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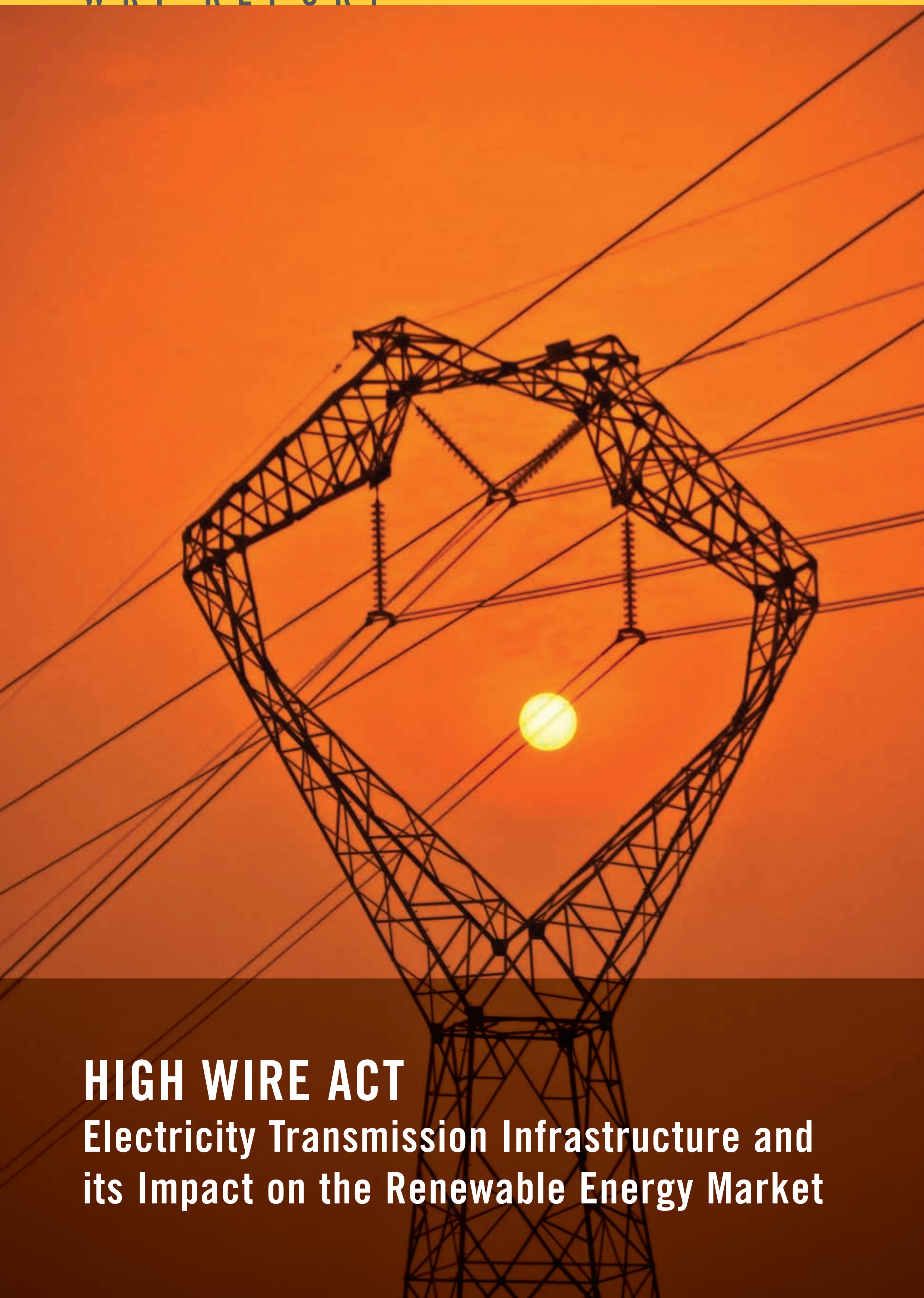

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HIGH WIRE ACT

Electricity Transmission Infrastructure and its Impact on the Renewable Energy Market


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Foreword

Renewable energy, particularly electricity generated from sun, wind, and waves, has a critical role to play in powering a low-carbon economy. As consensus builds for the world's spiraling energy needs to be met without the generation of additional greenhouse gases, renewables can serve both industrialized countries with mature power infrastructures as well as nations building the infrastructure needed to bring modern energy services to their populations.

Despite its potential, the scaling up of renewable energy presents unique challenges. While large-scale, centralized, renewable energy plants are likely to be the most economic low-carbon option in many electricity markets, excellent sources of sun, wind, and wave power are rarely conveniently abundant next to big power users like industrial centers and cities. The task of transmitting energy generated from remote places to heavily populated areas has to be successfully met.

Renewable energy is also intermittent–that is, dependent on the sun shining or the wind blowing. Typically the most cost effective way to manage intermittency is to source energy from a large geographic area. The wind may not be blowing in southern Spain today but it is likely blowing in northern Spain instead. This requires moving electricity across a more widely integrated grid than has historically been necessary.

Solving these key challenges of remote and intermittent resources depends on appropriate transmission infrastructure being in place. However, today's infrastructure is simply not up to the job. Often, new or upgraded hardware has to be extended to renewable energy generation sites to enable the energy to flow where it is needed. But just adding new wires will not resolve all of the obstacles to integrating renewable energy in the grid. Transmission policy, such as how electricity markets incorporate planning for intermittent sources and operations such as load balancing and fault tolerance, must also evolve.

High Wire Act examines the interrelationship of renewable energy and transmission across three growing renewable energy markets: the European Union, China, and the United States. Our research highlights how, in all three markets, transmission is currently a bottleneck to maximizing renewable energy's cost-effective contribution to the power mix. The main message for policy makers crafting renewable energy policies and for investors seeking to invest in this $240 billion a year market is a simple one. Transmission constraints have to be addressed upfront to improve the chances of reaping the long-term rewards of a future powered by renewable energy.


EVAN SHAY

As the report highlights, even in markets where governments have set aggressive renewable energy goals, transmission policy has not kept pace with clean energy ambitions, largely as a result of concerns over associated costs and reliability.

In addition, transmission decisions are as shaped by complex politics as they are by economics. A deep tension between locally borne costs and national or supra-national benefits plays out in three critically important areas: allocating transmission expansion expenditure, siting decisions for both power generation and transmission, and managing access to electricity markets. Each region examined in this report is uniquely grappling with this “local” versus “larger society” tension, based on its own political and regulatory norms. Success or failure in adapting transmission will have a direct impact on efforts in China, the European Union and the United States to tap large-scale renewable energy–and reduce greenhouse gas emissions–in the coming decade.

In a time of austerity, the issues raised by this report are all the more pressing. Public subsidies for renewables are under pressure and there is great reluctance to raise consumer costs to pay for renewable energy. Meeting renewable energy goals in the most cost effective manner is critical to the industry’s long-term success. But if the transmission issues highlighted by this research continue to fester, achieving competitive pricing with fossil fuel electricity will be all the more difficult and the goals themselves may fall by the wayside.

The lesson from this report is clear: if renewable energy investors and policy makers are to build a vibrant global renewable energy industry they must first transform the transmission landscape.

Jonathan Lash
President
World Resources Institute

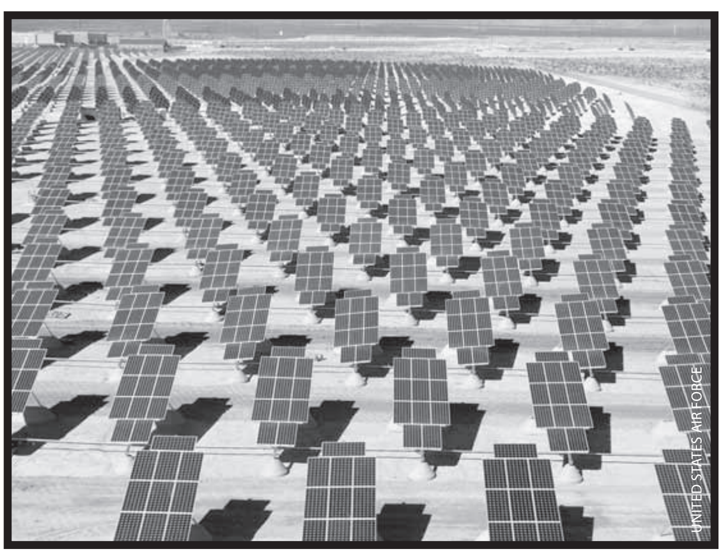
Executive Summary

CONTEXT

Renewable energy (RE)—electricity from wind, solar, and other naturally renewing energy sources—has drawn increasing attention in the quest to reduce greenhouse gases on a scale commensurate with the dictates of climate science. Renewables have the potential to substitute for a significant proportion of the conventional fossil fuels prevalent in today's electricity generation. However, two key features of renewable energy complicate this promise. First, renewable energy resources are location constrained and often available only in remote areas. Their energy must therefore be transported via connected transmission lines (the grid) to demand centers, such as cities. Second, because RE resources are typically intermittent, this energy must be stored or managed with other generation sources to provide a stable and reliable service to consumers. One effective way to address this intermittency is widespread interconnection to diverse resource areas so that low production in one location can be balanced by high production in another. These two important attributes, location-constrained generation and intermittency, mean that transmission is critical to unlocking the promise of renewable energy.[1]

ABOUT THIS PAPER

This paper examines transmission developments and challenges in the European Union (EU), China, and the United States—three regions that present entirely different pictures in terms of governance structures, institutions, and traditions for making decisions about transmission.


