by half from 2003 to 2006. However, when asked directly about tradeoffs between the economy and the environment, 64 percent of respondent prioritized the environment in 2006 and 53 percent prioritized the environment in 2003.” Thomas Curry, Stephen Ansolabehere & Howard Herzog, “A Survey of Public Attitudes towards Climate Change and Climate Change Mitigation Technologies in the United States: Analyses of 2006 Results,” April 2007, MIT Laboratory for Energy and the Environment, MIT LFEE 2007-01 WP, pages 6-7.

¹⁴ In 2007, the United States used approximately half the energy per unit of gross domestic product than it did in 1970 (8.78 thousand Btus per real (chained 2000) dollar in 2007 versus 17.99 in 1970). EIA, Annual Review of Energy 2007 (June 2008), page xix, Figure 3.

¹⁵ Examples of recent studies include: Steven Nadel, Anna Shipley and R. Neal Elliott, The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S. – A Meta-Analysis of Recent Studies, From the proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings; Electric Power Research Institute (“EPRI”), “Advancing the Efficiency of Electricity Utilization: “Prices to Devices” Background Paper for the 2006 EPRI Summer Seminar; McKinsey & Company, “Wasted Energy: How the US Can Reach its Productivity Potential,” 2006; InterAcademy Council, “Lighting the way Toward a sustainable energy future,” October 2007; OECD/IEA, “Tracking Industrial Energy Efficiency and CO2 Emissions,” October 2007; “National Action Plan for Energy Efficiency Potential,” 2006 and 2007 Reports; Optimal Energy, Inc., “Economically Achievable Energy Efficiency in New England,” Updated Report May 2005 prepared for the Northeast Energy Efficiency Partnership; Mike King, Kent Van Liere, Gene Meehan, Glenn R. George, Wayne P. Olson, Amparo D. Nieto, “Making a Business of Energy Efficiency: Sustainable Business Models for Utilities,” Prepared by NERA Economic Consulting for the Edison Electric Institute, August 2007; S. Pacala and R. Socolow, “Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies,” *Science*, August 13, 2004, Vol. 305. no. 5686, pages 968 – 972; Corinna Klessmann, Wina Graus, Mirjam Harmelink, and Fieke Geurts, of Ecofys International, “Making Energy-Efficiency Happen: From Potential to Reality - An assessment of policies and measures in G8 plus 5 countries, with recommendations for decision makers at national and international level,” paper prepared for WWF International, May 25, 2007; Michael Howard, EPRI, “How Much Can We Count On?” Edison Foundation Conference - Keeping the Lights On: Our National Challenge,” April 21, 2008.

¹⁶ Examples of entities with a keen interest in exploring power generation technology options include: EPRI; EEI; the Electric Power Supply Association; the Nuclear Energy Institute; the National Petroleum Council; the American Wind Energy Association; Stanford University’s Program on Energy and Sustainable Development; the Massachusetts Institute of Technology’s Energy Initiative; Carnegie Mellon Institute’s Electricity Center; the Aspen Institute’s Energy Forum; the U.S. Department of Energy (“U.S. DOE”) and its many National Laboratories, including the National Renewable Energy Laboratory (“NREL”); the National Association of Regulatory Utility Commissioners (“NARUC”); federal and state utility regulators; individual power generation companies and electric utilities; equipment manufacturers such as General Electric, ABB, Westinghouse; investment banks; ratings agencies; the North American Electric Reliability Council (“NERC”); the regional transmission organizations (e.g., the California ISO (“CAISO”), the Electric Reliability Council of Texas (“ERCOT”), the Midwest ISO (“MISO”), the New England ISO (“NE-ISO”), the New York ISO (“NYISO”), PJM, the Southwest Power Pool (“SPP”); and many others.

¹⁷ U.S. DOE, Office of Energy Efficiency and Renewables, “Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2007” (hereinafter “U.S. DOE Annual Wind Report”), May 2008, page 4.

¹⁸ EIA Electric Power Monthly, “Table ES3. New and Planned U.S. Electric Generating Units by Operating Company, Plant and Month, 2008 – 2009,” Report No.: DOE/EIA-0226, August 25, 2008 and EIA Electric Power Monthly, “Table ES3. New and Planned U.S. Electric Generating Units by Operating Company, Plant and Month, 2007-2008,” Report No.: DOE/EIA-0226, March 2008.

¹⁹ AWEA, “2nd Quarter 2008 Market Report,” July 2008. www.awea.org/publications/reports/2Q08.pdf

²⁰ U.S. DOE Annual Wind Report, May 2008, page 5.

²¹ Wind projects are intermittent, with the turbine producing power only when the wind blows. Capacity factors for wind projects vary according to the wind resource, with a range of 20-40 percent depending upon the region. http://www.ceere.org/rerl/about_wind/RERL_Fact_Sheet_2a_Capacity_Factor.pdf. By contrast, nuclear plants tend to operate at capacity factors above 90 percent, and natural gas fired combined cycles operating as cycling units may operate within a wide range of dispatch (e.g., from 25 to 75 percent), depending upon the relative price of natural gas and the heat rates of individual gas fired power plants.

²² U.S. DOE Annual Wind Report, May 2008, page 6.

²³ "Wind project installed costs declined dramatically from the beginnings of the industry in California in the 1980s to the early 2000s, falling by roughly \$2,700/kW over this period.[fn] More recently, however, costs have increased. Among the sample of projects built in 2007...[the average reported installed cost] is up \$140/kW (9%) from the average cost of installed projects in 2006 (\$1,570/kW), and up roughly \$370/kW (27%) from the average cost of projects installed from 2001 through 2003." U.S. DOE Annual Wind Report, May 2008, page 21.

