AMERICA'S
POWER PLAN

TRANSMISSION POLICY:

Planning for and Investing in Wires

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EXECUTIVE SUMMARY

America's power transmission network is critical to society, bringing the electricity needed to run homes, factories and businesses. Yet regardless of the energy mix involved – fossil fuels or renewables – the cost of moving power from here to there remains the smallest part of the typical consumer electric bill – about 11% on average[1] – compared with two-thirds of the bill for generation and a quarter for distribution. Needed investments in transmission can frequently be more than paid for by savings in energy costs the new capacity makes possible.

The primary barriers to building new high voltage lines and optimizing the grid aren't so much technical or economic but rather bureaucratic. Inefficient *institutions* and insufficient *policies* are the key factors preventing the United States from accessing its rich resources of clean energy, and spreading that wealth throughout the economy. This paper describes how to overcome these institutional and policy barriers, providing policymakers with clear guidance for planning and allocating the costs of badly-needed transmission upgrades.

As clean energy grows and modernizes America's power system, transmission can be either a strong enabler or the dominant constraint. Easing this constraint will require actions that sort into five categories:

1. Assess and communicate the benefits of transmission expansion.
2. Prioritize inter-regional lines that link balancing areas.
3. Harmonize grid operations and increase competition in electricity markets.
4. Slash the timeline for planning, building, and siting transmission.
5. Then, make the most of the lines once they are built.

1 *Transmission Projects: At a Glance*, Edison Electric Institute, March, 2013.

Transmission upgrades and expansion are a critical part of any long-term investment plan for America's future. In fact, there is a growing body of reports indicating that transmission investments deliver benefits far exceeding their costs, and they are essential to delivering higher levels of renewable energy to consumers at least cost. Fortunately, there are specific actions that policymakers can take today to accelerate the grid modernizations that would enable electricity customers to access the most valuable renewable energy resources. From making the most of what we have, to opening up more competition in the electricity sector, to linking together new regions of the country, the next steps are clear. America's policymakers can enable a grid that will maximize the value of the country's energy resources by delivering clean power to the homes and businesses that need it.

INTRODUCTION: ENERGY ON THE MOVE

America's power transmission network is critical to society, bringing the electricity needed to run homes, factories, and businesses. Yet regardless of the energy mix involved – fossil fuels or renewables – the cost of moving power from here to there remains the smallest part of the typical consumer electric bill – about 11 percent on average[1] – compared with two-thirds of the bill for generation and a quarter for distribution. Importantly, needed investments in transmission can frequently be more than paid for by savings in energy costs the new capacity makes possible.

High-voltage transmission lines make the grid more efficient and reliable by alleviating congestion, promoting bulk-power competition, reducing generation costs and allowing grid operators to balance supply and demand over larger regions. And these considerations will be ever more important in a high-renewable energy scenario. Solar, geothermal and wind energy can't be shipped in rail cars or pipelines like traditional fuels, but rather must be converted to electricity on-site and then transmitted to consumers. High-voltage transmission is essential for keeping these costs as low as possible, considering that many high value renewable resources are richest in remote regions far from population centers, where most energy is used.

The National Renewable Energy Laboratory's *Renewable Electricity Futures Study (NREL RE Futures)* concluded that building additional transmission and taking full advantage of the flexibility it affords would enable grid operators to balance supply and demand at the hourly level with very high levels of renewable energy – 80 percent or more.[2] When combined with the growing body of evidence that high voltage interstate transmission lines produce economic benefits far exceeding their costs – NREL's conclusion strongly suggests that there are few – if any – remaining technical or economic hurdles to a high renewable electricity future and the infrastructure to support it. What's more, NREL concluded that the incremental transmission investments needed to achieve an 80 percent renewable future are well within the recent historical range of utility transmission outlays, and thus would likely have minimal impacts on average electric rates.

The primary barriers to building new high voltage lines and optimizing the grid aren't so much technical or economic but rather bureaucratic. Inefficient *institutions* and insufficient *policies* are the key factors preventing the United States from accessing its rich resources of clean energy, and spreading that wealth throughout the economy. Currently, the main obstacles include:

- Disputes over how to allocate or share costs for new lines among ratepayers in different sub-regions of the electric grid.
- Concerns over whether the costs of new high-voltage transmission lines will outweigh benefits for ratepayers, and whether the cost of new lines will unfairly be allocated to customers who will not benefit from them.
- Concerns related to impact of siting the lines, including environmental and cultural impacts, and compensation to landowners, as well as inconsistent and uncoordinated state policies on transmission line siting.[3] (A separate paper in this series addresses siting concerns.[4])
- Failure to accord proper weight to the clean nature of renewable energy in much of the country, a failure that the falling cost of renewable energy is beginning to remedy, with major recent purchases of renewable energy requiring long-distance transmission by utilities motivated by economic considerations, not mandated by public policy.[5]

This paper describes how to overcome these institutional and policy barriers, providing policymakers with clear guidance for planning and allocating the costs of badly-needed transmission upgrades.

CROSSING BOUNDARIES

America's aging electric power system badly needs new and improved high-voltage lines to deliver renewable power from remote areas to population centers, and to link fragmented balancing areas and markets. Developers are naturally motivated: investments in transmission are usually profitable. High-voltage transmission projects are expensive, but can be built for profit because they cost less than the savings they create in lower costs for delivered energy and avoided congestion.

The challenge is that the most essential lines for a high-penetration renewable electricity future are often the most difficult ones to build. These transmission facilities typically must span hundreds of miles, carry price tags of hundreds of millions of dollars,[6] and most significantly, cross many boundaries of a balkanized regulatory framework that emerged almost a century ago[7] for local monopolies organized around central power plants serving retail markets. This institutional structure is fundamentally unsuited to the task of planning and building modern, efficient, regional and interregional transmission.

Due to these archaic institutional and political structures, some incumbent utilities and power plant owners benefit from the inefficiencies of the current system. By blocking new transmission, these power plant owners may protect themselves from competition from renewable energy that is priced below the marginal cost of their own fossil-fired power. Incumbents can use the outdated institutional structure to block grid modernization that would threaten the economic advantages they reap from today's inefficient transmission system.