UNITED STATES AIR FORCE

Transmission infrastructure can be either a roadblock or an enabling technology for meeting renewable energy deployment goals and thus presents a poorly understood risk to RE investment. To provide context for renewable energy investors, this report examines the policy challenges of providing transmission to:

- Move electricity from large-scale renewable energy generation in remote areas to distant demand centers; and
- Facilitate regional grid interconnections necessary to manage intermittency.

Because transmission is highly dependent on government decisions at both the political and administrative level, this paper emphasizes the regulatory trends in transmission that in turn affect renewable energy investments.[2]

KEY FINDINGS

The transmission challenges impacting RE investment in China, the EU, and the United States have some commonality but occur in three unique regulatory and governance landscapes that establish different incentives and roadblocks to reform. Financing new or upgraded transmission capacity faces the difficult task of allocating cost across users (RE generators, power consumers in various jurisdictions, and society broadly) while ensuring low-cost energy and profitable business models that attract private investment. In all three markets examined, transmission planning and siting is primarily constrained by ongoing tension between national (or in the case of Europe, pan-European) interests and local, state, and member-state interests. In all cases, unlocking greater RE potential through improved transmission is highly dependent on government and regulatory decisions that try to steer through these challenges.

European Union

The European Union uses a mix of private and public investment for grid development, has aggressive targets for developing renewable energy, and is making progress toward those goals. It is also using Directives and other policy tools to push member states to integrate their grids and make the necessary technical and policy changes for cross-border transmission that will allow the flow of renewable energy. The challenges to reaching these objectives can be seen in the still fragmented planning processes and the resistance of member states to fully integrate, making the EU efforts a work in progress. Member states also currently retain the authority to determine whether projects will have a net benefit or cost to domestic customers, and thus to thwart cross-border objectives that do not yield enough local benefit.

The differences among member states in determining cost allocation for transmission expansion, preferential regimes for network usage charges, or the technical grid connection requirements creates additional complexities for planning generation projects across Europe.

China

China has aggressive plans to continue the grid spending surge of the past five years in an effort to keep pace with growing electricity generation. The central government is planning for a likely doubling of electric power generation capacity by 2020 (from 2009 levels), driven by a large increase in electricity demand. Wind farms that are largely located in northwest China, where grid coverage is currently sparse, will provide a large part of anticipated new renewable energy. China recognizes the compelling need to transfer energy from such remote locations conducive to wind and solar generation to its growing megacities and is focusing on new approaches such as investing in ultra high voltage (UHV) transmission research.

Despite a clear commitment to renewable energy, China faces several challenges when integrating RE into the grid, including a lack of connection standards for generators to follow, uncoordinated build-out of new generation, inflexible dispatching, and a lack of financial incentives for grid operators to take up RE power. The central government attempted to resolve several of these issues through the 2009 amendments to the Renewable Energy Law, but it will take time for the effects to be widely felt.

United States

Even more so than the other two markets, United States electricity generation and transmission planning and siting are managed in a highly local and fragmented manner. Renewable energy goals are currently set by states, rather than by the federal government,

INCENTIVES DRIVING TRANSMISSION ACTION

	RE GOALS	COORDINATION EFFORTS	INNOVATIONS
European Union	EU Renewable Energy Directive (June 2009) sets goal of 20 percent power from RE sources by 2020 and mandates grid connectors to provide access to new RE to achieve EU climate policy	The European Network of Transmission System Operators for Electricity (ENTSO-E) and the Agency for the Cooperation of Energy Regulators (ACER) have transmission coordinating missions	EU Priority Projects defined and assigned an EU coordinator to push the project forward
China	Renewable Energy Law (2005, 2009) obligates power grid companies to connect all RE generation sites that fall in their grid coverage	Renewable Energy Law Amendments (2009) require coordinated RE and transmission planning	Development of UHV infrastructure with $59.7 billion in investment
United States	Thirty-one state Renewable Portfolio Standards	Federal efforts encourage regional transmission planning, though there are no requirements	Innovative cost allocation resolutions such as the Tehachapi and Southwest Power Pool projects

ROADBLOCKS TO SUFFICIENT TRANSMISSION ACTION

	LOCAL INTERESTS	COSTS
European Union	Transnational coordination and enforcement powers of EU institutions remain unproven while local opposition to large-scale infrastructure projects is significant in some areas	Transmission investment will be difficult in an era of austerity and slow economic growth
China	Disagreement between the grid operators and wind developers on technology standards and planning complicate RE generation connection	Vast distances between generation and load sites and chronic grid congestion necessitate massive transmission expansion
United States	Weak jurisdictional coordination in the transmission siting and approval process slows or stops transmission projects	Transmission cost allocation issues remain largely unresolved or are resolved at local level, reflecting narrow local interests

complicating broader regional planning for renewable electricity generation and supporting transmission. Whether the 112th Congress will set national goals, move transmission siting responsibility (in whole or in part) from states and local authorities to the federal government, or facilitate multi-state transmission project approvals is highly uncertain after the power shift during the 2010 midterm elections.

Cost allocation negotiations are also a significant challenge for proposed transmission projects, particularly those that cross utilities and/or states. Methods for allocating costs exist but cost allocation disputes between transmission companies or their regulators jeopardize large-scale transmission projects, particularly those not directly related to improved system reliability. The Federal Energy Regulatory Commission (FERC) is considering new federal rules for cost allocation, but reform would face both legal and legislative challenges.

LOOKING FORWARD: SIGNPOSTS FOR INVESTORS

Transmission siting and construction in general may be marginally easier to approve in the EU than in the United States; therefore, RE expansion may be more likely if the current European cooperative efforts succeed on schedule by 2014. This will depend on whether the controlling nature of the relevant EU directives and policies can prevail over local interests in practice. The potential generation that could be unlocked through transmission expansion in the United States and China may, however, be relatively greater, due to the large domestic tracts of land with significant RE generation potential that are currently inaccessible because of transmission constraints.

These opportunities could prove tougher to capture in the United States as a result of difficult-to-resolve regulatory and political uncertainties. If reform efforts bring greater certainty to the United States, investors will be able to respond and shape renewable energy projects accordingly. Even if not all roadblocks are addressed with legislation or regulatory reform, any increase in certainty regarding transmission siting coordination, cost allocation, and national energy policy would unlock new potential in the United States.

Perhaps the market most likely to remove transmission barriers and unlock the real potential of RE is China, as the central government methodically works to reform transmission to support its national renewable energy goals. China faces primarily technical and capacity barriers rather than the paralyzing political debate seen in the United States. China's future market depends on its ability to overcome the resistance of grid companies in a regulatory environment that at least appears more opaque than those in the United States or EU.


ROBERT COUSE-BAKER

Introduction

Transmission is key to renewable energy. The electricity grid—the way energy is transmitted from generators to consumers—is a central concern in climate change policy and clean energy debates. A robust, adaptable grid is necessary to accommodate the growing contributions from solar, wind, and other renewable energy technologies (hereafter "RE") that will be necessary to replace conventional fossil fuels. The International Energy Agency (IEA) predicts business-as-usual investment in transmission between 2010 and 2050 will top $2.5 trillion.[3] However, to cut global energy-related carbon dioxide (CO_2) emissions in half by 2050 (the IEA's BLUE scenario), the IEA projects an additional $1.7 trillion investment in transmission will be required. Combined, this global investment averages just over $100 billion a year. To put these figures into perspective, United States' 2009 investment in transmission was $9 billion.[4]

Renewable energy poses new challenges to transmission infrastructure. High quality RE resources are often distant from electricity markets, whether the resources are in the North Sea, North Dakota, or Xingjian Province. This contrasts with conventional generation, historically located relatively close to the load center it serves. In the United States and Europe it has been more economical to ship the fossil fuel to the load center rather than transmit the electricity. RE fuels, however—the sun, wind, or tides—are location bound and often no large-scale transmission infrastructure yet exists in remote locations where they occur.

RE also poses the problem of intermittency, where the power generated changes from moment to moment as the wind varies or clouds pass in front of the sun. Power demand and supply must be finely balanced on the grid at all times. Traditionally, demand fluctuates and managers compensate by adjusting supply, including drawing additional supply from regional generators through the grid.[5] Fluctuating supply creates a new complexity, but this can be addressed through a combination of strategies, including drawing from a geographically disperse pool of intermittent sources and relying on reserve generation that can be ramped up on demand, such as natural gas–fired turbines. In the longer run, effective storage mechanisms for RE and efforts to make demand more flexible will also compensate for RE intermittency. In the meantime, aggregation of geographically spread sources could reduce intermittency by as much as 75 percent according to some studies, although spreading supply around a much larger network will require both more and upgraded transmission.[6]

Additional transmission will be required even if large-scale RE build-out is minimal. How much transmission must be expanded to integrate large quantities of RE is dependent on more than just where the best RE resources are located compared to the load centers and the backup generation requirements. For economic or political reasons, policy makers may choose to emphasize energy efficiency, demand management, or distributed, small-scale RE ahead of large-scale RE. Each one of these approaches would decrease the demand for large-scale RE installations and in turn the need for long distance transmission. However, even these options will require new transmission to support the backup generation required for the intermittent distributed sources, as well as upgrades to the distribution infrastructure.[7] Additionally, the transition to a low-carbon power system will require such substantial transformation that all of these options will be required to some degree. While an extensive new transmission superhighway may or may not be necessary, significantly expanded and upgraded transmission will be. In his recent book, *Smart Power,* Peter Fox-Penner estimates that even a utility policy that minimizes transmission will still require 30,000 to 40,000 new miles of transmission in the United States by 2030, a potential tripling of the current annual transmission build-out.[8]

Additional drivers exist for transmission reform. There are other reasons for transmission reform, beyond the need for a low-carbon energy infrastructure. While grid infrastructure and technology has evolved over the past 100 years, there is a growing consensus that it is reaching its technological limits and requires renewed investment to maintain reliability and meet other modern challenges such as competitive generation markets and energy security concerns.[9] However, grid reform must clear a number of regulatory, structural, and financial hurdles to be successful. In this paper, World Resources Institute (WRI) addresses the RE investor rather than other stakeholders in the complex transmission reform debate, analyzing the specific policy challenges in moving large-scale renewable energy often generated in remote areas to distant demand centers and in facilitating the grid interconnections necessary to assure reliability. We focus our analysis on three key but very diverse markets: the United States, China, and the European Union.