²⁴ Note the prior discussion on increases in fossil fuel prices. The price of oil is now nearly six times the level in 1990. Since then, natural gas prices have risen nearly fourfold, with most of the increase since the year 2000. The average wellhead price of natural gas in 1990 was \$1.71/mcf; in 2007, it was \$6.39/mcf. At their height following the hurricanes at the end of the summer of 2005, wellhead natural gas prices averaged \$10.33/mcf in the month of October 2005. <http://tonto.eia.doe.gov/dnav/ng/hist/n9190us3A.htm>

²⁵ "Under present law, an income tax credit is allowed for the production of electricity from qualified wind energy facilities and other sources of renewable energy. The current value of the credit is 2 cents/KWh of electricity produced. The credit was created under the Energy Policy Act of 1992 (at the value of 1.5 cents/KWh, which has since been adjusted annually for inflation) and applies to electricity produced by a qualified wind facility placed in service after December 31, 1992, and before January 1, 2009. The production tax credit (PTC) is only applicable to utility-scale wind turbines, not smaller turbines used to power individual homes or businesses. Current Status: The PTC is scheduled to expire on December 31, 2008. Since its establishment in 1992, the PTC has undergone a series one or two year extensions, and has been allowed to lapse in three different years: 1999, 2001 and 2003. The federal government's uninterrupted commitment to the PTC from 2005 through the present has given the industry a steady base to build upon, enabling three straight years of growth. The most impressive expansion of the wind industry was seen in 2007, when a record 5200 MW of new wind power capacity were added." American Wind Energy Association website, <http://www.awea.org/legislative/>, accessed August 28, 2008.

²⁶ "In the best wind resource areas, capacity factors in excess of 40% are increasingly common. Of the 112 projects in the sample installed prior to 2004, for example, only 4 (3.6%) had capacity factors in excess of 40% in 2007 (in capacity terms, 56 MW, or 1%, exceeded 40%). Of the 58 projects installed from 2004 through 2006, on the other hand, 15 (25.9%) achieved capacity factors in excess of 40% in 2007 (in capacity terms, 836 MW, or 16.7%, exceeded 40%). These increases in capacity factors over time suggest that improved turbine designs, higher hub heights, and/or improved siting are outweighing the otherwise-presumed trend towards lower-value wind resource sites as the best locations are developed." U.S. DOE Annual Wind Report, May 2008, pages 23-24.

²⁷ "Well-structured regional wholesale electricity markets operated independently allow far greater amounts of renewable energy and demand response resources to be integrated into the nation's electric grid. In fact, approximately 73 percent of installed wind capacity is now located in regions with such markets, while only 44 percent of wind energy potential is found in these areas. Large, regional energy markets provide for cost-effective balancing of generation and load with significant penetrations of variable, non-dispatchable power sources, and they facilitate delivery of resources remote from load centers. A summary of utility industry research by the Utility Wind Integration Group (www.uwig.org) states that 'well-functioning hour-ahead and day-ahead markets provide the best means of addressing the variability in wind plant output'.... Independently run regional grid operators can foster renewable energy and demand response development by:

- Eliminating 'pancaked' transmission rates that are assessed across every utility area;
- Providing energy markets where variable or intermittent resources can sell excess energy or purchase shortages at a transparent and fair price;
- Minimizing operational impacts of variable resources by netting out aggregate load and generation over a wide region;
- Facilitating regional transmission planning to access generating resources as well as address reliability, congestion, and load growth in the most efficient overall manner;

- Providing a mechanism to purse regional cost allocation policies; and
- Providing for flexible transmission tariffs that allow rates to be paid on an as-used basis as opposed to a capacity reservation basis.”

Letter from Robert Gramlich, AWEA, and 21 other signatories from environmental, wind development and others, to Chairman Joseph Kelliher, FERC, 2-26-07. <http://www.ferc.gov/eventcalendar/Files/20070228090023-AWEA%20Ltr%20on%20Reg%20Grid%20Ops.pdf>. See also, Susan Tierney, “Wind Power Development and New York’s Electricity Market,” July 28, 2008 memorandum to the New York ISO.

²⁸ See, for example, the results of public opinion surveys conducted by researchers at MIT, who asked respondents the following question (among others): “The following technologies have been proposed to address global warming. If you were responsible for designing a plan to address global warming, which of the following technologies would you use?” The respondents’ answers in surveys conducted in 2003 and 2006 showed relatively high and growing support for wind (in addition to solar, energy efficiency and more fuel-efficient cars) as shown below (percentages are estimated):

Technology to address global warming	% Definitely Use (2003)	% Definitely or Probably Use (2003)	% Definitely Use (2006)	% Definitely or Probably Use (2006)
Solar	54	82	59	84
Wind	48	75	55	79
Biomass/Biofuels	26	59	36	66
Energy Efficient Appliances	57	81	60	82
Energy efficient Cars	54	80	59	82
Nuclear	14	37	16	38
Carbon Capture & Sequestration	9	29	12	30

Thomas Curry, Stephen Ansolabehere & Howard Herzog, “A Survey of Public Attitudes towards Climate Change and Climate Change Mitigation Technologies in the United States: Analyses of 2006 Results,” April 2007, MIT Laboratory for Energy and the Environment, MIT LFEE 2007-01 WP, pages 3, 39.

²⁹ “Without utility-scale wind, solar and geothermal facilities and adequate transmission access, we won’t be able to meet future energy demand, much less reduce carbon emissions to levels needed to avoid the damaging effects of climate change.” “WRA Smart Lines’ Report,” 2008, page 2.

³⁰ “One visible testament to the surging interest in wind is the amount of wind power capacity currently working its way through the major [transmission] interconnection queues across the country...[While] there is a growing recognition that many of the projects currently in interconnection queues are very early in the development process, and that a large number of these projects are unlikely to achieve commercial operations any time soon,...the amount of wind capacity in the nation’s interconnection queues is astounding, and provides some indication of the number and capacity of projects that are in the planning phase. At the end of 2007, there were 225 GW [equivalent to 225,000 MW] of wind power capacity within the eleven interconnection queues reviewed for this report—more than 13 times the installed wind capacity in the United States at the end of 2007. This wind capacity represents roughly *half* of all generating capacity within these queues at that time, and is *twice as much* capacity as the next-largest resource in these queues (natural gas)...Much of this wind capacity is planned for the Midwest, Texas, and PJM regions: wind in the interconnection queues of MISO (66 GW), ERCOT (41 GW), and PJM (35 GW) account for nearly two-thirds of the aggregate 225 GW of wind in all eleven queues. At the other end of the spectrum, the Northeast exhibits the least amount of wind capacity in the pipeline, with the New York ISO (7 GW) and ISO-New England (2 GW) together accounting for about 4% of the aggregate 225 GW. The remaining six queues include SPP (21 GW), California ISO (19 GW), WAPA (10 GW), BPA (10 GW), PacifiCorp (9 GW), and Xcel’s Colorado service area (4 GW).” U.S. DOE Annual Wind Report, May 2008, page 9.