EASIER THAN IT LOOKS

The *RE Futures Study* reaches a striking conclusion about the feasibility of a clean energy future for the U.S.: an 80 percent clean energy economy by 2050 is both technically achievable and affordable, and that the most efficient means of reaching that goal include major investments in the expansion and improvement of the nation's high-voltage electric grid. The NREL study made several assumptions to facilitate the evaluation of various high-renewable energy futures, notably:

- No new laws, such as carbon pricing, cap-and-trade policies, or additional state renewable portfolio standards, were assumed to take effect during the study period beyond the provisions of existing laws. (See RE Futures Study pages 1-13)
- Distribution-level upgrades were not considered.[8] (1-12)
- Renewable electricity that was not delivered due to system management curtailment and transmission losses was not counted toward the 80 percent renewable electricity level. (1-12)
- Pre-existing transmission infrastructure was assumed to continue operation throughout the study period, and existing line capacity was assumed to be usable by both conventional and renewable generation sources. (1-32)
- Transmission cost assumptions spanned a wide range as is shown in table A-6 below, and transmission losses were assumed to reflect current experience, despite likely improvement from new technologies and production economies, as well as increased use of direct-current lines.

Table A-6. Assumptions for Transmission and Interconnection

CATEGORY	RANGE
Inter-BA line costs ($/MW-mile)	$1,200-$5,340
Substation costs ($/MW)	$10,700-$24,000
Intertie (AC-DC-AC) costs ($/MW)	$230,000
Base grid interconnection costs ($/MW)	$110,000
Intra-BA line costs ($/MW-mile)	$2,400-$10,680
Transmission losses	1% per 100 miles

Grid and market operators around the country are rapidly gaining experience managing ever-larger amounts of renewable energy on their systems. This real-world experience is challenging long-held assumptions about the cost and difficulty of integrating large amounts of renewable energy into the electric system. Almost uniformly, experience suggests that common assumptions overestimate – perhaps dramatically – the cost and technical difficulty of integrating large amounts of renewable energy, specifically the need for balancing generation and curtailment of variable renewable resources.

How MISO Got it Done

Joe Gardner, Executive Director of Real-Time Operations for the Midwest Independent System Operator (MISO), told his Board of Directors in February of 2012 why integrating more than 12,000 MW of wind generation, about ten percent of MISO's total generating capacity, has been relatively painless:

- **Geographic diversity.** The wind blows at different times in different places across MISO's twelve state footprint – smoothing out the variation at any single location.
- **Better forecasting tools** make it easier to accurately predict wind turbine output.
- **Transmission expansions and upgrades** are being approved and constructed, giving operators greater flexibility to manage all resources, and giving consumers more choices via competition.
- **Grid operators around the country and the globe are learning from each other** as they successfully integrate ever larger shares of renewable energy on their systems.

Another presentation by MISO confirms that they have seen very little increase in their need for operating reserves, even as they successfully integrate ever larger shares of renewable energy on their systems.

Transmission Projects: At a Glance, Edison Electric Institute, March 2013. <https://docs.google.com/viewerurl=http%3A%2F%2Fwww.eei.org%2Fourissues%2FElectricityTransmission%2FDocuments%2FTrans_Project_lowres.pdf>

A study of lessons learned by the Midwest Independent System Operator (MISO) identified larger balancing areas and shorter dispatch periods as critical factors in MISO's success at integrating large amounts of variable wind generation at minimal cost.[9] A more recent presentation by MISO confirms that they have seen very little increase in their need for operating reserves, even with this large amount of wind energy on their system.[10]

If the recommendations in *New Utility Business Models: Implications of a High-Penetration Renewable Future* and *Renewable Energy and Transmission Siting* are taken to heart, new transmission will play an accelerating role in the electric sector ecosystem of the future, delivering benefits to grid operators, utilities and electricity customers alike.

In fact, throughout the U.S., other recent developments have favored the rapid growth of new transmission investments that are easing the transition to a higher renewable energy scenario:

- Renewable energy sources such as solar and wind are rapidly falling in price.
- Recent federal actions (described below) and the growth in the number of independent system operators mean more competition and less risk in the market for new transmission, stimulating new investments.

- More industry actors are recognizing the multiple benefits of planning and sharing transmission over larger regions, reducing the number of separate "balancing areas" where utilities are required to balance internal generation with internal demand at all times.

Transmission planners must also account for the rapid growth of demand-side resources, such as demand-response, energy efficiency, distributed generation, storage and "smart grid" technologies that have reduced the required new transmission capacity from the massive amounts that would be necessary if such demand-side resources were not available. Transmission planners must evaluate how these resources may affect the need for specific transmission investments, their timing and the capacity of the grid to reliably and cost-effectively achieve high levels of renewable integration. While demand side resources are unlikely to substitute for transmission investments needed to access remote high quality renewable resources, serve high-voltage loads, maintain regional power quality or expand balancing areas, they are likely to mitigate variability and reduce the need for balancing generation. Moreover, a planning process that fully considers demand side resources will build confidence in and broaden support for any new transmission investments, which are identified. Planning that fully accounts for demand-side options as they evolve will offer a net benefit to the ability to gauge and meet transmission needs appropriately.