Transmission is a complex issue, deeply influenced by utility policy, politics, and a dizzying array of stakeholders. While it is by no means the only or even the main issue constraining RE market development, transmission infrastructure and reform will mold the final shape of the RE market itself. Transmission infrastructure can be either a roadblock or an enabling technology for meeting renewable energy deployment goals and is a poorly understood risk to RE investments.

SECTION II

Conflicting Transmission Agendas

KEY POINTS

- Renewable energy project developers have two main concerns related to transmission:
  - Does the physical infrastructure exist to move electricity to the market where it is needed; if it does not exist today, when might it?
  - How much will it cost to connect to and use that transmission infrastructure?
- In contrast:
  - Transmission system operators (TSOs) are primarily concerned with ensuring system security and reliability in the face of new intermittent sources.
  - Local governing institutions or regulators are focused on ensuring maximum benefits for their constituents at the lowest cost possible.

Three main roles converge at the intersection of RE generation and transmission: RE project developers, transmission system operators, and regulators. Each stakeholder approaches transmission with their own priorities and can find themselves at odds with the others. These competing agendas shape how RE is integrated into the grid.

RENEWABLE ENERGY PROJECT DEVELOPERS

Renewable energy project developers are concerned about two central aspects of transmission: 1) does the physical infrastructure exist to move the electricity they generate to their market of choice; and 2) what will it cost to connect to and use that infrastructure?

Infrastructure Capacity

If transmission capacity does not already exist close to a new RE generation location, it will have to be built before that electricity can reach markets. The length of time required to plan, site, permit, and build transmission infrastructure, particularly in the Western economies, is a major constraint for RE projects. There is a significant risk that local opposition or regulatory uncertainty will kill a transmission project entirely. The challenges of coordinating investment decisions are summarized by the American Wind Energy Association:

> "A typical transmission line takes five years or more to be planned and built, while a renewable power plant can be constructed in less than a year. Transmission developers are hesitant to build transmission to a region without certainty that a power plant will be built to use the line, just as wind and solar developers are hesitant to build a power plant without certainty that a transmission line will be built."[10]

In large emerging economies, the rapid expansion of renewable generation capacity or generation capacity in general can outpace transmission. For example, in China wind turbines often sit idle, waiting to be connected to a slower-growing grid already at capacity.[11] At the end of 2007, only 70 percent of wind turbine capacity was connected, though the situation has since improved. Moreover, once connected, turbines sometimes need to be shut down to prevent overloading the grid.

The Costs of Connection

There are several aspects to the cost question for the RE project developer. The first is how much of the cost of the transmission infrastructure build-out the developer will have to bear. This differs greatly from jurisdiction to jurisdiction and is often decided through a lengthy regulatory process or negotiation, adding uncertainty to project economics.


UNITED STATES AIR FORCE

The second aspect is the cost of the physical connection. The equipment required to connect RE generation equipment to the grid differs from market to market and can also add cost and uncertainty to a project. In some markets, such as China, authorities have not yet settled on equipment standards, creating uncertainty that impedes RE development. In others, such as some jurisdictions in Europe, the requirements are clear, but also onerous, for example, pushing management of the intermittency back on the generator, rather than through the larger network. These requirements can raise costs for the generator or limit the power that can be sold into the system.

A third area of cost relates to system charges or network tariffs, which are of equal concern to all generators. In some jurisdictions, renewable energy receives preferential rates. In other cases, traversing several jurisdictions to move RE from a resource-rich area to a load center results in "pancaked" tariffs (each jurisdiction charging a usage fee resulting in a high overall cost) that make reaching lucrative markets economically pointless.

The RE project developer is also impacted by how the grid is operated. Physical capacity, policy decisions, and processes constrain whether the RE project developer can sell all of the electricity generated at a reasonable price and who bears the risk if the RE capacity goes unused. For example, it is a common policy directive from regulators trying to support RE development to require that RE capacity is used first. However, the grid operators may limit the power they accept from RE generators in order to limit the intermittency they must cope with or because the transmission infrastructure cannot cope with the increased load.

TRANSMISSION SYSTEM OPERATORS

Renewable energy cannot simply be connected to the grid; it must be fully integrated into a complex system that was originally built with a different model of energy generation in mind. Transmission System Operators (TSOs),[12] often called grid operators, are responsible for that integration and face a set of priorities that often put them in conflict with RE project developers. TSOs are mandated by regulators to oversee the smooth operation of the grid. They manage the actions of generators and coordinate with neighboring TSOs to provide acceptable levels of service across their service area.[13] This focus on daily and moment-by-moment management of the grid is paramount among their priorities.

Depending on the market structure, a variety of entities ranging from vertically integrated public utilities to investor-owned grid operators serve as TSOs. They may be state-owned, community-owned, or investor-owned, but they are always a regulated institution that must consider a variety of service factors such as reliability. They may be constrained in their decision making, for example, in their capacity to build transmission capacity ahead of the need—exacerbating the timing mismatch between generation development and transmission development. While TSOs are usually responsible for long-term planning, local regulators often have final decision-making authority on what to build.

Because one of the top priorities for system operators is maintaining grid reliability, they can be somewhat hostile to the new pressures intermittent RE sources place on the grid. Their historic responsibilities have been to support economic growth through, for example, universal service, reliability, and by ensuring low-cost transmission. Unless they are specifically mandated to consider other issues, as is the growing trend in Europe and is proposed by the Federal Energy Regulatory Commission in the United States, they may not have the capital to invest in upgrading and reinforcing the grid to manage increased intermittency.

LOCAL GOVERNMENTS/REGULATORS

State and local governments or regulators, whether local jurisdictions in China, national regulatory agencies in EU member states, or public utility commissions in the United States, are a critical and sometimes unpredictable element in the transmission discussion. They represent local public interests with the relatively narrow focus of capturing the maximum benefit for their constituents. Their legal authority over permitting the infrastructure and allocation of costs to classes of consumers can result in numerous complications for RE scale-up.

Local governments often particularly create barriers to the development of a more interconnected grid where RE can flow across jurisdictions. They are driven to do this for a variety of reasons. If the transmission infrastructure crosses their jurisdiction but does not lower domestic energy prices or boost the local economy, it can be hard to identify enough local benefits to justify the perceived downsides (including local environmental impacts)—even if the actual financial costs can be allocated elsewhere.

When a government (e.g., state governments in the United States or countries in Europe) sets an RE goal, it often wants to ensure maximum revenue generation and job creation from meeting this goal. This argues for building the generation capacity within the government's jurisdiction whenever possible, rather than importing it from another state or country, even if local RE resources are more expensive to develop and thus cost customers more. Legislation under consideration in California in 2009 (Assembly Bill 64), for example, would have explicitly limited how much out-of-state electricity could be used to meet the state's 2020 renewable energy goal.[14] While that particular bill was vetoed, the underlying concerns remain unresolved a year later, as an editorial from one of California's leading newspapers makes clear:

> "In too many instances, the utilities have turned to energy producers outside California for renewable energy. Out-of-state facilities provide no tax benefits or jobs to California. That makes no sense. Californians are expected to pay for renewable energy. As much of that money as possible ought to remain in California."[15]

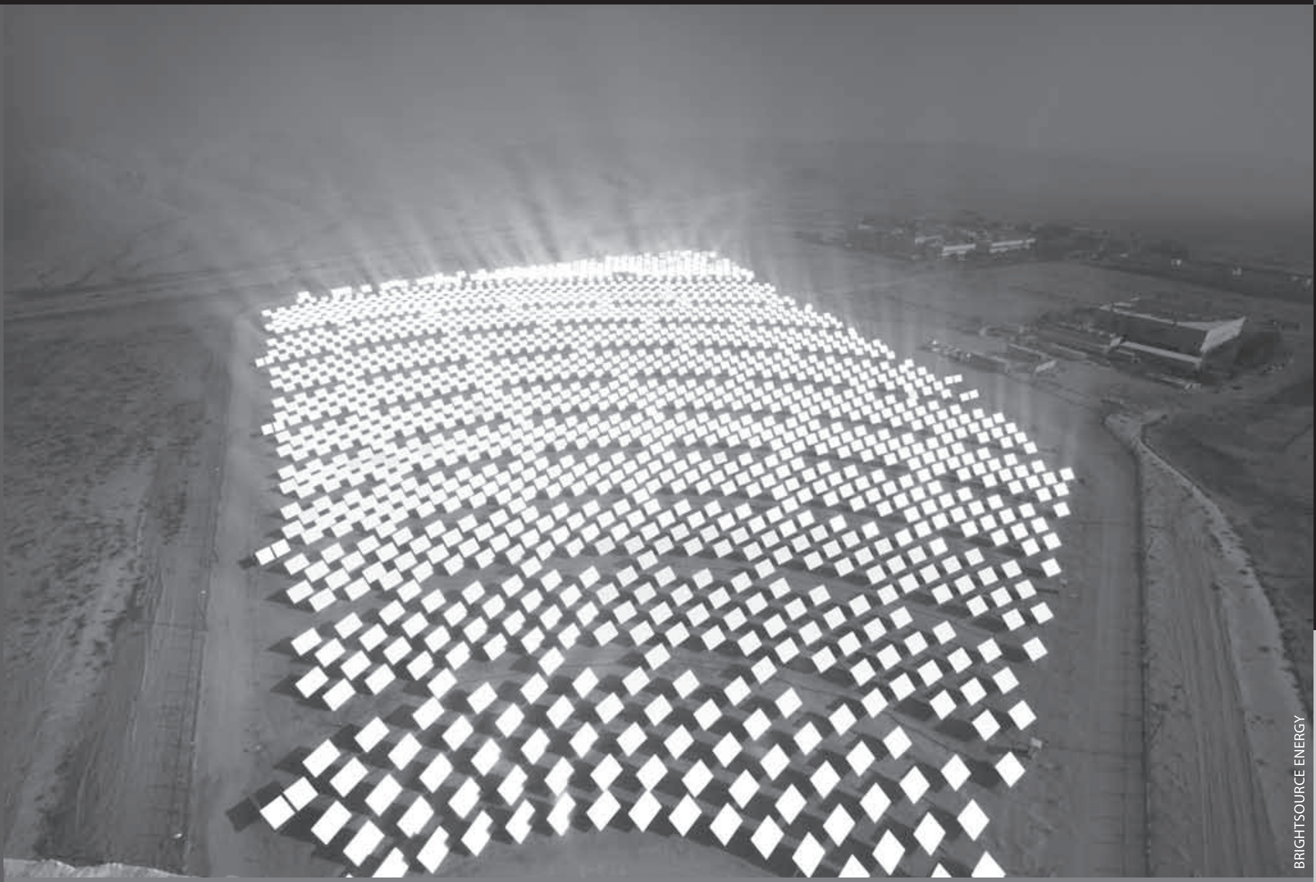
When these entities are independent countries, as in the EU, they are also frequently uncomfortable with importing electricity for fear of developing fragile cross-border dependencies, for example, when a neighboring supplier member-state may cut off exports to meet their own energy needs or to further interstate political goals.