³¹ Western Governors’ Association Clean and Diversified Energy Committee report at: <http://www.westgov.org/wga/initiatives/cdeac/>, cited by WRA Smart Lines Report, 2008, page 6.

³² WRA Smart Lines Report, 2008, page 2.

³³ U.S. DOE, Solar Energy Technologies Program, “Solar Energy Industry Forecast: Perspectives on U.S. Solar Market Trajectory,” May 27, 2008, www.eere.energy.gov/solar/solar_america/; James Mason Zweibel and

Vasilis Fthenakis, “A Solar Grand Plan: By 2050 Solar Power Could End U.S. Dependence on Foreign Oil and Slash Greenhouse Gas Emissions,” *Scientific American Magazine*, December 16, 2007.

³⁴ For example, the U.S. Department of Energy has estimated that the installed cost of utility/commercial scale solar systems will drop by approximately one-third from 2006 to 2010, and then again by another third from 2010 to 2015, as manufacturers realize cost reductions across the value chain. “Solar Energy Industry Forecast: Perspectives on U.S. Solar Market Trajectory,” Presentation by the U.S. Department of Energy Solar Technologies Program, May 27, 2008.

³⁵ “Solar Energy Industry Forecast: Perspectives on U.S. Solar Market Trajectory,” Presentation by the U.S. Department of Energy Solar Energy Technologies Program, May 27, 2008.

³⁶ Frost & Sullivan predicts a compound annual growth rate of 30.2 percent between 2007 and 2014. “North American Residential Solar Power Markets, - N2B5-14,” Frost & Sullivan, 2007, page 3-6. <http://www.frost.com>.

³⁷ WRA Smart Lines Report, 2008, page 2.

³⁸ Janice Francis-Smith, “Southwest Power Pool transmission plan caught in Catch-22,” *The Journal Record (Oklahoma City)*, Sep 17, 2007. http://findarticles.com/p/articles/mi_qn4182/is_20070917/ai_n20503465.

³⁹ Matthew Wald, “The Energy Challenge: Wind Energy Bumps Into Power Grid’s Limits,” *The New York Times*, August 26, 2008.

⁴⁰ AWEA, “Transmission Fact Sheet,” http://www.awea.org/policy/documents/Transmission_Fact_Sheet.pdf

⁴¹ U.S. DOE 20% Wind Report, May 2008, page 93.

⁴² FERC Staff Report, “Assessing the State of Wind Energy in Wholesale Electricity Markets,” November 2004, pages 3-4. Also from the same report, “Commission-approved RTOs and ISOs may remove many of the challenges that wind generation faces. RTOs and ISOs effectively remove pancaked rates, allow for scheduling flexibility and create real-time imbalance markets. These centralized markets reduce imbalance penalties, optimize transmission capability through region-wide dispatch, and provide for independent regional planning to expedite grid expansion,” page 4.

⁴³ Sandy Smith, Utility Wind Integration Group, “An Overview of Current Initiatives to Expand Transmission Infrastructure to Accommodate Utility Interconnection and Integration of Wind Power,” Presented at DistribuTECH/TransTECH 2008, January 22, 2008, page 1.

⁴⁴ WRA Smart Lines Report, 2008, page 7.

⁴⁵ U.S. DOE 20% Wind Report, May 2008, page 11.

⁴⁶ The technically feasible transmission grid shown in Figure 9 results from a collaboration between the American Wind Energy Association (“AWEA”) and American Electric Power – Transmission (“AEP”). AWEA and AEP worked together to formulate a conceptual transmission vision for wind integration on a national scale. It involved several assumptions and approaches, as described by AEP’s Lisa Barton: “Existing transmission constraints often limit the development of new generation resources. Existing infrastructure will not enable the interconnection of significant wind resources. As such, expansions of wind power relies on new transmission development. [The] location of wind resources modeled in the overlay was based on information provided by AWEA and NREL.” The transmission principles guiding the development of an EHV overlay were as follows: “a national, robust interstate EHV transmission system would be used to serve as the foundation for the wide scale integration of renewables. An integrated EHV network would provide the maximum customer benefit by: (i) promoting efficient markets; (ii) facilitating the deliverability of economic and environmentally friendly energy to load centers. [An] AC system was selected as the model in order to ensure maximum connectivity and deliverability on a system wide basis.” The scope of the vision produced: “approximately 19,000 of 765 kV transmission; roughly \$60 billion investment; estimated new transmission capacity of 200-400 GW; 765 kV overlay could also reduce peak losses by more than 10 GW, reducing CO2 emission by some 15 million metric tons annually.” Lisa Barton, AEP, “Expanding the Wind Industry: Wind Vision Initiative – Part 2,” presentation to the Windpower 2007 Conference, June 2007.

⁴⁷ Nancy Ryan, Chief of Staff, Office of Commissioner Peevey, California Public Utilities Commission, “Renewable Rules and Markets: A California Perspective,” Presentation to the Harvard Electricity Policy Group, October 2, 2008.

⁴⁸ California Independent System Operator, “California ISO Board Approves Generation Queue Reforms,” July 10, 2008. <http://www.reuters.com/article/pressRelease/idUS170320+10-Jul-2008+BW20080710>.

⁴⁹ The nation’s strong and growing demand for electricity is described at the beginning of this paper.

⁵⁰ Kevin M. Kolevar, Assistant Secretary for Electricity Delivery and Energy Reliability, U.S. Department of Energy, before the Senate Energy and Natural Resources Committee, July 31, 2008.

⁵¹ Colin Whitley, Statement of the American Public Power Association for the Senate Energy and Natural Resources Committee, Hearing to “Examine the State of the Nation’s Transmission Grid, as well as the Implementation of the 2005 Energy Policy Act Transmission Provisions, Including Reliability, Siting and Infrastructure Investment,” July 31, 2008.