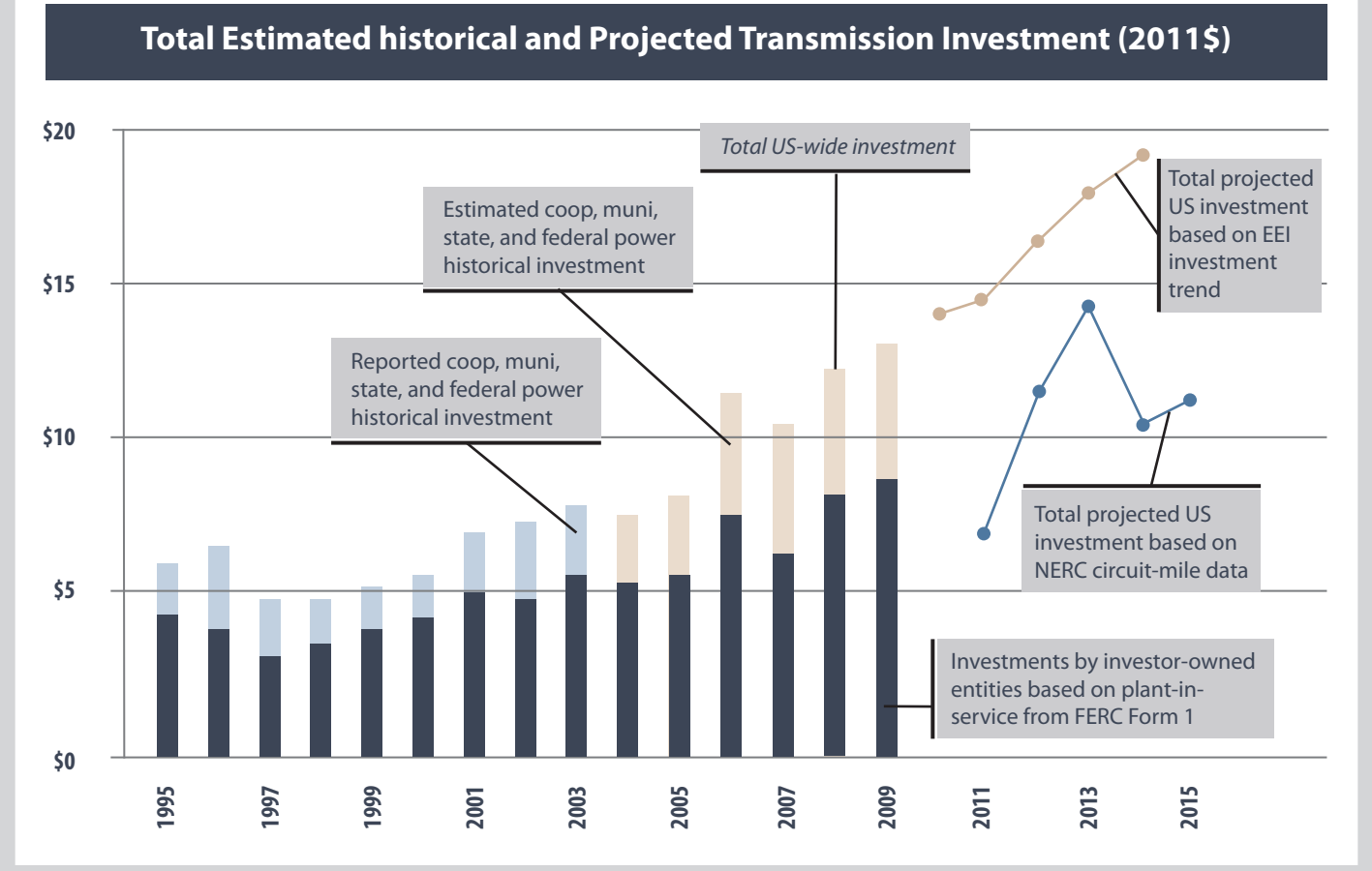

Figure 1. Recent and projected transmission investment.[11]

Figure 1 shows that investment in high voltage transmission has increased in every region of the country over the past decade, most rapidly in regions with linked planning and cost allocation processes operating across large geographic regions (e.g., Midwest Independent System Operator and Southwest Power Pool). The Edison Electric Institute projects that transmission investments will peak in 2013, and then gradually decline in subsequent years.[12] Transmission policy reforms and adoption of aggressive renewable energy standards or greenhouse gas targets would likely change those projections.

Now, let's take a closer look at each of the trends listed above, all of which are encouraging new investments in both renewable energy and transmission.

REASONS FOR OPTIMISM

Renewable energy grows as prices fall

Wind has become cost-competitive with wholesale electricity generation in many parts of the country. In 2012, private investors poured $25 billion into the industry, adding a record 13 gigawatts of new generating capacity, and bringing total installed wind in the U.S. to more than 60 gigawatts – a five-fold increase since 2007.[13] Solar power also had a record year in 2012, with more than three gigawatts installed, employing about 120,000 people across the industry.[14,15] Cost parity has already been achieved for utility-scale renewable energy in many regions – infrastructure is a chief barrier to further development.

The growth of renewable energy generation (combined with retirement of old, fossil fueled electric-generating plants) is already driving increased investment into the transmission industry. The vast transmission market opportunity is attracting new entrants to the business; merchant developers, utility spin-offs, and smaller operators are taking advantage of the opportunities to make long-term, stable and remunerative investments.

Demand-side options are helping

Regional transmission planning increasingly requires consideration of a vast array of alternative resources that can reduce or even eliminate the need for some transmission investments. Demand-side resources are increasingly available to meet reliability and economic goals that automatically prompted proposals for increased central generation and accompanying transmission from traditional utility planners. These options should thus allow the capital available for new transmission to be better focused on capacity to provide access to clean energy that would otherwise remain undeliverable. Smart planners and markets will weigh new transmission against alternative resources such as distributed generation, demand-response, energy efficiency, storage and "smart grid" technologies. This process can deliver a portfolio of investments – including transmission – that achieve grid operators' goals while delivering the best long-term value to customers. Consistently and comprehensively considering alternatives in the planning process will ensure that new investments in transmission are focused on the highest value opportunities.

Regulatory moves have increased competition

At the regional level, Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) have grown to cover large swaths of the country's electric systems in the past decade. The expansion of RTOs has resulted in more open, competitive wholesale electric markets. Today, nearly two thirds of the U.S. population is served by competitive transmission markets and organized wholesale electricity markets run by ISOs and RTOs.[16] And RTOs are expected to expand further in coming years. Transmission delivers the greatest value in regions with RTOs and open markets because coordinated planning and cost allocation prioritizes the most cost-effective transmission investments, while electricity markets ensure that cost savings enabled by new transmission are realized.

At the national level, three recent actions are likely to accelerate competition and investment in transmission:

- A recent federal requirement that opens markets and reduces risks for independent transmission developers (FERC Order 1000).
- Reform of policies governing Federal Power Marketing Administrations.
- Clarification of guidance for incentive rates of return.

The Federal Energy Regulatory Commission's (FERC) Order 1000 went beyond basic guidance for transmission planning and cost allocation to include a requirement that incumbent utilities surrender their right of first refusal to build transmission projects in their service area, as long as the proposed new projects result from the Order 1000 planning process. If this is sustained in FERC's implementation processes and in the Court of Appeals where it has been challenged, this aspect of Order 1000 increases market competition in the transmission industry. First, it allows independent developers to compete directly with incumbent utilities from the start. Second, and less obvious, it prohibits incumbent utilities from taking over projects initiated by independent developers in which the utilities hadn't properly exercised their first right of refusal. This change helps drive down risks for transmission investors, who have previously had to weigh the possibility that a new project could be taken over after considerable time and investment.

Modernizing the policies governing Federal Power Marketing Administrations (PMAs) holds additional promise for increasing investments in transmission and promoting competition in the electric sector. Specifically, the PMAs can expand transmission infrastructure by implementing authorities already on the books; operating existing transmission more openly and efficiently; and coordinating investments and operations with other utilities, regional transmission organizations and balancing authorities. As initiated in March 2012 (by then-Energy Secretary Steven Chu), these changes in PMA operations would open access to underutilized transmission resources and stimulate new transmission investment. Despite vocal opposition from

PMA customers,[17] these reforms would accelerate efforts to expand, modernize and more efficiently operate of the grid in the most renewable energy-rich regions of the country – with potentially huge benefits for customers and local economies of those regions and beyond. There is no necessary incompatibility between a modern, integrated and competitive regional grid in the PMA areas and the preservation of historic economic benefits the PMA customers in those regions have enjoyed, but without such improvements to the grid and its operations, it is clear that the rich resources of renewable energy in that region will not achieve their potential to offer clean energy economically to broad regional and interregional markets.