UNLOCKING THE RENEWABLE ENERGY POTENTIAL

The balance of this paper examines how the EU, China, and the United States have addressed these competing agendas—to develop and sell renewable energy to the most lucrative markets, to ensure grid reliability, and to capture the maximum benefits at the lowest cost for local constituencies. Each country or region achieves this balance through a different political process. Their choices, in turn, have the potential to either catalyze or cripple the market for developing large-scale, location-constrained RE resources over the coming decade, regardless of what RE targets are set.

Box 1. Transmission Costs and Benefits Frustrate Regulators

Recent events in the U.S. state of Arizona illustrate the legal and political challenges of generating renewable energy in one jurisdiction for transmission into another. Parallels exist in both the EU and China. Southern California Edison (SCE), which serves more than 13 million people in 180 cities in a 50,000 square-mile area of central, coastal, and Southern California, sought approval in 2006 for a power line that would take energy into California from an area of Arizona considered one of the largest potential U.S. solar fields.[16] The line was initially rejected by the Arizona Corporation Commission, the Arizona regulator, which feared the project would not sufficiently benefit Arizona citizens.[17] For example, they wanted to require SCE to add transmission from the solar farms to Arizona cities at the California ratepayer's expense, which SCE refused to do. In May 2008, SCE initiated an appeal to the U.S. federal government to override the state rejection; this was opposed by Arizona.[18] The federal government instructed SCE to apply to the Arizona Corporation Commission a second time to try to reach an agreement.[19] SCE eventually abandoned the project in 2009, citing, among other reasons, increased RE generation in California, lower natural gas prices, and reduced electrical needs.[20] Commentators also pointed out the potential uncertainty for such a line California Assembly Bill 64 creates, which could block California from buying renewable power from other states.[21] After the economic crisis in 2008, these alternatives were less expensive and less risky than transmission from Arizona, once the Commission added their requirements and the California Assembly became concerned with imports. Arizona Commissioners who had previously bargained so hard with SCE went on to complain that Arizona's solar resources were going undeveloped.



SECTION III

European Union

KEY POINTS

- The EU has aggressive policies to support attaining renewable energy goals; development of these resources to date suggests optimism for achieving the goals.
- Through directives and other processes, the EU is pushing member states to integrate grids and make other changes to facilitate cross-border trading and transmission of renewable energy.
- Potential barriers to achieving grid integration include historical member state reluctance to cede their authority and slow and unpredictable permitting processes.

In 2009, total electricity generating capacity of countries in the European Network of Transmission System Operators for Electricity (ENTSO-E) stood at approximately 880,473 megawatts (MW), with RE, excluding conventional hydroelectric generation, accounting for 101,245 MW (11.5 percent) of that total.[22] Bulk transmission in the larger European network involves more than 305,000 kilometers of transmission lines managed by 42 different operators that serve 525 million customers in 34 European countries.[23]

The European Union's June 2009 Renewable Energy Directive made a strong commitment to the development of renewable energy by requiring member states to meet a 20 percent goal for renewable energy economy wide by 2020.[24] Member states were required to submit National Action Plans to the Commission on June 30, 2010, that detailed how they will achieve this target.[25] Since the transportation sector cannot achieve a 20 percent shift to renewable energy in that timeframe, most estimates suggest that the economy-wide target will require a larger contribution from the power sector. To meet the goal, between 30 and 35 percent of electricity consumption will need to be generated from RE, and the bulk of this electricity will be provided by intermittent sources such as wind and solar.[26]

The changing forecast for EU wind capacity in 2020 in particular illustrates the rapid growth of RE in Europe to date. Between 1999 and 2008 the European Commission's estimates for wind capacity in 2020 grew from 47 gigawatts (GW) to 120 GW; from 2002 to 2008 the IEA's estimates for 2020 grew from 57 GW to 183 GW; and from 2000 to 2009 the European Wind Energy Association's estimates grew from 150 GW to 230 GW.[27]

TRANSMISSION INFRASTRUCTURE

Achieving a 30–35 percent mix of RE in electricity consumption will require substantial changes in Europe's grid and interconnection practices. As early as 2001, the EU acknowledged the need to ensure that transmission and distribution system operators "guarantee the transmission and distribution of electricity produced from renewable energy sources without prejudicing the reliability and safety of the grid."[28] However, changes will be necessary beyond simply requiring access to the grid.

The central challenge to incorporating such a large proportion of intermittent and far-flung electricity resources is cross-border market integration. This in turn requires more robust physical interconnections, as has been recognized in both regional cooperation agreements and in EU Directives. This is also the source of the vision for a European "supergrid" that would move RE throughout the continent. To this end, the European Commission (EC) is funding feasibility studies and launching blueprint planning processes on the North Sea offshore grid project; the Mediterranean Energy Ring; the Kreiger's Flak project, sited between Denmark, Germany, and Sweden; and interconnections between Baltic and Nordic countries.[29]

Some private-sector organizations have also mobilized to promote expanding transmission. For example, in April 2010, ten global companies formed "Friends of the Supergrid" to support the development of a policy and regulatory framework to enable a pan-European supergrid that can support RE sources. The need for a robust grid is also recognized by European institutions, within EU member state governments, and across the energy sector,[30] a position summarized by the European Commission's Joint Research Centre:

> "The importance of electricity transmission grids—the backbone of the European Union's economy—is higher than ever…Furthermore, in order to address the challenges of energy security and climate change, transmission grids need to become more interconnected and 'smarter' by seamlessly integrating a wide range of users (generators, consumers and/or other grids)."[31]

Even with EU Commission and private-sector support for an EU-wide grid capable of supporting extensive RE generation, significant implementation challenges remain.

Challenges to Siting Transmission Projects

Siting new infrastructure in Europe faces two key challenges. The first is the classic challenge every large infrastructure project faces: unhappy neighbors. The public appetite is quite low for large infrastructure projects and their impact on local property values, ecosystems, and other aspects of a community. Cross-border transmission lines particularly raise community opposition since they are perceived as "transit lines" with no local benefits. The second challenge is in the complex and heterogeneous permitting and approval process projects face. The time required to site transmission is three to five times as long as siting RE generation, and there is always a risk that the transmission infrastructure will never be built.[32]

To facilitate siting, the EC can identify priority projects as "of European relevance" and appoint an EC coordinator who works to mediate conflicts between the member states involved. The EC has no siting authority yet. However, in its full implementation in 2014, the 3rd Legislative Package proposals for the European Internal Market in Energy (the 3rd Legislative Package), adopted in July 2009, will provide more authority to new pan-European bodies to make binding regulatory decisions on transmission lines that cross national boundaries when national regulators cannot agree on a solution.[33]

In the current system, member states' regulatory agencies must determine whether or not the project will have a net benefit or cost to customers in that member state. The 3rd Legislative Package requires that National Regulatory Agencies (NRAs) to neither seek nor take instruction from their member state governments, and thus pushes toward a growing separation between the NRAs and the member state governments. While this firewall is not complete yet—five of the 27 member states' governments[34] still have some voice in grid development through their NRAs—it will eventually relieve the agencies from some political pressure.[35] However, the NRAs' continuing legal responsibility to determine an appropriate rate of return for system operators still gives them considerable power to determine if a project is

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efficient, economic, and provides a benefit to customers. This determination can override the project's importance to the larger European grid.

While coordinated transmission infrastructure is central to integrating markets and achieving a "supergrid," the Progress Report for the 2009 Directive concluded: "national electricity markets still have very different characteristics and remain nationally segmented." In an effort to improve coordination, the 3rd Legislative Package created two new pan-European bodies, one for European TSOs and another for the NRAs from the member states.

First, 42 European TSOs from 34 countries formed ENTSO-E.[36] ENTSO-E will coordinate the operation of the formerly more fragmented EU TSOs for transmission planning and siting and facilitate the exchange of operational information and the development of common standards for reliability purposes. ENTSO-E is also tasked with developing biennial 10-year investment plans to bring infrastructure planning to the EU-wide level and will target investments to boost energy supply security based on ongoing conversations with the investment community.