⁵² Marsha Smith, Commissioner, Idaho Public Utility Commission, remarks on behalf of NARUC, presented to the Senate Commission on Energy and Natural Resources, Hearing on “on “State of the Nation’s Electric Transmission Grid,” July 31, 2008.

⁵³ <http://www.westgov.org/wga/initiatives/wrez/index.htm>

⁵⁴ WRA Smart Lines Report, 2008, page 7.

⁵⁵ Paul Bonavia, President, Utilities Group, Xcel Energy Inc., <http://www.20percentwind.org/20p.aspx?page=Newsroom>

⁵⁶ NERC, “Long-Term Assessment to Assure Reliability of the Bulk Power System 2007-2016,” October 2007, page 18.

⁵⁷ The Keystone Center, “Regional Transmission Projects: Finding Solutions,” A Report of the Keystone Center, June 2005, p. 1. The Keystone Center’s findings were endorsed by the participants in the dialogue leading up to the 2005 report. These participants included individuals affiliated with the following organizations: Electricity Consumers Resource Council (ELCON); International Transmission Company; American Transmission Company; VanNess Feldman; National Grid; Public Service Commission of Wisconsin; PJM; NARUC; Pennsylvania Office of Consumer Advocates; PG&E; AEP; Calpine American Wind Energy Association (AWEA); Great River Energy; FERC; Xcel Energy; Western Governors Association; Northeast Utilities; U.S. Department of Energy; BLM; Iowa Utility Board; Midwest ISO; Cinergy; California ISO; former members of the Pennsylvania Public Utility Commission; and Western Area Power Administration.

⁵⁸ U.S. DOE, Annual Wind Report, May 2008, Page 27.

⁵⁹ “FRCC” is the Florida Reliability Coordinating Council; “MRO” is the Midwest Reliability Organization; “NPCC” is the Northeast Power Coordinating Council; “RFC” is the ReliabilityFirst Corporation; “SERC” is the SERC Reliability Corporation; “SPP” is the Southwest Power Pool’ and “WECC” is the Western Electricity Coordinating Council.” See, NERC, “2008 Summer Reliability Assessment,” May 2008, page 5.

⁶⁰ This list of issues is drawn from the experience of the author, as well as from a variety of observations in the literature, including: Ross Baldick, Ashley Brown, James Bushnell, Susan Tierney, Terry Winter, The Blue Ribbon Panel on Cost Allocation, “A National Perspective on Allocating the Costs of New Transmission Investment: Practice and Principles,” A white paper prepared for WIRES (Working Group for Investment in Reliable and Economic Electric Systems), 2007; Lisa Barton, AEP, “Expanding the Wind Industry: Wind Vision Initiative – Part 2,” presentation to the Windpower 2007 Conference, June 2007; Consumer Energy Council of America, “Keeping the Power Flowing: Ensuring a Strong Transmission System to Support Consumer Needs for Cost-Effectiveness, Security and Reliability - A Report of The Consumer Energy Council of America Transmission Infrastructure Forum,” January 2005; Keystone Center, “Regional Transmission Projects: Finding Solutions,” A Report of the Keystone Center, June 2005; National Grid, “Transmission and Wind Energy: Capturing the Prevailing Winds for the Benefit of Customers,” September 2006; Marsha Smith, Commissioner, Idaho Public Utility Commission, remarks on behalf of NARUC, presented to the Senate Commission on Energy and Natural Resources, Hearing on “on “State of the Nation’s Electric Transmission Grid,” July 32, 2008; U.S.-Canada Power System Outage Task Force, “Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations,” April 2004, p. 4; U.S. DOE 20% Wind Report, May 2008; U.S. DOE, Secretary of Energy’s Energy Advisory Council’s Task Force on Electric System Reliability, “Maintaining Reliability in a Competitive U.S. Electricity Industry – Final Report of the Task Force on Electric System Reliability,” September 29, 1998; U.S. DOE, Electricity Advisory Board, “Transmission Grid Solutions Report,” September 2002; U.S. DOE, Office of Electric Transmission and Distribution, “Transforming the Grid to Strengthen Electric Reliability and the Economy,” December 2003; U.S. DOE, “National Transmission Grid Study;” FERC Staff Report, “Assessing the State of Wind Energy in Wholesale Electricity Markets,” Docket No. AD04-13-000, November 2004; Western Governors’ Association, “Final Report of the Transmission Task Force,” of the Western Governors’ Association Clean and Diversified Energy Initiative,” May 2008; and WRA Smart Lines Report, 2008.

⁶¹ See prior footnote 15, above and corresponding text.

⁶² See, for example, FERC, "2007 Assessment of Demand Response and Advanced Metering," Staff Report, September 2007.

⁶³ See footnote 16, above and corresponding text.

⁶⁴ Including Texas, 14 percent of the nation's population lives in the ten states with the most wind potential. Figures are AEP calculations based on data from the American Wind Energy Association and the U.S. Census Bureau.

⁶⁵ Ray Carter. "Federal official notes wind power potential, limits," *The Journal Record*, April 12, 2002.

⁶⁶ WRA Smart Lines Report, 2008, pages 2, 9.

⁶⁷ U.S. DOE, "20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply," May 2008, page 95.

⁶⁸ Initial parts of AEP's 765 kV system in the Midwest went into operation in 1969. As of May 2008, AEP's 765-kV system has 2,116 miles of facilities at this voltage level, with the system planned as a network and integrating over 11,000 MW of generation capacity.

⁶⁹ Evan Wilcox, "765 kV Transmission System Facts For the Southwest Power Pool (SPP) Cost Allocation Working Group," May 28, 2008, page 16.

⁷⁰ Evan Wilcox, "765 kV Transmission System Facts For the Southwest Power Pool (SPP) Cost Allocation Working Group," May 28, 2008, page 17. The SPP Overlay study showed the following line losses for a configuration with three 345 kV lines, compared to a single 765 kV option: at \$50/MWh, the cost of these losses is over \$40 million annually, with a present value over 40 years approximately \$540 million. The study also indicated that for a 3,900 MW power transfer over 150 miles, six 345 kV circuits would lose 77 MW more than a single 765 kV circuit (83 MW vs. 160 MW); at \$50/MWh, the cost of these losses is over \$20 million annually, with a present value over 40 years approximately \$270 million. *Ibid*, page 11.