The scope of transmission planning is expanding

As mentioned above, FERC finalized Order 1000 in 2012. Among other changes, this new order requires that all utilities participate in a regional transmission planning and cost-allocation process; that planners account for public policies like state renewable portfolio standards (RPS), federal environmental regulations and other laws and regulations that could affect the electric industry; and that they coordinate with neighboring regions. Early indications suggest that Order 1000 is having the intended effect of expanding the scale and scope of regional transmission planning. Specifically, Order 1000 is forcing planners to work together over larger areas to consider the benefits to ratepayers of region-wide transmission investments that expand balancing areas, deliver remote renewable resources to customers and allow the electric system to meet public policy requirements at least cost. Separately, but also significant, the Department of Energy has funded even larger scale planning and analysis activities – at the interconnection level – which have laid important analytical and process groundwork for inter-regional coordination yet to come under Order 1000.

Meanwhile, RTOs are increasingly recognizing the benefits of coordinated planning, cost allocation and market operations at the regional scale. ISOs and RTOs in regions with strong renewable energy resources and state policies driving the development of those resources are implementing regional transmission plans with clear methods for cost allocation. Recent experience suggests new lines will be able to facilitate larger balancing areas:

- The Midwest Independent System Operator (MISO) used a broad-based, stakeholder-driven planning process over 18 months to secure agreement to share the costs of 17 high-voltage transmission lines addressing critical constraints throughout a twelve-state region. According to MISO, the transmission investments were driven by the need to deliver renewable resources from remote areas to population centers. MISO estimates that the 17 Multi-Value Projects (MVPs) will create $15.5 to $49.2 billion in net present value economic benefits over a 20 to 40-year timeframe, which means they will deliver benefits 1.8 to 3.0 times their costs. For retail customers, that translates to $23 in annualized benefits from lowered delivered energy costs for about $11 a year in investment - a 109 percent return.[18]
- The Southwest Power Pool (SPP) completed its first 20-Year Integrated Transmission Plan Assessment in January, 2011, and estimates that the nearly 1500 miles of 345 kV lines and 11 transformers in the plan will reduce the cost of generating and supplying energy by more than five times their $1.8 billion engineering and construction cost, while simultaneously giving the region the flexibility to respond to potential policy initiatives such as carbon regulation.[19] SPP's "Highway-Byway" cost-allocation methodology, approved by FERC in 2010, allocates transmission facility costs based on facility voltage. For projects of 300kV and above, all costs are allocated on a uniform (i.e., "postage stamp") basis equally across the entire SPP region. For projects below 300kV but above 100kV, one-third of the cost is allocated on a regional basis, and the remaining two-thirds of the cost are allocated to the SPP zone where the facilities are located. For projects of 100kV or less, all costs are allocated to the zone where the facilities are located.
- In January of 2013, the Nevada-based Valley Electric Association became the first out-of-state utility to join the California Independent System Operator (Cal-ISO). The partnership gives California additional capability to import inexpensive and abundant out-of-state renewable resources to help meet its goal of 33 percent renewable energy by 2020. This move is part of a larger Cal-ISO effort to work with neighboring states to achieve the efficiencies offered by regional collaboration.[20]

- In February of 2013, PacifiCorp and the California ISO announced their plans for a real-time imbalance market to be operation in 2014.[21]
- Entergy recently gained approval from federal and state regulators to integrate its high-voltage transmission system into MISO by the end of 2013. The transaction will not only add 15,800 circuit-miles of high voltage lines in Louisiana, Arkansas, Mississippi and Texas to MISO, it will extend MISO's groundbreaking markets, transmission planning processes and cost allocation procedures to the Southeast.

WILDCARDS

Although the trends described above are well underway, several wildcards could have important impacts on transmission planning and build-out in the coming years:

- Dramatic cost reductions in offshore wind, distributed generation or bulk electricity storage.
- Development of cost-effective DC circuit breakers.
- Broad adoption new technologies that allow the transmission system to be operated more efficiently, such as synchrophasors and "Dynamic Line Rating."
- Accelerated use of cost-effective and efficient grid operational practices, such as intra-hour transmission scheduling, improved wind and solar forecasting, dynamic transfers of variability between balancing areas, real-time path ratings and improved reserve sharing.
- Dismantling state and local barriers to a more integrated, competitive and cost-effective transmission system.

Big changes in any of these areas could significantly alter the actions that America takes to update and expand its power system.

Dramatic reductions in the cost of offshore wind, distributed resources or storage

Technological breakthroughs reducing costs in any of these areas could essentially re-draw the clean energy resource map in ways that would significantly affect both the value and nature of on-shore transmission investments. For example, a large drop in the cost of offshore wind would open development of very large renewable resources close to eastern population centers, and reduce the value of new capacity transmitting on-shore wind from the Midwest to the East coast. Further price drops in distributed renewable generation and/or electricity storage technologies could allow more generation to be located closer to load, potentially reducing the value of inter-regional transmission investments.

Practical high-voltage DC circuit breakers

Global electronics giant ABB announced last year that it had developed "a fast and efficient circuit breaker for high-voltage direct-current (DC) power lines, a device that has eluded technologists for 100 years."[22] If the technology proves cost-effective, it could make possible a resilient high-voltage DC transmission grid; could help make possible the cost-effective undergrounding of long distance, high-voltage DC lines; could reduce line losses over long distances and drastically reduce siting concerns in sensitive areas.

DC transmission is especially well suited to connecting inter-regional electricity markets due its ability to schedule power flows that precisely match market signals. Customers on the receiving end get lower prices, while generators get increased revenue. When designed as integrated elements of the AC systems, DC lines have the potential to tie RTOs and interconnections together in an extremely cost effective manner.

Broad deployment of technologies that make grid operations more efficient

Many technologies now exist which would allow the high voltage transmission system to be operated much more efficiently – at very low costs compared with building new lines. While these technologies will never substitute for some new investments, such as lines to increase transfer capacity between RTOs or lines to access large remote renewable resources, they can allow grid operators to get the most out of every existing line, every new line, and the transmission network as a whole. Two good examples of these types of technologies now in limited deployment around the country are synchrophasors and dynamic line rating systems.