Second, the 3rd Legislative Package established the Agency for the Cooperation of Energy Regulators (ACER). ACER's primary objective is to coordinate National Regulatory Agency (NRA) inter-operability through the creation of European network rules. It will act as a pan-European regulator and make binding decisions with terms and conditions for access and operational security for cross-border infrastructure, if NRAs cannot agree among themselves. The 3rd Legislative Package also strengthened the member-state-level NRAs' ability to issue binding decisions on companies involved in the energy markets, take appropriate measures in cases where electricity markets are not functioning efficiently, and impose penalties on companies that do not comply with their legal obligations or with decisions of the NRA.[37]

While the 3rd Legislative Package will not be fully implemented until 2014, critics already complain that reforms will not be sufficient to establish the conditions under which network operators can build EU-wide transmission lines.[38] A great deal depends on whether member states implement the new rules.

NETWORK COSTS

Since 2001, EU legislation has required that RE is guaranteed priority access to the grid, including transparent and fair rules for connections and cost allocation. This has not entirely resolved the access question.[39] A significant barrier is the heterogeneity of cost regimes. The differences among member states in determining cost allocation for transmission expansion, preferential regimes for network usage charges, or the costs of meeting technical grid connection requirements makes planning generation a complex and somewhat risky equation.

Allocation of Network Expansion Costs

Each NRA decides how to allocate costs between the generator and customers using methods ranging from "shallow" to "deep" (see Table 1 for explanation). While some member states choose a cost allocation method based on whether the expansion primarily serves the public good or the needs of the generator, other member states have no stated cost allocation preference and decide on a project-by-project basis.[40]

Deep connection charges in particular create a free-rider problem. The first RE project developer to build in a remote or new location faces a steep barrier to market entry, while those who follow pay much lower costs and reap higher rewards.

This free-rider problem can be addressed by spreading the cost of the transmission upgrade for a confirmed generation project across the consumers (using a shallow cost allocation, which pushes the cost out to the customer), but a related strategy can also be considered. Under the assumption that there are society-wide benefits in resolving the free-rider issue, TSOs can invest in infrastructure in expectation of RE projects rather than waiting for generators to fully fund their portion of the cost or even fully commit to building projects. Building transmission ahead of the RE project development puts the risk that the transmission assets may end up unused on the consumer but resolves the free-rider problem and some of the timing mismatch between developing transmission and developing generation capacity. The United Kingdom's NRA is evaluating this "predict and provide" model in its current planning, but most TSOs are far more conservative.[41] Beyond small experiments, fully realizing the potential of anticipatory building will require more regional planning cooperation between TSOs.

Connecting to the grid is only the first cost hurdle for RE generators. Just like conventional generators, they also face use of system charges or network tariffs. However, several member states offer more favorable charges to RE than conventional generation as part of larger RE subsidy schemes.[42]

Connection Requirements

Technical standards for connection to the grid, the rules for how generators are allowed to interact with the grid, are necessary to ensure both security and predictable operation. However, across Europe there is currently significant fragmentation in the requirements TSOs place on RE generators. Initially the rules for conventional generators, whose power interruptions are dissimilar from the interruptions experienced with RE, were applied to RE generators. These requirements may impose unnecessary costs on RE generators, forcing them to interact with the grid as though they were producing baseload electricity. At the opposite extreme, in cases where guidelines have been written specifically for wind connections, for example, the guidelines have been repeatedly revised as turbines have increased in size and wind has captured a larger and larger proportion of generation capacity. Typically the requirements have become increasingly onerous, as the TSO attempts to integrate larger and larger quantities of intermittent sources and push the technical challenge back on wind power generators. This imposes increased costs to generators in actual project design and increased uncertainty or risk, which in turn drives up costs. In response, ENTSO-E is engaged in a harmonization exercise and will begin stakeholder consultations in 2011.[43] In the meantime, the European Wind Energy Association warns of "gross inefficiencies for manufacturers and developers."[44]

Table 1. EUROPEAN CONNECTION COST ALLOCATION METHODS

CHARGING METHOD	BRIEF DESCRIPTION
"Shallow"	Generator pays only for the cost of equipment needed to make the physical connection to the grid. Any upstream costs of grid reinforcement due to the generator's connection are borne by the TSO. Often these costs are recovered through "Use of System" tariffs or other tariffs.
"Deep"	The generator pays for all costs associated with its connection. This includes the cost of the physical connection to the grid along with the costs of any upstream network work arising from the generator's connection.
"Mixed" or "Shallowish"	A hybrid of the shallow and deep charging methods. The generator generally bears the cost of the physical connection to the grid (the shallow costs) plus a proportion of any upstream network reinforcement costs. This proportion is usually based on an assessment of the generator's proportional use of any new infrastructure.
"True"	The costs paid by the generator for the new connection are equivalent to the cost of connecting the generator to the nearest point on the grid system at which the grid has sufficient capacity to accommodate the generator without network reinforcement.

Note: Fulli et al. 2009, p. 48.

TRANSMISSION IN 2020

The key question for renewable energy investors is how integrated the European transmission infrastructure of 2020 will be, both technically and from a policy perspective. Less integration will cause higher barriers to entry for renewable energy and ultimately attach a higher cost to reaching the RE targets.

Planning and siting new transmission infrastructure is likely to remain difficult regardless of market integration because of local resistance to large infrastructure projects, the complexities of cost allocation when two or more jurisdictions are involved, and the fiscal and regulatory constraints many TSOs face in building infrastructure before generation is available to use it. These are issues concerning how much burden individual communities are willing to bear in support of the larger European energy and climate policy goals.

If ongoing market integration is slow, the heterogeneity of cost structures across member states will continue to affect decisions about where to locate RE generation and potentially increase the cost of reaching the 30–35 percent RE electricity consumption target. Each project developer has to weigh:

- Cost allocation for transmission infrastructure extension (shallow to deep);
- Challenges of delays and even overt barriers to siting and building transmission;
- Cost of connection requirements;
- Incentives such as preferential access to the grid and lower network tariffs;
- Access to electricity markets they deem profitable;
- Subsidy regimes for generation, which are uncertain in the current fiscal crisis in some member states;[45] and
- Risk of curtailment due to system inadequacy.

How these factors are implemented means, as a practical matter, that some regimes will be more lucrative than others for RE projects, driving investment to particular countries, regardless of whether their RE resource is optimal.

Electricity does seem to be progressing toward an integrated, competitive European-wide market, driven by successive EU Directives and Legislative Packages since 2001. The 3rd Legislative Package in particular is a significant step forward, fixing issues identified through implementation of earlier directives. As the European Regulator's Group for Electricity and Gas, a forerunner to ACER, pointed out in 2009:

> "The…[the 3rd Package], which provides for more strict separation between network ownership and generation and supply interests, increased transparency and a stronger voice for European regulators, should help to address some of the fundamental barriers to the deployment of new [renewable] generation…Furthermore, the forthcoming legally-binding [technical standards such as] network codes for cross-border trading, such as those relating to network connection, third-party access and balancing, should contribute to resolving some of the issues [facing wind generation]."[46]

Efforts to create framework guidelines for ACER before it comes into effect are on track, and if ENTSO-E meets its goals to develop grid guidelines, substantial integration could be accomplished by 2014. This would, among other things, resolve regulatory uncertainty such as the technical requirements for wind generators to connect to the grid.

These goals were assisted further in March 2010, when the European Commission allocated €903 million ($1.2 billion[47]) to nine electricity interconnection projects as part of its European Economic Recovery Plan.[48] The EC's financing guidelines give priority to planned projects that strengthen networks and EU cohesion, using the following measures: 1) reducing regional isolation, 2) enhancing cross-border capacity, 3) boosting the security of supply through source diversification, 4) connecting to RE sources, and 5) increasing the safety, reliability, and inter-operability of the EU network.[49]

Efforts at integration will continue to face the competing local versus pan-European agendas. If NRAs will not cooperate on an EU-wide transmission plan, and ENTSO-E and ACER are unable to enforce their decisions in the face of member-state intransigence or slowness to respond to Europe-wide needs, the EU supergrid will recede into the distance.

SECTION IV

China

KEY POINTS

- The current growth in RE generation facilities is not yet matched by transmission infrastructure, leaving some generating facilities disconnected from the grid.
- Even where transmission infrastructure exists, several barriers remain to integrating RE into the larger grid, particularly a lack of dispatching flexibility.
- The central government has aggressively addressed transmission challenges, and this may open the door to truly massive growth in RE.

In 2009, China's generating capacity stood at 874 GW and was growing rapidly.[50] The Chinese government estimates that by the end of 2010 low-carbon sources, such as hydro, nuclear, and wind power, together will provide 250 GW of capacity, a quarter of the country's total capacity.[51] Transmission is dominated by two state-owned enterprises (SOEs), The State Grid Corporation of China (SGCC) and The China Southern Power Grid Corporation (CSG). The grid includes 12 regional networks with weak interconnections, but since the 10th Five Year Plan launched in 2001, the government has been working toward a unified national power grid made up of three to four synchronous grids interconnected with high-voltage direct current (DC) lines.[52]

Since 1986, China has been slowly restructuring its energy sector toward a market model. These reforms are focused on driving improvement in the capacity and efficiency of both generation and transmission, but they are rooted in the overriding goal of supporting China's long-term development plans.[53] As with several electricity markets in the United States, it is unclear when or even whether the Chinese will complete the shift to a fully liberalized electricity market. Prior to 2002, the State Power Corporation (SPC) acted as the vertically integrated national utility, operating as a monopoly for generation, transmission, and distribution.[54] As China's economy grew at an astonishing rate, power demand also rose dramatically. The power supply struggled to keep pace and power rationing was a problem. In an effort to draw investment into the generation sector, the central government chose to separate generation from transmission and introduce limited competition into generation. In 2002, Chinese electricity industry reforms broke up the SPC.[55] In its place, these reforms established two major state-owned grid companies and five generating companies and divided the assets among them.[56] The two transmission companies act like vertically integrated utilities in partially deregulated markets in the United States and interact through long-term power purchase agreements with the generating companies.