⁷¹ "What Stopped the August 14 Blackout From Cascading Further?...As seen in Phase 6, the cascade progressed into western Ohio and then northward through Michigan through the areas that had the fewest transmission lines. Because there were fewer lines, each line absorbed more of the power and voltage surges and was more vulnerable to tripping. A similar effect was seen toward the east as the lines between New York and Pennsylvania, and eventually northern New Jersey tripped. The cascade of transmission line outages became contained after the northeast United States and Ontario were completely separated from the rest of the Eastern Interconnection and no more power flows were possible into the northeast (except the DC ties from Québec, which continued to supply power to western New York and New England)." U.S.-Canada Power System Outage Task Force, "Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations," April 2004, pages 75-77.

⁷² "At 16:10:50 EDT, Ontario and New York separated west of the Ontario/New York interconnection, due to relay operations which disconnected nine 230-kV lines within Ontario. These left most of Ontario isolated to the north. Ontario's large Beck and Saunders hydro stations, along with some Ontario load, the New York Power Authority's (NYPA) Niagara and St. Lawrence hydro stations, and NYPA's 765-kV AC interconnection to their HVDC tie with Québec, remained connected to the western New York system, supporting the demand in upstate New York..." U.S.-Canada Power System Outage Task Force, "Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations," April 2004, page 99.

⁷³ "In addition, 765-kV faults are usually momentary and involve only one of three phases, allowing application of single-phase switching. Station equipment for 765-kV has matured and transformer bank sizes up to 3,000 MVA have been demonstrated throughout the world. The necessity of using banks of single-phase transformers allows sparing to be easily achieved with a fourth single-phase transformer connectable to any phase without physical moves, reducing outage duration." Michael Heyeck, "The Next Interstate System: 765-kV Transmission – AEP advocates a 765-kV transmission overlay for the entire United States," *Electric Light and Power*, 2007. http://uaelp.pennnet.com/display_article/284510/34/ARTCL/none/none/1/The-Next-Interstate-System:-765-kV-Transmission/

⁷⁴ U.S. DOE 20% Wind Report, May 2008, page 98.

⁷⁵ U.S. DOE 20% Wind Report, May 2008, page 98.

⁷⁶ U.S. DOE 20% Wind Report, May 2008, page 95.

⁷⁷ U.S. DOE 20% Wind Report, May 2008, page 96.

⁷⁸ U.S. DOE 20% Wind Report, May 2008, pages 96-97.

⁷⁹ U.S. DOE 20% Wind Report, May 2008, pages 91-92. "Large Balancing Areas Reduce Impacts...The system-balancing function is performed by authorities who operate a portion of the system called a "balancing area."Today there are about 130 balancing areas in the U.S. grid. The largest is the PJM grid, which is part of the Eastern Interconnection with a peak load of 145,000 MW. A small balancing area, in contrast, might be a small utility with a peak load of a few hundred megawatts. Balancing areas are an outgrowth of the evolution of power systems. In some areas, the current patchwork nature of the grid resulted when a number of small isolated systems were combined into a single balancing area such as PJM. Systems became interconnected for a number of reasons, mostly having to do with reliability and economics. Consider this example: If three adjacent systems, each with a peak load of 3,000 MW, had a single largest contingency (loss of a line or generator) of 300 MW, each would carry 300 MW of reserves. If the three systems were interconnected, and the single largest contingency was still 300 MW, each system would need only 100 MW of reserves to cover contingency reserve requirements. In this example, and as another advantage, the peak load of the combined system would be less than 9,000 MW because of diversity in the load of the three systems. Finally, operators can call on the most efficient and lowest cost producers available across the combined system and shift production away from more expensive units. This approach ensures that the generation mix used to meet the aggregated system's changing load is always relatively more efficient. Overall, the three interconnected systems are able to operate more efficiently at a reduced operating cost." *Ibid*, pages 91-92.

⁸⁰ WRA, Smart Lines Report, 2008, page 3.

⁸¹ §1241 of EAct 2005. For example, the Energy Policy Act of 2005 directed the FERC to develop incentive-based rate treatments for transmission of electric energy in interstate commerce, adding a new section 219 to the Federal Power Act. <http://www.ferc.gov/industries/electric/indus-act/trans-invest.asp>. Additionally, FERC received new responsibilities in the area of transmission line siting. <http://www.ferc.gov/industries/electric/indus-act/siting.asp>

⁸² Congress called the system the "National System of Interstate and Defense Highways," when it enacted legislation establishing the interstate system in 1956. The principle platform in the statute declared that "[I]t is hereby declared to be essential to the national interest to provide for the early completion of the 'National System of Interstate Highways,' as authorized and designated in accordance with section 7 of the Federal-Aid Highway Act of 1944." (Section 108 of the act.) <http://www.tfhr.gov/pubrds/06jan/01.htm>

⁸³ In general, the funding formula for interstate highways was 90% federal, 10% state and/or local. Parson Brinckerhoff Quade & Douglas, with John Pucher, Rutgers University, New Brunswick, NJ: "Report 42, Consequences of the Interstate Highway System for Transit: Summary of Findings," Transportation Research Board, National Research Council, National Academy Press, 1998. http://onlinepubs.trb.org/Onlinepubs/trcp/trcp_rpt_42.pdf

⁸⁴ There have been countless attempts to quantify the impacts – both positive and negative – of the interstate system over the past half century. For example, a major study carried out by the Transportation Research Board of the National Research Council ("TRC – NRC") some forty years after the highway system had begun, made the following findings: "In an assessment of the economic impacts of the interstate highway system, Louis Berger International (1995) reports that three of the primary impacts of the interstate highway system have been to reduce travel costs, improve safety, and increase connectivity of regions. The interstate highway system has increased traffic capacity and travel speeds.... The travel cost reductions had widespread effects on the economy, lowering the cost of consumer goods and improving the competitiveness of businesses. Furthermore, the interstate highway system has half the accidents per mile compared with travel on other types of highways. Interstate highways are safer because of limited access and wide lanes designed for high-speed travel. Improved safety is one of the reasons that trucking has become reliable. In addition, the interstate highway system increased connectivity of regions and metropolitan areas spurring a growth in trucking and shift in logistics, such as to just-in-time deliveries."