Synchrophasors monitor electrical conditions hundreds of times faster than current technologies – 30 to 120 times per second – and time-stamp every measurement to synchronize data across large regions of the high voltage transmission system. Grid operators can use this information to detect disturbances that would have been impossible to see in the past, and to take actions to address them before they lead to much more serious and costly problems, like severe congestion, voltage reductions or widespread loss of power. Broad deployment of synchrophasors would allow grid operators to contain or even prevent catastrophic outages like the "Northeast Blackout of 2003," which affected 55 million people, cost billions of dollars and contributed to six deaths in New York City.[23]

With support from the Department of Energy's $3.4 billion Smart Grid Investment Grant (SGIG) program, the Western Electricity Coordinating Council (WECC) is installing more than 300 phasor measurement units across the Western Interconnection – providing 100 percent coverage for the Western Interconnection. The technologies are expected to enable an additional 100 MW of operational capacity on the California-Oregon Intertie. Similar system benefits are possible in other parts of the system.

Most existing high voltage transmission lines have conservative voltage ratings, set low to make sure the lines work under worst case conditions. Under normal weather conditions, that means that substantial transfer capacity is left on the table. Some weather conditions (i.e., cold temperatures or high wind conditions) may actually increase the transfer capacity further, since the line is better able to shed resistance heat. Dynamic Line Rating, a.k.a. "automated transfer capacity evaluation," can much more precisely match the transfer capacity of high voltage lines to their actual operating environment in real time, increasing their transfer capacity by 10-20 percent or more in most cases. Broad deployment of Dynamic Line Rating – already required in Europe – would increase transmission capacity at extremely low cost, change our understanding of existing transmission capacity and constraints, and potentially increase the capacity – and value – of transmission expansions and upgrades. Moreover, when wind conditions permit stronger than average generation of wind-powered electricity, those same conditions could potentially permit above-normal use of the transmission lines that deliver that power.

More efficient grid operational practices

Even the most technologically advanced transmission system will fail to benefit ratepayers and advance clean energy unless it is operated efficiently. Significant parts of the U.S. have yet to implement proven practices that make the transmission system more efficient and more friendly to renewable energy, including: intra-hour transmission scheduling, improved wind and solar forecasting, dynamic transfers of variability between balancing areas, real-time path ratings and improved reserve sharing. Uniform implementation of these and other efficient grid operational practices would accelerate transmission development and development of renewable energy resources by expanding the regions with the most favorable conditions for both types of investments.

State and local policy barriers to a more integrated transmission system

A powerful but under-appreciated group of barriers to a more efficient and integrated transmission system are provisions of state RPS's which give preferential treatment to in-state resources or even exclude out-of-state resources entirely. These provisions are generally aimed at spurring development of local renewable resources and related economic activity, a laudable goal. For modest RPS goals, the cost to ratepayers of excluding higher quality and cheaper out-of-state resources may be small. But for high levels of renewable energy, such as those examined in the RE Futures study, the costs to ratepayers of these market barriers is likely to be high. If states maintain or strengthen preferences for in-state renewable resources, or if the courts do not invalidate them as unconstitutional under the Commerce Clause of the U.S. Constitution, consumers may be forced to pay dramatically higher costs for clean energy, accept greater local impacts from producing and transmitting that energy and lose the geographic-diversity benefits of broader regional access to locally variable resources. In this case, potentially cost-effective interstate transmission lines would also be excluded from regional plans.

POLICY RECOMMENDATIONS

To achieve low levels of renewable energy penetration within certain regions – such as the ten percent of capacity already achieved in MISO – incremental changes in transmission planning and markets would be sufficient. Yet for the very high levels of renewable electricity penetration described in the *RE Futures Study*, there are no alternatives to major new transmission capacity investments.

As the U.S. moves toward much higher levels of renewable penetration, transmission can be either a strong enabler or the dominant constraint. Easing this constraint will require actions that sort into five categories:

1. Assess and communicate the benefits of transmission expansion.
2. Prioritize inter-regional lines that link balancing areas.
3. Harmonize grid operations and increase competition in electricity markets.
4. Slash the timeline for planning, building and siting transmission.
5. Then, make the most of the lines once they are built.

Assess and communicate the benefits of transmission expansion

As described in the examples above, careful analysis shows that the economic benefits of transmission consistently exceed their costs – often by a wide margin. But the complexity of the grid makes it difficult to impossible to calculate with any precision how those benefits accrue to specific groups of ratepayers in different regions over time. Despite these inherent limitations, enhanced analysis and communication of transmission benefits can help policymakers arrive at better decisions about planning and cost allocation. A comprehensive recent study for the WIRES Group of transmission companies by the Brattle Group[24] laid out the many benefits that can be attributed to a transmission system investment and provides explicit guidance to regulators, utilities and customers on evaluating those benefits for purposes of planning and cost allocation. It remains to be seen whether the stakeholders will embrace the broader view of transmission benefits the report proves appropriate, and whether regulators will modify their traditional formulas for approval and ratemaking to reflect them. FERC and DOE should also explore methods for financing the relatively small cost of analytically robust, accessible and transparent planning processes. Such planning (if continued as it is being conducted at present) should pay off in a few years with much greater consensus about the costs and benefits of new transmission, and better agreement about allocating those costs and benefits.

Traditional justifications for new transmission lines have been limited to narrowly-defined economic and reliability benefits – leading both planners and ratepayers to under-invest in them. Analysis such as that performed by Brattle for WIRES can begin to account for the full scope of benefits from transmission investments to help planners make better decisions about how much to invest and when and where to do it. Specifically, regulators should quantify benefits from:

- Meeting public policy goals.
- Linking and consolidating balancing areas.
- Increasing reserve sharing.
- Reducing the total variability of renewable resources, loads and conventional generators by aggregating larger areas.
- Accessing higher quality renewable resources.
- Enabling the price-suppression effect from renewable resources with marginal costs verging on zero that reduce generation by more expensive resources.

Better analysis of the benefits of transmission will accelerate investments only if it is trusted by stakeholders can be effectively communicated to diverse and non-technical audiences. Education and outreach are crucial to building support for new investments. In many regions of the country, customers simply do not understand the financial benefits they could realize from new transmission, competitive electricity markets and high levels of renewable energy. The MISO MVP process[25] is an excellent example of how robust analysis; stakeholder engagement and communication can be combined to reach broad agreement on transmission investments that deliver enormous net benefits to customers.