TABLE 2. SUMMARY OF THE CHINESE TRANSMISSION SECTOR, 2009

	THE STATE GRID CORPORATION OF CHINA (SGCC)[a]	THE CHINA SOUTHERN POWER GRID CORPORATION (CSG)[b]
Electricity Provision to End-Users (TWh)	2,274.8	523.9
Annual Revenue		
in Chinese Yuan (billion)	1,265.98	313.60
in U.S. Dollars (billion)[c]	186.60	46.22
Transmission Lines (kilometers)	553,382[d]	76,688[e]
Population Served (million)	1,080 (2008)	230

Notes:

a. State Grid Corporation of China, "2008 Corporate Social Responsibility Report of State Grid Corporation of China," available at: http://www.sgcc.com.cn/ywlm/responsibility/2008.pdf (accessed August 11, 2010); State Grid Corporation of China, "Corporation Introduction," Translated from Chinese, available at: http://www.sgcc.com.cn/gsjs/gsjj/default.shtml (accessed August 5, 2010).
b. China Southern Power Grid Co, LTD, "Welcome to China Southern Power Grid," available at: http://eng.csg.cn (accessed December 2, 2010).
c. All RMB to USD conversions were calculated at $1:¥6.8.
d. SGCC transmission line length includes lines of 100 kV and above.
e. CSG transmission line length includes lines of 220 kV and above.

The five generation companies were designed to each control no more than 20 percent of the country's generation capacity and to compete to sell electricity to the grid companies.[57] Five years later, in 2007, central government–owned enterprises controlled 54 percent of the generation capacity, up from the 46 percent that SPC had owned. Local government–owned enterprises controlled 41 percent of the generation assets, and private and foreign companies controlled 6 percent.[58] Wholesale and retail electricity prices are determined and capped by the National Development and Reform Commission (NDRC), though there have been some small experiments with free market pricing. The wholesale prices theoretically offer a 12 percent to 15 percent return to generators. However, this price inflexibility can create pressure on generators' margins when fuel costs rise. For example, in 2008, generators took losses when coal prices rose dramatically, but the NDRC refused to adjust wholesale prices because of the potential impact on inflation overall. This unstable return has put a damper on private investment in generation.

China codified its commitment to renewable energy in the 2006 Renewable Energy Law, which stipulates that economic incentives should be provided for RE production.[59] These include discounted lending, direct subsidies to cover capital cost and preferential tax treatment. The law also required the grid companies to purchase all of the electricity RE generators could produce. Additionally, the law created a Renewable Energy Fund to support R&D, localization efforts, demonstration projects, and resource surveys. The Chinese government has made additional efforts to support wind power technology R&D. The National Basic Research Program (973 program), the National High-Tech R&D Program (863 program), and the National Key Technology R&D Program have been the driving force of technological innovation in the wind sector.[60]

China's electricity generation capacity is expected to increase from 874 GW at the end of 2009 to 1,600 GW in 2020.[61] The 2007 National Mid- and Long-Term Plan for the Development of Renewable Energy adopted a 15 percent RE target for total consumption of energy by 2020.[62] This target included nuclear energy and hydropower. The 2007 Plan specifically set proportional goals for non-hydro renewable energy for both grid connected electricity in total and for large producers specifically.[63]

The Global Wind Energy Council estimates that China's mandated RE market share represents 80–100

TABLE 3. CHINA'S MANDATORY MARKET SHARES

	MANDATORY MARKET SHARE	
	2010	2020
Total Generated Electricity	1%	3%
Large Producers	3%	8%

Note: Global Wind Energy Council, "Global Wind Energy Council—GWEC: China," available at: http://www.gwec.net/index.php?id=125 (accessed November 4, 2010) [hereinafter "GWEC n.d."].

GW of new renewable energy capacity by 2020.[64] The actual pace of growth in RE has forced the government to revisit the targets. By 2008, nuclear, hydro, and wind made up nearly 19 percent of total electricity generation. Wind capacity has doubled annually for the last four years, reaching 25.8 GW in 2009. As part of the 2009 economic stimulus, China adjusted its 2020 solar goal from 1.8 GW to 20 GW of installed capacity. The wind target was adjusted even more dramatically from 30 GW to 150 GW.[65] Analysts within the wind industry suggest this goal could even be revised to fall between 200 and 230 GW.[66] In the summer of 2009, Zhang Xiaoqiang, the NDRC's vice-minister for international cooperation, suggested that China could even reach 20 percent renewable energy as a proportion of total energy consumption by 2020.[67]

Planning for 150 GW of wind power in 10 years is unprecedented. Total global installed capacity in 2009 was only 158 GW.[68] To accomplish the massive build-out, the central government through the National Energy Bureau is planning seven power bases with a total capacity of 138 GW.[69] These 10+ GW complexes will include dozens of individual wind farms and thousands of turbines sited in the highest wind resource areas. For example, in the fall of 2010, the first phase of the Jiuquan wind power base in Gansu was completed, which included 3,500 turbines that represented an installed capacity of 5.16 GW.[70]

Growing electricity demand plus government commitments will continue to expand the renewable energy marketplace in China, creating opportunities for both the SOEs and private investors. While foreign investment in the construction or operation of power grids is restricted to a minority stake in a joint venture, foreign investment in RE projects and manufacturing is officially encouraged.[71] However, over 80 percent of the current wind generation capacity is owned by the five state-owned power generators, a result of the RE concession policies the central government pursued prior to 2009 and the SOE generators' efforts to meet their RE mandatory market share targets.[72]

TRANSMISSION INFRASTRUCTURE

The transmission infrastructure in China is in a very different stage of development than the grids in the United States and EU. Rather than making incremental changes to a fully built system, China is still building much of the system. Even so, RE generators face similar issues: physical access to the grid and selling their electricity effectively.

Physical Access

Most of China's abundant wind, solar, and geothermal resources are found in remote western China, where the population is relatively more disperse and grid coverage is sparse. The planned power bases are at the edge of the current grid and they face a weak transmission system.[73] The power bases are intended to be "big base into big grid," and there are economies of scale in building transmission to massive installations rather than many small installations. However, taking up that quantity of variable power and safely transmitting it thousands of kilometers is a massive technical challenge.

The grid companies, particularly SGCC, which manages the grid in the northern wind rich areas, are investing heavily in expanding the grid. In the past five years, there has been rapid growth in investment, from $23 billion (156.4 billion Yuan) in 2005 to over $50 billion (340 billion Yuan) in 2010, an average annual growth rate of 23 percent.[74] In 2008, SGCC planned to more than double its investment for the next two years to a total of $169.9 billion (1.16 trillion Yuan) for transmission construction nationwide.[75]

However, this increased investment has been plagued by poor planning and coordination. The market reforms that split the State Power Corporation into generating companies and grid companies created a gulf between the two. The NDRC retains many of the planning responsibilities, but it has failed to ensure that generation and transmission siting are done in close cooperation. On a very fine scale, there seems to have been great difficulty in even coordinating the transmission extension with the various phases of individual wind farms' build-out or ensuring the layout of a farm is conducive to transmission.[76] The Global Wind Energy Council suggests that the grid companies are planning for wind targets that are far lower than installation trends indicate. Even though China does not face the local government siting challenges that characterize the United States and EU decision processes, there are formidable challenges to building transmission extensions that inevitably take longer to complete than the wind farms themselves. When this mismatch is combined with planning that is uncoordinated and based on low targets, it is difficult for grid companies to reach wind farms with new transmission in a timely way.

When the grid company does reach the wind farm, transmitting that wind power requires standardized grid connection codes. China lacks nationwide technology standards for grid interconnection with RE generators.[77] The United States and EU have resolved this with moratoriums on building until connection standards are set; in China, the build-out has accelerated under policies that rewarded new capacity rather than power generation. This has created an installed wind base with serious technical constraints in the view of the grid companies.[78] RE generators report that the grid companies use their own technology standards to deny RE generators' right to grid connections. In response, the grid companies complain that many RE generators blindly enter the market without appropriate technology capacity and therefore build un-connectable RE projects. For example, the grid companies would like to require that turbines contain low voltage ride-through technology to ensure they handle drops in voltage in a predictable way, rather than risking shocks to the larger transmission network. Chinese wind manufacturers do not currently have the technology to provide this protection.[79] They disagree with estimates that they could adopt and domestically manufacture the technology quickly and they complain about the increased cost per turbine. They could purchase the technology from foreign companies, but this would also raise prices, as they pay for the intellectual property. For their part, the grid companies have already seen faults spread through local systems as a result of low-voltage faults in wind turbines and are cautious about adding so much capacity without adequate safeguards.

In 2005, the NDRC addressed these issues in non-mandatory Guidelines of Technology Standards on Wind Farm Interconnection to Grid,[80] which expired in 2008.[81] The NDRC thereafter commissioned the China Power Engineering Consulting Group to draft mandatory, nationwide technology standards, which were circulated in early 2010 (Technology Standards on Wind Farm Interconnection to Grid[82]). The dispute between the grid companies and the wind manufacturers has been aired in public workshops and written responses. The largest domestic manufacturers, such as Goldwind, have supported stricter standards because they feel they will have a competitive advantage and will survive where some of the smaller domestic manufacturers will fail.[83] These larger manufacturers are also increasingly thinking of the international marketplace, where these technologies would be required.