Further, this same report of the TRC – NRC cited other studies of the long-term economic impacts of the interstate highway system: "Garrison and Souleyrette (1996) argue that transportation innovations that lower travel costs and increase connectivity, which the interstate highway system does, spur companion innovations. Transportation is essential for moving goods and people. Improved highways, for example, allowed the use of

the larger trucks. This changed the nature of the warehousing industry by supporting the replacement of dispersed locations that served multiple clients with consolidated locations operated by individual retailers. But Kemp and Cheslow (1976) notes that improvements in travel conditions were often short-lived. Interstate highways created the expectation that there would be free-flowing traffic at high speeds at all times. The benefits to travelers were often less than expected because of latent demand. Some interstate highways rapidly became congested during peak periods because the improved travel conditions encouraged more travel or caused shifts in travel from other routes, times, or modes."

Finally, the TRC – NRC study observed that "A recent review of the impacts of highways on land use by the Transportation Research Board (1995) takes the middle ground. It concludes that highway expansion did influence urban form, but only in conjunction with other societal forces and public policies supporting suburbanization. The study drew the following conclusions about the effects of highways on urban land use:

- Early highway capacity expansions, such as construction of interstate highways, dramatically reduced travel costs and increased access to undeveloped land. Lower land costs enticed households and firms to move to areas on the urban fringe that had improved accessibility.
- Highway capacity expansions interacted with population growth, rising personal income, increased automobile ownership, decreased cost of transportation, and land use policies to channel the location of growth within metropolitan areas.
- Additions to the highway system made at the same time a metropolitan area was growing influenced the location of residential and employment development because the corridor where the investments were made became more attractive for development.
- Additions to highway capacity that reduced the cost of travel supported sprawl when other conditions also supported dispersed development. The effect was greatest when access to large tracts of rural land on the urban fringe was improved.

In sum, the study finds that building highways, including the interstate network, in urban areas improved accessibility to suburban and exurban locations, facilitating the development of housing and employment at the urban fringe and encouraging the expansion of metropolitan areas. The highways did this by interacting with a variety of other factors that supported dispersed development." Parson Brinckerhoff Quade & Douglas, with John Pucher, Rutgers University, New Brunswick, NJ: "Report 42, Consequences of the Interstate Highway System for Transit: Summary of Findings," Transportation Research Board, National Research Council, National Academy Press, 1998. http://onlinepubs.trb.org/Onlinepubs/tcrp/tcrp_rpt_42.pdf.

⁸⁵ There are competing claims about whether the first leg of the Interstate Highway System occurred in Kansas or Missouri. Either way, this is America's heartland.

⁸⁶ The Joint Coordinated System Plan participants include representatives of MISO, SPP, PJM, TVA, MAPP, NYISO, ISO-NE and other interested parties. See John Lawhorn, MISO, "Economic Transmission Development Work-to-Date," presentation to NARUC, July 20, 2008.

⁸⁷ "In late 2007, the California ISO received FERC approval for a new transmission interconnection category for "location constrained resources," such as renewable energy facilities. Once a resource area has been identified, transmission would be built in advance of generation being developed, and costs would be initially recovered through the California ISO transmission charge. California also started the Renewable Energy Transmission Initiative to help define renewable energy zones in and around the state, and to prepare transmission plans for those zones. Progress was also made in 2007 on a number of specific transmission projects that are designed to, in part, support wind power. In March 2007, for example, the California PUC approved the first three of ultimately 11 segments of Southern California Edison's Tehachapi transmission project. Fully developed, the project will transmit up to 4,500 MW of wind power." U.S. DOE Annual Wind Report, May 2008, page28.

The California Energy Commission reports that "California has adopted energy policies that require substantial increases in the generation of electricity from renewable resources. Extensive improvements, however, are needed to California's electric transmission infrastructure to get the electricity generated by new renewable power facilities to consumers. The Renewable Energy Transmission Initiative (RETI) is a statewide initiative to help identify the transmission projects needed to accommodate these renewable energy goals, support future energy policy, and facilitate transmission corridor designation and transmission and generation siting and permitting. RETI will be an open and transparent collaborative process in which all interested parties are encouraged to participate. RETI will assess all competitive renewable energy zones in California and possibly also in neighboring states that can provide significant electricity to California consumers by the year 2020. RETI also will identify those zones that can be developed in the most cost effective and environmentally benign manner and will prepare detailed transmission plans for those zones identified for development." RETI website, <http://www.energy.ca.gov/reti/index.html>

⁸⁸ On July 17, 2008, Texas officials "gave preliminary approval to a \$4.9 billion wind power project that will add a massive system of transmission lines to help move electricity generated along the windy patches of West Texas to power-hungry metropolitan areas such as Austin. If the plan wins final approval, it would be the country's largest investment in clean and renewable power...The decision, approved on a 2-1 vote, triggers continued plans for ramping up the state's power grid system, adding more than 2,000 miles of heavy-duty transmission lines from West Texas near the town of McCamey and the Panhandle to the major population hubs of Austin, Dallas-Fort Worth, Houston and elsewhere...The [\$4.9 billion] plan wouldn't be in place for several years, but it could result in a \$4 increase on Texas consumers' monthly bills, according to the PUC." Claudia Grisales, "State supports \$4.9 billion wind power plan: Texas power grid expansion would aid renewable projects," *American-Statesman*, Friday, July 18, 2008. <http://www.statesman.com/news/content/news/stories/local/07/18/0718wind.html>.