Transmission planners frequently have difficulty overcoming resistance to new transmission investments even when the aggregate benefits of those lines exceed their costs by wide margins. In many cases, regulations prevent planners from allocating costs to ratepayers in neighboring regions, even when they benefit from the lines, unless those ratepayers voluntarily agree to chip in. Sharing the costs of groups of lines over large regions with competitive markets solves this problem by ensuring that everyone who benefits from *any* of the lines helps to pay for *all* of them. The benefits of the lines are then shared by everyone who participates in the competitive market.

Transmission lines are vulnerable to political opposition when their costs and benefits are evaluated on an individual basis. New lines can expose previously protected power plants to competition, reduce electricity prices or threaten long-standing arrangements that give subsidized electric rates to select groups – galvanizing constituencies who stand to lose if the line is built. Meanwhile, the more numerous and dispersed beneficiaries of new lines are less motivated because they anticipate a modest benefit, rather than a significant threat. Aggregating lines over large areas can smooth out uneven impacts, but policy makers should also explore options for compensating groups who end up worse off even after costs are widely shared, rather than allowing them to hold up projects with broad benefits.

Smoothing out uneven costs and benefits is easiest to accomplish in regions where competitive markets automatically distribute the benefits of new transmission investments fairly to ratepayers via lower prices. The greatest promise for broadening support for transmission investments needed for a high renewable energy future lies in strategies to even out cost and benefits – like aggregation – and, where necessary and feasible, approaches which directly address the more stubborn distributional impacts of an integrated transmission system.

DECISION-MAKER	RECOMMENDATION
DOE, NARUC, ISOs/RTO[26]	Embrace updated scope and analysis of transmission benefits.
ISOs/RTOs/RPEs, DOE/EIA	Improve cost and benefit estimates for new lines (see LBNL[27], others). Deliver estimates to FERC and PUCs.
PUCs, FERC	Take care of distributional effects via clear procedures for allocating costs and comprehensive evaluation of benefits.

Prioritize inter-regional lines that link balancing areas

To enhance reliability and resilience, it will be important to build new inter-regional lines that link balancing areas and authorities, increase transfer capacity between interconnections, deliver high quality renewable resources from remote areas to population centers and allow for sharing and balancing of variable and dispatchable resources with complementary characteristics. To accelerate this process, FERC could provide incentive rates for transmission lines that deliver on these goals.

FERC's existing legislative authority allows it to adopt rates for interstate transmission and interstate sales of power. This authority requires a determination that the rates adopted are "just and reasonable" and "not unduly discriminatory," and should permit FERC to offer rate incentives for any new transmission that is judged to face higher business risks than other transmission (perhaps as a function of distance, variability of power sources or costs of construction) that delivers consumer benefits (from clean energy access) that pay back more than the incentive costs over the lifetime of the project. FERC could propose such a policy, and adopt it — after appropriate administrative procedures and input from stakeholders — within a few months.[28]

DECISION-MAKER	RECOMMENDATION
FERC, NERC, PMAs, PUCs	Prioritize inter-regional lines that connect balancing areas.
FERC, NERC	Update the criteria for approving the creation of new balancing authorities, especially cases of balancing authority consolidation or expansion.[29]
FERC	Consider whether transmission providers have taken steps to minimize integration costs (e.g., cooperating with other balancing areas, using dynamic scheduling, or opening energy imbalance markets) before deciding how much ancillary service cost should be assigned to new variable resources.
FERC	Build on Order 1000 to prioritize transmission that delivers renewable energy and to further mitigate risks for inter-regional projects.
ISOs/RTOs/RPEs	Seek good faith collaboration on inter-regional lines.

Harmonize grid operations and increase competition in electricity markets

Competitive, open and efficient wholesale electricity markets are ideal, almost necessary, structures to broadly distribute the benefits of market-enabling transmission investments. Policies that provide and enhance incentives for utilities to join competitive markets and the RTOs that run them will help deliver the full benefits of urgently needed transmission investments. Consumers in competitive markets will become the most vigorous advocates of new transmission, as they benefit from the transmission's role in providing access to the cleanest, most reliable and least cost generation resources. At the same time, some incumbents may see competitive markets as threats to their profit margins, even when competitive markets clearly benefit their customers. More than two thirds of U.S. electric customers are now served by RTOs operating competitive markets, a number that will continue to grow in coming years. Regions outside RTOs that resist reforms will increasingly find themselves competitively disadvantaged relative to those that experience the enormous economic, reliability and clean energy benefits of large, efficient and competitive electric markets.

Transmission lines are even more valuable in competitive electric markets that are scheduled and cleared on short intervals. Many regional electric systems are not operated with sufficiently short dispatch intervals to reap the full benefits of transmission investments. In fact, transmission opponents are often motivated by the antiquated and inefficient market rules and operational practices in their regions that *prevent* ratepayers from benefiting from transmission upgrades and improved grid operations. Modernizing grid operations and making electricity markets more open and competitive are proven ways to benefit electricity customers and to improve the efficiency and reliability of the electric system.[30]

There is no remaining doubt that region-wide wholesale electricity markets work well under existing FERC principles and standards and also that they enable the efficient use of transmission. We also know that renewable energy thrives in environments where both competitive markets and robust transmission infrastructure are present (e.g. MISO). FERC or RTOs themselves could offer incentives to attract more transmission owners to join competitive markets with large scale regional planning and cost allocation processes. Transmission owners who operate in competitive markets could receive higher rates of return to reflect the risks they bear by operating without the traditional protection granted to vertically-integrated monopoly utilities by regulators. RTOs might be able to offer supplemental or attractively-priced energy from their demand-response or integrated multi-state markets to utilities outside their markets, but only on the condition that those utilities join a similarly competitive market to ensure that prices remain a fair reflection of the value.

To alleviate resistance from stakeholders who believe that market efficiencies would reduce their current advantages, FERC and policy-makers could – if necessary – design temporary or permanent economic offsets to mitigate their losses. This type of payment could be more than covered by the large financial benefits of transmission, and would still allow utilities and customers to capture other benefits of the new technology, new capacity and new access to lower-cost resources. This type of payment would help reduce any disincentives to transition to competitive regional power markets.

Beyond competitive markets for electricity and grid services, opening competition for building the transmission lines themselves will improve the cost-effectiveness of transmission solutions. Under Order 1000, the FERC removed the federal "right of first refusal" for the regional and interstate transmission lines most critical to renewable energy development. Forcing these lines into an open, competitive process will allow planners to evaluate a full range of transmission solutions proposed by incumbents and independents, and to choose the most cost-effective investments for ratepayers.