Inflexible Dispatching Options

Typically grid operators rely on flexibility in their supply management to keep supply and demand balanced from moment to moment and keep transmission within the constraints of their physical infrastructure. The variable nature of renewable energy, particularly when hourly and daily generation forecasting is not sophisticated, requires the grid operator to look for flexibility in other parts of the supply. Demand management is a growing option but has limited applicability in China, where government goals are to end electricity rationing.

Supply flexibility can be achieved through importing electricity from elsewhere on the grid where the sun is still shining or the wind is still blowing. It can also be achieved using rapid-response supply, such as gas-fired generators or hydropower to compensate. In cases of transmission congestion, where too much power floods the transmission infrastructure, balance can be achieved by disconnecting generators or having them stop generating.

In China, where wind power already makes up 8 percent to 23 percent of the minimum load on the local grid in some northern provinces, flexibility is more difficult to achieve.[84] Despite a decade of work, China's transmission infrastructure is still characterized by weak interconnections between and within transmission regions. This is in part because the regions themselves are vast—larger than any comparable balancing region in the United States.[85] This is also a result of demand growing at a breakneck rate, outstripping both supply and the transmission infrastructure.[86]

Weak transmission infrastructure creates two problems for integrating large quantities of wind power. First, congestion is a serious problem that limits the amount of generated power that can move to the hungry load center at all. Second, grid operators cannot effectively draw supply from one region in order to balance the variable nature of the wind farms in another region. The variability has to be accommodated by local supply options, which are almost entirely coal.

CHANGHUA COAST CONSERVATION ACTION

Coal is not a rapid response supply option. It takes hours to days for a boiler to get hot enough to generate electricity. As a result, it lacks the flexibility to address peak electricity demand or a drop in wind supply. When all the coal capacity is in use, there is almost nothing additional to deploy in China, whereas in the United States, grid operators might call on a "super peaker" gas-fired power plant that will run just a few hours a year. In some cases, inflexibility was built into the Chinese system. Combined heat and power (CHP) plants that provide district heating in the winter also generate electricity. They were built without bypass technology that would allow them to continue to generate heat without generating electricity.[87] In the winter, when wind is blowing the strongest and producing the most electricity, the CHP plants are also producing electricity. If there is no demand for all the electricity being produced the wind power will be curtailed or disconnected from the grid, despite the Renewable Energy Law mandating it be purchased.

This lack of flexibility is not always technical. It can also come from the economic agreements in place before wind power integrated with the grid. In the case of the CHP plants, economic incentives could be put in place to introduce the bypass technology and encourage flexibility.[88] In a similar example, coal-fired electricity is transmitted from Inner Mongolia to the Beijing-Tianjin-Tangshan power grid.[89] Wind power is now also available from Inner Mongolia, but the coal power takes priority over the wind power because of a long-standing fixed quantitative delivery contract. Any change in throughput needs approval by the local governments in addition to the grid company. As a result, even when the wind is blowing steadily in Inner Mongolia, wind power is taken off the grid in preference for coal-fired generation.

The preference for coal-fired generation presents a significant revenue issue for wind generators, who (rather than the grid companies, despite purchase requirements in the Renewable Energy Law) end up absorbing these losses. In 2009, nearly 15 terawatt-hours (TWh), or 12 percent of the total wind power generated, was lost to curtailment.[90] Until these issues with dispatching are resolved, significant quantities of wind power will remain unused, even after transmission infrastructure reaches the turbines.

NETWORK COSTS

RE generators in China are not required to pay for the transmission infrastructure necessary to carry their power to load centers; this entirely avoids the cost allocation disputes that slow transmission construction in the United States and EU.[91] The grid companies pay for the transmission expansion directly and are required by the 2005 Renewable Energy Law to connect any RE generation within their geographic region that meets minimum (although as yet unspecified) requirements. The grid companies are partially reimbursed through a government subsidy based on the distance between the generation site and the main grid infrastructure. However, the subsidy falls short of the actual cost of integrating the electricity. Enforcement of the connection requirement has also been lax to date.

While China has begun market reforms in the electricity sector, a free market does not determine prices paid to generators. The grid companies enter long-term power purchase agreements at rates largely determined by the central government. Generation prices for RE are set in one of three ways:

- Cost-Plus: Currently used for solar photovoltaics (PV), solar thermal, geothermal, and tidal power, a price is set for a particular project on the principle of reasonable production cost plus reasonable profit.[92] This approach presents significant uncertainty for project developers, but is favored by the central government to stimulate nascent technologies.
- Concessions: A competitive tender model, project developers essentially compete for long-term power purchase agreements, with price and domestic content as the key criteria.[93] The NDRC held five bidding rounds between 2003 and 2007 for 3.35 GW of onshore wind capacity and some provinces followed suit.[94] The concession approach is still used

TABLE 4. RE TRANSMISSION EXTENSION SUBSIDY AND ACTUAL TRANSMISSION COSTS FOR GRID COMPANIES

RE TRANSMISSION SUBSIDY[A]	ESTIMATED ACTUAL COST[B]
<50 km = 0.01 Yuan/kWh ($0.0014/kWh)	25 km = 0.012 Yuan/kWh ($0.0017/kWh)
50–100 km = 0.02 Yuan/kWh ($0.0029/kWh)	75 km = 0.033 Yuan/kWh ($0.0049/kWh)
>100 km = 0.03 Yuan/kWh ($0.0044/kWh)	120 km = 0.054 Yuan/kWh ($0.0079/kWh)

Notes:

a. J. Li et al., "2010 China Wind Power Outlook," (Chinese Renewable Energy Industries Association, October 2010), available at: http://www.greenpeace.org/china/en/press/reports/wind-power-report-english-2010 (accessed November 4, 2010).

b. L. Jiang, "Integration of Wind Power in China—Status and Future Requirements," presentation at the International Workshop on Large Scale Wind Power Grid Integration, Beijing, October 22–23, 2009.

for offshore wind. The concession approach has led to downward price pressure and unprofitable onshore wind generation, deterring further private capital investment. The state-owned generation companies were able to support their losses in wind through indirect state budget support and thus dominate the existing wind installed base.

- Feed-in-Tariff: The NDRC sets the rates all generators can charge the grid companies for the electricity they provide to the grid. Indicating that they feel wind generation is reaching a level of technological maturity and in an effort to provide investors with more certainty, in 2009 the government set nationwide guidance on the tariff for wind energy. This tariff replaces the project-by-project cost-plus and the concession models, both of which were previously used for wind power, and is guaranteed for 20 years. Regions with poorer wind resources are paid a higher tariff to ensure profitability despite their lower productivity. Ranging from 0.51 Yuan/kWh to 0.61 Yuan/kWh ($0.075/kWh to $0.090/kWh), the rates are significantly higher than the average 0.34 Yuan/kWh ($0.05/kWh) paid to coal-fired generators. The rates are also significantly higher than the concession tariffs had been.[95] The NDRC has also announced plans to set similar tariffs for large-scale solar PV in the near future.[96]

These relatively expensive RE prices compared to coal generation and the requirement to give priority to dispatching RE electricity puts significant pressure on the grid companies, particularly since the rates they can charge consumers are set as a part of China's larger economic policy and there is no guaranteed rate of return to the grid companies. While the government officially takes a cost-plus approach for the grid companies in an effort to protect the rate of return and encourage investment, the grid companies can face a revenue shortfall if the central government refuses to allow consumer rates to rise to match increased costs. As an analysis by the China Wind Power Center explains:

> "…grid enterprises have little stake in increasing the amount of renewable energy in their grid, since they do not profit from its integration financially. On the contrary, the integration of renewable energy is a considerable drain of working capital due to the extra costs incurred in the grid connection and electricity purchase."[97]

Recognizing the larger public good in RE, the government established the Renewable Energy Fund as a part of the Renewable Energy Law in 2005.[98] The fund originally supported development of a domestic wind industry through R&D, localization efforts, and government-funded generation projects. The 2009 Renewable Energy Law amendments expanded the uses to include subsidizing the grid companies for the costs of integrating RE that they cannot recover from electricity sales to consumers. The fund is provisioned through a small surcharge paid by every consumer nationwide. The surcharge was 0.001 Yuan/kWh ($0.00014/kWh) in 2006 and was raised to 0.002 Yuan/kWh ($0.0003/kWh) in 2008 and 0.004 Yuan/kWh ($0.0006/kWh) in 2009 to keep pace with the growing RE generation.[99] The fund is also supported directly through government budgets.

While transmission expansion in China does not face the crippling cost disputes that hinder expansion in the United States and the EU, the cost sharing model they use still has not ensured that expansion keeps pace with the RE growth. The cost structure is very advantageous to RE developers, but under the feed-in tariff model they indirectly pay the price for the lack of transmission investment when they cannot sell their electricity into the grid.

TRANSMISSION IN 2020

The central government has recognized many of the ways transmission is constraining RE generation growth and has taken action on a range of fronts to address the issues. Transmission expansion was a priority for the economic stimulus package, and it is expected that transmission expansion will be included the 12th Five Year Plan, as it was in the 10th and 11th.[100] In 2009, the NDRC also introduced amendments to the Renewable Energy Law in an effort to deal with the most critical gaps.

These 2009 amendments helped grid companies by accessing the Renewable Energy Fund to cover the gap between the cost of the RE feed-in tariffs paid to generators and the prices paid by customers as well as the additional capital costs of transmission extensions.[101] The law also authorizes a fine of twice the economic loss of the RE generator if the grid companies refuse to buy RE electricity. Whether this fine will be sufficient to motivate change is questionable, but it does imply the central government is more serious about enforcement of the priority dispatch of RE than it was previously.