⁸⁹ There are other regional and state-level initiatives, such as:

- The Western Governors' Association;
- The SPP EHV Overlay Study and "X Plan" (described previously);
- The Midwest ISO *Transmission Expansion Plan 2006* (Midwest ISO 2006), described in the U.S. DOE 20% Wind Report, pages 93-95;
- Colorado's requirement that utilities "submit biennial reports designating energy resource zones (ERZs) and...applications for certificates of public convenience and necessity (CPCN) for these areas. In October 2007, Xcel Energy identified four potential ERZ areas, created in large measure to support renewable energy development, and the Colorado PUC recently approved Xcel's application for a 345-kV line in northeastern Colorado." U.S. DOE 20% Wind Report, pages 27-28;
- New Mexico Renewable Energy Transmission Authority; and
- Minnesota utilities' Capital Expansion Planning process.

Additionally, there are many industry associations and ventures working on wind and transmission, including:

- Utility Wind Integration Group;
- National Wind Coordinating Council;
- Wind on the Wires;
- ISO/RTO Council;
- American Wind Energy Association; and
- AWEA/AEP collaborative study to develop a conceptual EHV overlay.

⁹⁰ This view has been expressed by the chairman of the FERC in recent testimony before Congress: "Like the interstate highway system, however, the transmission grid is not merely a collection of local systems that can be planned on a stand-alone basis. The need for, and effect of, transmission expansions must be considered on a local, sub-regional, and regional basis. To that end, Order No. 890 required transmission providers to expand their planning processes to provide for coordination among transmission providers in the same region. Transmission providers also were directed to establish planning processes to consider not only upgrades that are necessary to maintain reliability of the transmission grid, but also additional expansions that, although not strictly needed for reliability, could enhance the economic operation of the grid. The consideration of both reliability and economic needs, on a local and regional level, is essential to ensuring the proper functioning of the interstate transmission system." Joseph Kelliher, Chairman, Federal Energy Regulatory Commission, Testimony before the Committee on Energy and Natural Resources, U.S. Senate, July 31, 2008.

⁹¹ This analysis is described in Joe Eto, LBNL's Transmission Research Program, "Strategic Benefits Quantification for Transmission Projects," Presentation to WECC TEPPC, June 12, 2008.

⁹² The project research team included: Joe Eto of CERTS and Lawrence Berkeley National Laboratory; Vikram Budhraj, Fred Mobasher, John Balance, and Jim Dyer of CERTS and the Electric Power Group; and Alison Silverstein, a CERTS consultant..

⁹³ This committee included: DeDe Hapner, Vice President, FERC and ISO Relations, Pacific Gas & Electric; Les Starck, Director of T & D Business Unit, Southern California Edison; Caroline Winn, Director of T&D Asset Management, San Diego Gas & Electric; Sean Gallagher, Director of Energy Division, California Public Utilities Commission; Steve Ellenbecker, Energy Advisor to Wyoming Governor Freudenthal; and Jim Bushnell, Research Director, UC Energy Institute.

⁹⁴ Note that the LBNL study included recommendations that address many of these modeling and estimation issues: For example, the following advice was given:

- "For assessing the long-lived asset value, use social rate of discount to calculate the PV of benefits for the new transmission project since transmission system is a 'public good,' assets are long life, and benefits accrue over time. ["In a restructured market, the high voltage transmission lines have become *Public*

Good. The benefit from a new project cannot be denied to any retail customers nor generation owners. For calculating the present worth of a *Public Good* project, one should use the *social rate of discount* instead of regulated rate of return (opportunity cost of capital)].

- For a project with 30-years of economic life and a constant annual benefit of \$50 million, the present worth of benefits will be...Mitigating the Benefits of Extreme Events: Extreme Reliability Events -- Multiple Contingency, Cascading Events; Transmission system performance is analyzed for N-1 and N-2 events but not for extreme events; Methods to assess value of transmission in reducing magnitude and impact of multiple contingencies (N-3, 4, 5, 6) need to be researched and quantified; Quantification approach should focus on network carrying capacity under multiple contingencies. Alternatively, a policy or expert consensus approach can be used for 'value equals xx% of cost' of project. [For] Extreme Market Volatility, [the recommendations were] Insurance industry utilizes extreme event probability distribution eg hurricane and earthquake insurance; Such approaches are data dependent; In the absence of such data to calculate insurance value of avoiding extreme price volatility, a policy consensus approach can be used; Policy consensus can be encouraged via polling of policy makers or more formal approaches such as the Delphi method or risk tolerance and value at risk analysis; Social rate of discount instead of cost of capital can be used to calculate the present value of the stream of future benefits for transmission project similar to other public projects; Possible calculation 'insurance value equals xx% of project cost';...Fuel diversity benefit: assess impact of significant resource resources development over price of natural gas; Reliability improvement from extreme system multiple contingency events: assess impact of transmission project in mitigating N-3, N-4, N-5, N-6 events; incorporate 'transmission reserve margin' concept similar to spinning or planning reserves for generation; Risk mitigation for low probability/high impact extreme market events: estimate risk mitigation benefit to society; research use of value at risk, option value, and insurance premium approaches; Dynamic analysis – construction of new generation: recognize changing benefit streams over asset life due to construction of new generation in exporting region." Joe Eto, LBNL's Transmission Research Program, "Strategic Benefits Quantification for Transmission Projects," Presentation to WECC TEPPC, June 12, 2008, pages 10-11, 13.

⁹⁵ This analysis is described in Joe Eto, LBNL's Transmission Research Program, "Strategic Benefits Quantification for Transmission Projects," Presentation to WECC TEPPC, June 12, 2008.

⁹⁶ Western Governors' Association's Clean and Diverse Energy Initiative," May 2006, page Report of the Transmission Task Force, page 10.