DECISION-MAKER	RECOMMENDATION
ISOs/RTOs, PUCs, IPPs, utility associations, customers	Continue progress toward open competition and generation dispatch at short intervals.
ISOs/RTOs, FERC, PUCs	Offer grid services (demand-response, linked balancing areas) to others in competitive markets.
FERC	Maintain incentive rates for new lines in competitive markets.

Slash the timeline for planning, building and siting transmission

The average time it takes to build a new high voltage transmission line – from the time it becomes part of a plan to the time it is placed in service – is in the range of decade or longer for most planning regions. This timing data is almost exclusively based on transmission lines that are built entirely within one planning region – e.g. MISO, SPP, ISONE, CAISO, etc. For the lines most important to high renewable electricity futures – those crossing multiple planning regions, balancing areas, RTOs, markets, state borders or even interconnections – the time to construction is expected to be longer, since there is no established process for deciding how to plan and allocate costs for these lines.

In contrast, renewable energy generation facilities can be built quickly – typically in less than two years. The actual construction time required to build high-voltage transmission lines (depending on their length and size) is actually much closer to the timeline for building renewable energy generation. What this means is that speed and scale of renewable resource deployment depends critically on the speed of transmission deployment. If the time for planning, cost allocation and siting transmission can be reduced, renewable resources can ramp up quickly. If the transmission building process remains stuck, renewable resources will hit a wall, and isolated parts of the grid will be forced to rely on more expensive and dirtier alternatives.

A relatively painless first step for accelerating transmission siting would be to maximize the potential for joint use of existing rights-of-way for other transportation and transmission functions. The U.S. is crisscrossed by railroads, highways and other infrastructure that already take up land. These existing rights-of-way could provide dual service as routes for new bulk-power transmission lines. Such dual usage could not only offer additional revenues to the land-owners, but could offer potential benefits for electrification of railroads or electric vehicle charging stations along interstate highways. Since land-owner objections are a main driver in the slowness of transmission-line approval, concentrating on routes that are already in use could speed approvals. The first step will be to study the potential for joint-use of rights-of-way, with actual development to follow as appropriate.

Another way that state and federal authorities can accelerate new transmission is to designate and study potential transmission corridors in advance of any specific project proposals. The locations of the highest-value renewable resources are well known, right down to local micro-climate conditions. Transmission should be planned and routes put into the approval process to connect such areas to the grid and the major load centers. This would help in three ways. First, it would lower up-front costs and risk to potential project developers. Second, it would directly cut down on the time to construct an approved line — right now, the regulatory approval for land-use take about four times longer on average than the construction of the actual line. And third, it would stimulate competition from renewable project developers to build in approved locations so that they could access the new transmission.

Finally, developers could be required to incorporate costs of mitigating significant environmental, physical or visual impacts into their bids — these would include funds for strategies such as re-routing around sensitive areas, undergrounding, landowner compensation and other actions to minimize physical impacts and expedite siting of new lines. This would incentivize them to minimize these impacts. Such mitigation of line impacts must be accomplished via siting processes, and are therefore covered in more detail in *Renewable Energy and Transmission Siting*, another paper in this series. From the overall perspective of transmission planning and development, however, any progress in solving siting issues will drive improvement in the economics of new transmission additions.

DECISION-MAKER	RECOMMENDATION
DOT, state/federal highway regulators, railroad regulators	Use existing rights of way.
PMAs, DOI, state/federal authorities with right to approve	Get a head start on approving likely corridors before a specific project applies.
State authorities with right to approve	Accelerate line permitting and approval. Allow federal backstop for lines over 765KV or direct current lines.
Developers	Include payments for siting (overcoming environmental and cultural impacts) in transmission costs.
FERC, NERC	Approve dynamic line rating for transmission line owners, making clear that capacity will be limited under peak demand conditions.

Make the most of lines once they are built

Given the enormous effort and time required to put new transmission lines into service, their extremely long lifetimes (40 years or more), and the similar time frame for achieving high-renewable energy penetration, a bias toward larger lines makes more sense than the current bias toward minimizing the size of new lines. High voltage transmission lines are almost never taken out of service due to under-use, and are almost always used at full rated capacity. In fact, the *RE Futures Study* is one of a growing body of research that indicates *increased* congestion on the high voltage system in the future, even after the addition of thousands of miles of high voltage transmission to access renewables and link fragmented regions. That means it is important to take advantage of new lines being built now, so that their additional capacity can be used in the future.

Another way to make the most out of existing and new lines is to implement dynamic line rating (described in the wildcards section above). With approval from FERC and the North American Electric Reliability Corporation (NERC), transmission line owners could increase the capacity of America's transmission system today, without needing to build anything new. Dynamic line rating would increase transmission capacity at all times except under peaking conditions, rather than capping the throughput based on worst case conditions of a hot, wind-less summer day. Once approved, transmission owners should be eager to install dynamic line rating technology to get the most out of their investments.

DECISION-MAKER	RECOMMENDATION
Developers, FERC, PMAs	Make sure lines being built have the right capacity–"right size" them to enable more capacity in the future.
FERC	Clarify that regional transmission expansion plans may allocate costs for projects that will not be used immediately, if the projects use scarce rights of way or serve location-constrained generation.
FERC, State PUCs	Allow incentive rates of return on investments in advanced grid management technologies, such as: synchrophasers, automated grid operations, transfer capacity rating systems, and strategically placed hardware (e.g., flywheels, capacitors) that cost-effectively addresses voltage fluctuations throughout an interconnection.

CONCLUSION

Transmission upgrades and expansion are a critical part of any long-term investment plan for America's future. The barriers to making these urgently needed investments are institutional – and not due to costs or technical issues. In fact, the *RE Futures Study* is the latest in a growing body of reports indicating that transmission investments deliver benefits far exceeding their costs, and they are essential to delivering high levels of renewable energy to consumers at least cost. Fortunately, there are specific actions that policymakers can take today to accelerate the grid modernizations that would enable electricity customers to access the most valuable renewable energy resources. From making the most of what we have, to opening up more competition in the electricity sector, to linking together new regions of the country, the next steps are clear. America's policymakers can enable a grid that will maximize the value of the country's energy resources by delivering them to the homes and businesses that need them.

DECISION-MAKER	RECOMMENDATION
DOE, NARUC, ISOs/RTOs[31]	Embrace updated scope and analysis of transmission benefits.
ISOs/RTOs/RPEs, DOE/EIA	Improve cost and benefit estimates for new lines (see LBNL , others).[27] Deliver estimates to FERC and PUCs.
PUCs, FERC	Take care of distributional effects via clear procedures for allocating costs and comprehensive evaluation of benefits.
FERC, NERC, PMAs, PUCs	Prioritize inter-regional lines that connect balancing areas.
FERC, NERC	Update the criteria for approving the creation of new balancing authorities, especially cases of balancing authority consolidation or expansion.[29]
FERC	Consider whether transmission providers have taken steps to minimize integration costs (e.g., cooperating with other balancing areas, using dynamic scheduling or opening energy imbalance markets) before deciding how much ancillary service cost should be assigned to new variable resources.
FERC	Build on Order 1000 to prioritize transmission that delivers renewable energy and to further mitigate risks for inter-regional projects.
ISOs/RTOs/RPEs	Seek good faith collaboration on inter-regional lines.
ISOs/RTOs, PUCs, IPPs, utility associations, customers	Continue progress toward open competition and generation dispatch at short intervals.
ISOs/RTOs, FERC, PUCs	Offer grid services (demand-response, linked balancing areas) to others in competitive markets.
FERC	Maintain incentive rates for new lines in competitive markets.
DOT, state/federal highway regulators, railroad regulators	Use existing rights of way.
PMAs, DOI, state/federal authorities with right to approve	Get a head start on approving likely corridors before a specific project applies.
State authorities with right to approve	Accelerate line permitting and approval. Allow federal backstop for lines over 765KV or direct current lines.
Developers	Include payments for siting (overcoming environmental and cultural impacts) in transmission costs.
FERC, NERC	Approve dynamic line rating for transmission line owners, making clear that capacity will be limited under peak demand conditions.
Developers, FERC, PMAs	Make sure lines being built have the right capacity – "right size" them to enable more capacity in the future.
FERC	Clarify that regional transmission expansion plans may allocate costs for projects that will not be used immediately, if the projects use scarce rights of way or serve location-constrained generation.
FERC, State PUCs	Allow incentive rates of return on investments in advanced grid management technologies, such as: synchrophasers, automated grid operations, transfer capacity rating systems, and strategically placed hardware (e.g., flywheels, capacitors) that cost-effectively addresses voltage fluctuations throughout an interconnection.

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1 *Transmission Projects: At a Glance*, Edison Electric Institute, March 2013. <https://docs.google.com/viewer?url=http%3A%2F%2Fwww.eei.org%2Fourissues%2FElectricityTransmission%2FDocuments%2FTrans_Project_lowres.pdf>

2 Transmission investments are central to two of the five tools identified by NREL for integrating high levels of RE: larger balancing areas and more transmission. Transmission also bolsters a third NREL tool, flexible supply, by enabling diverse renewable resources over large regions to smooth out variability.

3 See America's Power Plan report by Zichella and Hladik. Siting is not covered in this report.

4 See America's Power Plan report by Zichella and Hladik.

5 Alabama Power Company and Georgia Power Company contracted in December 2012 and April 2013 for significant wind energy purchases from Oklahoma.

6 *Multi Value Project Portfolio: Results and Analysis*, Midwest Independent System Operator, January 10, 2012. <https://www.misoenergy.org/Library/Repository/Study/Candidate%20MVP%20Analysis/MVP%20Portfolio%20Analysis%20Full%20Report.pdf>

7 The Federal Power Act, Chapter 12 of Title 16 of the U.S. Code (entitled "Federal Regulation and Development of Power") was enacted as the Federal Water Power Act in 1920, and was amended in 1935 to grant the Federal Power Commission (FPC, now the Federal Energy Regulatory Commission), power over the rates charged for interstate transmission of electricity and wholesale power sold for resale. The fundamental authority over siting and construction of transmission lines, which had emerged as an adjunct to state utility regulation from the beginning of the electric utility industry, was not changed despite the new economic authority of the FPC. <http://www.thecre.com/fedlaw/legal12q/fedpowr.htm>

8 NREL did not examine issues at the distribution level, but importantly did not conclude that distributional upgrades would not be needed.

9 *Transmission & Wind: Lessons from the Midwest,* Dale Osborn, Jennifer Christensen, Mike Gregerson, January 2013.

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14 <http://www.seia.org/research-resources/solar-industry-data>

15 <http://thesolarfoundation.org/research/national-solar-jobs-census-2012>

16 This figure includes: CalISO, ISONE, NYISO, PJM, MISO, SPP and ERCOT. Using data from: *2010 ISO/RTO Metrics Report,* ISO/RTO Council, December 2010. <http://www.isorto.org/site/apps/nlnet/content2.aspx?c=jhKQIZPBImE&b=2708737&ct=8961273>

17 Criticism for the reform came from PMA customers and their Congressional delegations, who were concerned that such reforms might change their historical preference rights and the resulting economic benefits they enjoy.

18 *Multi Value Project Portfolio: Results and Analysis*, Midwest Independent System Operator, January 10, 2012. <https://www.misoenergy.org/Library/Repository/Study/Candidate%20MVP%20Analysis/MVP%20Portfolio%20Analysis%20Full%20Report.pdf>

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24 Judy W. Chang, Johannes P. Pfeifenberger, and J. Michael Hagerty (The Brattle Group), "The Benefits of Electric Transmission: Identifying and Analyzing the Value of Investments," performed for the WIRES Group, July 2013, <http://www.brattle.com/_documents/UploadLibrary/Upload1153.pdf>

25 <https://www.misoenergy.org/Library/Repository/Study/Candidate%20MVP%20Analysis/MVP%20Portfolio%20Analysis%20Full%20Report.pdf>

26 See Appendix 1 for list of policymaker acronyms.

27 Mills, Andrew, Ryan Wiser, and Kevin Porter. *The Cost of Transmission for Wind Energy: A Review of Transmission Planning Studies*. Lawrence Berkeley National Lab: Environmental Energy Technologies Division. February 2009.

28 These incentive rates would, of course, be controversial. FERC should be ready and able to win a debate about whether the attributed benefits of clean energy would truly more-than offset the real costs of the incentives.

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30 See America's Power Plan report by Hogan.
31 See Appendix 1 for list of policymaker acronyms.
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APPENDIX 1: ACRONYMS

DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
FERC	Federal Energy Regulatory Commission
IPPs	Independent Power Producers
ISOs	Independent System Operators
NARUC	National Association of Regulatory Utility Commissioners
NERC	North American Electric Reliability Corporation
PMAs	Federal Power Marketing Administrations
PUCs	State Public Utilities Commissions
RPEs	Regional Planning Entities (other than ISOs or RTOs)
RTOs	Regional Transmission Organizations