⁹⁷ These principles have been advanced by WRA. "Transmission planning needs to be forward-thinking to bring the region to an energy policy fitting for the 21st century. Accordingly, WRA has developed a transmission planning platform to ensure that new power lines will be 'smart.' In short, smart lines involve the concepts of: efficiency/distributed generation, clean energy sources and lands/wildlife protection. First, WRA recognizes that the smartest power line is the one that is never built. Eliminating the need for new power lines can be accomplished by ensuring that energy demand is first met by maximizing investments in energy efficiency and distributed generation sources such as rooftop solar. Increasing energy efficiency and utilizing local 'distributed' generation sources that don't need transmission can not only avoid the need for new power plants, but also can eliminate the need for some new transmission lines and associated corridors. Second, smart lines need to focus on tying-in clean energy sources energy such as wind and solar to reduce air pollution and combat climate change. Finally, with the vast amount of public lands and natural resources within the western U.S., smart lines must be planned, located and mitigated in a manner that protects the region's treasured wildlife, land, air and water resources. Of particular importance is the current 'energy corridor' process whereby the Department of Energy, working with other federal and state agencies, is designating energy transmission corridors – for power lines and other energy transmission – on public lands within the 11 western states of Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Idaho, Washington, Oregon and California." See <http://www.westernresourceadvocates.org/energy/xmission.php>

⁹⁸ There may be various ways to establish mechanisms to create incentives for investment, allow cost recovery in tariffs, and allocate investment costs to users in large regions. Some approaches might require new legislative authority. Whether investment occurs through actions of private utility companies, independent merchant transmission companies, publicly owned utilities, or any combination of the above, qualifying investment in strategic pieces of the transmission system could be recovered in transmission tariffs charged by transmission entities, with costs spread across many systems. In turn, the revenues could be collected by transmission entities, and redistributed through repayment formulae that track the source of underlying investments. Issues associated with needed changes in statutory authority, investment recovery and cost-allocation mechanisms, and associated transmission access rights should be the topic of lively discussion, further technical studies, and policy mechanisms, with the goal of finding investment recovery and cost-allocation pathways that support an "interstate electric highway system" paid for by users of electricity service, and presumptively not by taxpayers.

⁹⁹ This was the view of the 2005 Keystone Center dialogue on regional transmission projects: "one of the most challenging problems is the jurisdictional split in authority among state, federal, and local governments over transmission planning, cost allocation (and related ratemaking treatment), and siting. The process for making decisions about transmission planning, cost allocation, cost recovery, and siting has not evolved in all regions of the country to reflect the regional nature of electricity markets and transmission needs to support bulk power transactions.....When a transmission owner or vertically integrated utility develops plans for new transmission, it must first consider the needs of customers within its service territory, even though the boundaries seldom coincide with potential beneficiaries within the regional market. When the state issues a certificate of need for a new facility, its authority to evaluate the need and benefits typically stops at the state border. States and local governments retain authority over siting transmission on private and state land; federal land managers have jurisdiction over siting on federal lands. Yet the need for bulk power or "backbone" transmission facilities is regional in scope, covering multiple jurisdictions. Cost allocation and cost recovery decisions may be divided among state, federal, and non-jurisdictional entities (such as federal power authorities). The long-term beneficiaries of regional lines typically include most of the region's inhabitants, calling for a broader allocation of costs than emerges from any single jurisdiction. The rational development of a transmission system for the 21st century begs for a regional perspective to transmission planning." Keystone Center, "Regional Transmission Projects: Finding Solutions," 2005, page 2.

¹⁰⁰ http://www.spp.org/publications/SPP_Wind_Integration_OA.pdf

¹⁰¹ Les Dillahunt. "SPP's Vision: The Future of Transmission Expansion," *EnergyBiz*, March/April 2008, pp 28-29. http://energycentral.fileburst.com/EnergyBizOnline/2008-2-mar-apr/FA_Grid_Sub_SPP_Vision.pdf

¹⁰² Jay Caspary. "X Plan Status," August 22, 2007.

http://www.nationalwind.org/pdf/Caspary_X_Plan_Status_NWCC_SPP_Aug_2007_DRAFT.pdf

¹⁰³ Janice Francis-Smith, "Southwest Power Pool transmission plan caught in Catch-22," *The Journal Record (Oklahoma City)*, Sep 17, 2007. http://findarticles.com/p/articles/mi_qn4182/is_20070917/ai_n20503465

¹⁰⁴ Esther Whieldon. "Study suggests reinforcing SPP grid with EHV lines would cost more than \$6 billion," *Platt's Inside F.E.R.C.*, March 17, 2008.

¹⁰⁵ According to the Quanta Study, the four EHV overlay designs offered many benefits which exceeded their costs: Each of the four designs included most of the following benefits (with some differences in avoidance of environmentally sensitive areas and other local enhancements): reliability reinforcement of the SPP system providing improved voltage support throughout the system and in particular areas; significantly increased export capability to support access to energy markets; enhanced import capability to get access to low cost regional energy; assistance to the SPP states in becoming leading providers of environmentally friendly, renewable energy for the US.; a tightly coupled electric grid that will allow "environmentally friendly balancing of wind energy with local area natural gas generation"; the development of "effective interconnections for EHV system development by SPP's neighbors to the north and east"; "cost effective solution[s] with minimized ROW [right of way] impacts on local area communities and landowners versus lower voltage transmission." The range of costs was from \$6.74 billion cost (Design 1); \$7.01 Billion (Design 2); \$7.13 Billion (Design 3); and \$6.93 Billion (Design 4). Quanta's final recommendations were that: "All of the mid point designs provide SPP, its members and its stakeholders improved reliability for the SPP electric system while providing the ability to be a leading provider of sustainable energy for the United States. All designs are flexible and allow for alternative interconnections to the east and for the wind collector system. Based upon cost, summer peak performance, export capability and losses, Mid Point Design 2 and Mid Point Design 4 are the top two performing options...It is further recommended that SPP present all of these designs for consideration in inter-regional planning conducted by the Joint Coordinated System Planning committee formed by SPP, MISO, PJM, and TVA." Quanta Technology, "Updated SPP EHV Overlay Study – Final Version," March 3, 2008, pages 3, 23, 29, 34, 39, 59.

¹⁰⁶ EEI, FERC Energy Supply Review, June 2008, http://www.eei.org/members/International_Affiliates/energy_supply_June_2008_final.pdf

¹⁰⁷ This summary is from the author's notes of the July 28th, 2008, meeting of the RSC.

¹⁰⁸ This summary is from the author's notes of the July 28th, 2008, meeting of the RSC.

¹⁰⁹ Janice Francis-Smith, "Southwest Power Pool transmission plan caught in Catch-22," *The Journal Record (Oklahoma City)*, Sept. 17, 2007. http://findarticles.com/p/articles/mi_qn4182/is_20070917/ai_n20503465.