The amendments also instituted an extensive planning process for new RE generation facilities that requires provincial and national coordination.[102] These Renewable Energy Development and Utilization plans are required to include a transmission extension plan, so they may help ensure some coordination in construction.

The 2009 amendments obligate renewable energy generators to abide by grid connection codes, which are still being written. They also clarify that the grid companies' priority is the safe operation of the grid and that generators must coordinate with the grid companies to ensure stability. While there is currently controversy over what the codes will require, the certainty provided by clear codes will help the industry move past this particular growing pain.

Finally, China is aggressively addressing the weak interconnection issue and trying to build a national grid by 2020. Given the unique scale of distance and capacity that China faces, they have been forging a new technical path. Through investments in research and development over the last decade, they have become global leaders in ultra high voltage transmission technology.[103] In January 2009, SGCC deployed a 640-kilometer, 1,000-kilovolt (kV) UHV DC project and now plans another 17,000 kilometers by 2012.[104]

UHV transmission technology is especially suitable for China's geographically uneven distribution of renewable and fossil energy resources. On average, UHV lines (defined in China as 1,000 kV or above for alternating current [AC] lines or 800 kV or above for direct current [DC] lines) could triple the effective transmission distance compared to 500 kV lines, reduce electricity loss by between 25 and 40 percent, and bring down overall land surface occupied by transmission infrastructure by 60 percent.[105] This is a significant consideration where infrastructure corridors are already crowded with other urban services.

The widely reported idle wind capacity illustrates China's transmission challenges. The Global Wind Council and Chinese Renewable Energy Association take issue with reports that a quarter of the installed capacity sits idle.[106] They argue that the gap between "hoisting" installed capacity (25 GW of wind turbines installed in farms at the end of 2009) and the nationally recognized grid-connected capacity (17 GW of connected wind turbines at the end of 2009) is a reasonable pipeline of projects awaiting physical connections and certifications. They suggest that less than 1.4 GW of the capacity was unconnected because of grid company reluctance to act.

While this somewhat nuanced analysis of the idle wind capacity may strike some as splitting hairs, it is clear that turbines are being added faster than the system can digest them, driven originally by mandated RE goals on the state-owned generators and now by generous feed-in tariffs. However, the willingness of the central government to adjust its goals upward, commit financial resources, and fine tune regulation to remove barriers suggests a deep commitment to renewable energy. The electricity sector has built astonishing amounts of new generation annually for more than a decade and has coped with a vast amount of change. The barriers to new transmission are technical and economic rather than political, perhaps rendering them easier to overcome.

The truly daunting fact is that even with this massive investment in wind, China's fossil fuel growth will also be huge. All of this effort is required for non-hydro renewable energy to achieve just an 8 to 9 percent share of national generation capacity.

IAN MUTTOO

United States

KEY POINTS

- Historical state and local dominance over utility regulation creates serious challenges for grid integration and development of the long-range transmission necessary to carry large quantities of renewable energy.
- These challenges are compounded by cost allocation negotiations, which also tend to be more complex when proposed projects cross state lines or try to support multiple utility projects.
- The possibility of legislative or regulatory reform at the federal level is highly uncertain in the 112th Congress.

In 2009, U.S. electricity net summer generating capacity stood at just over 1,000 GW, with RE, excluding conventional hydroelectric generation, accounting for 48 MW (4.7 percent) of that total.[107] Bulk transmission for the continental United States was more than 167,000 circuit-line miles divided into three nearly distinct interconnections (with a few DC intertie lines): the Western, Eastern, and Energy Reliability Council of Texas (ERCOT).[108] Within these interconnections in 2007, 71 percent of U.S. customers were served by 210 investor-owned utilities; 14 percent were served by 2009 public utilities; and approximately 13 percent were served by 883 electric cooperatives.[109] In 2009, annual revenues from the entire system were over $353 billion, paid by approximately 143 million electricity customers.[110]

There is currently no federal renewable portfolio standard (RPS) and the future of even existing renewable energy subsidies may be in doubt after the 2010 midterm elections shifted the House of Representatives to conservative hands. States have been more active. By 2009, 31 states had adopted RPS mandates; the aggregate effect of these mandates could add about 208 GW of renewable energy generation capacity by 2030.[111] To meet this need, at least 30,000 to 40,000 miles of new transmission lines will be required by 2030, and much of that will need to be built before some RE resources can be used at all. The IEA estimates 300 GW of wind power projects are waiting on transmission in the United States, though not all of these projects would be built even if transmission issues were resolved.[112]

In an effort to jumpstart the grid upgrade, the American Recovery and Reinvestment Act (ARRA), the stimulus bill signed in February 2010, included $4.5 billion for electric grid improvements, tranches of $3.25 billion each to the Western Area and Bonneville Power Administrations for transmission system upgrades, and $6 billion for renewable energy and electric transmission technology loan guarantees.[113] However, as detailed below in the discussion of regulatory and planning policy (or lack thereof), financing, while uncertain, is only one constraint on transmission expansion affecting RE in the United States.

TRANSMISSION INFRASTRUCTURE

In 2009, the California Independent System Operator (CAISO) Chair, Mason Willrich, authoring a paper for the Massachusetts Institute of Technology energy program, called the U.S. regulatory framework a "hodgepodge" lacking "a coherent national vision and policy."[114] Critically, there is no single U.S. body to plan the investment in transmission required to carry electricity between generation and load sites across country. Instead, states (and even local governments) have approval authority and there is limited federal power to require coordination (backstop authority). Thus, RE project developers must understand how siting decisions are made in each jurisdiction the transmission lines will cross; each presents a regulatory stop, increases the complexity of the siting process, and raises the risk of failure.

In about 30 states siting is conducted at the state level, while the remaining 20 rely on local land use laws and eminent domain.[115] Siting approval and eminent domain[116] authority typically start with a "needs" analysis that varies state by state and often county by county. This needs analysis can be a barrier because, in the case of transmission projects, many of the benefits of the project (i.e., reliability, lower prices, lower emissions) may occur beyond the jurisdiction while costs are largely in-jurisdiction. The resulting analysis may be skewed against approval because jurisdictions do not count external benefits and are sometimes even barred by law from doing so.[117]

Projects crossing federal land face additional scrutiny. The federal requirement to conduct environmental impact analyses (EIAs) for "major federal actions,"

TABLE 5. LEVELS OF U.S. GOVERNMENT OVERSIGHT OF ELECTRIC INDUSTRY POLICY			
	FEDERAL	STATE	LOCAL
Electric Industry Structure	✓	✓	
Reliability Standards	✓		
Wholesale Rate Design	✓		
Resource Adequacy	✓	✓	✓
Retail Rate Design		✓	✓
Resource Mix		✓	✓
Transmission Cost Recovery	✓	✓	
Transmission Siting	✓	✓	✓

Note: M. Willrich, "Electricity Transmission Policy for America: Enabling a Smart Grid, End-to-End," MIT IPC Working Paper 09-003, (Cambridge, MA: Massachusetts Institute of Technology, Industrial Performance Center, Energy Innovation Working Paper Series, July 2009), available at: http://web.mit.edu/ipc/research/energy/pdf/EIP_09-003.pdf (accessed August 3, 2010).

as defined by Council on Environmental Quality regulations and interpreted by a large body of judicial case law, means that federal agencies must identify and evaluate alternative potential routes to those proposed. The EIA process can delay approvals and result in extended litigation, though in 2006 the federal government made efforts to simplify the process through an interagency memorandum of understanding on review of transmission facilities on federal land that created a one-stop approval process.[118]

While there are three large interconnects in the United States, there are over 100 individual balancing areas within these interconnects, each managed by a different system operator.[119] Utilities voluntarily belong to these balancing authorities, limiting how directive the operators can be. However, these Transmission System Operators, working across utilities, can do some regional transmission planning. Regional Transmission Operators (RTOs) and Independent System Operators (ISOs) are particularly large and can provide planning coordination, improved grid reliability, and integration of larger quantities of renewable energy. However, large RTOs like PJM Interconnection (PJM), an RTO that coordinates the wholesale electricity market in 13 eastern states and the District of Columbia, must also balance a wide range of stakeholder needs and this can complicate their efforts.[120] While RTOs provide a means of developing and operating unified, coordinated power systems, large areas of the country, particularly in the West (with the exception of the California ISO and ERCOT, which covers Texas) where the majority of renewable energy potential exists, do not belong to ISOs/RTOs.[121] In these cases, the grid is operated by local utilities focused on point-to-point transmission infrastructure rather than creating a large wholesale market. They lack incentives to expand transmission in order to create long distance connections between RE generation and load centers.

Interstate compacts are another, albeit underutilized, tool for states to develop dynamic, self-regulated systems through a coordinated legislative and administrative process.[122] Interstate compacts allow governors and legislatures to negotiate regionally specific solutions to cross-state transmission lines and bring multi-year certainty to the region, allowing investors to plan and execute projects with less risk of the regulatory approval stalling or failing entirely.

The federal government has also tried to support regional planning through electricity regulation. The final rule for FERC Order 890, issued February 2007, required U.S. transmission providers to:

1. "Participate in a coordinated, open and transparent planning process on both a local and regional level;" and
2. "Ensure the planning process meet[s] [FERC's] nine planning principles, which are coordination, openness, transparency, information exchange, comparability, dispute resolution, regional coordination, economic planning studies, and cost allocation." [123]

Despite the efforts of RTOs/ISOs and the federal government, siting new transmission projects in the United States remains an extremely local process and efforts to centralize it meet fierce resistance from the states and some members of the U.S. Congress who cast the efforts as a federal power grab of states' rights.[124]

NETWORK COSTS

In the United States, RE project developers encounter uncertainty in assessing how much of the transmission infrastructure cost they will be required to pay, just as project developers do in Europe. When the RE project developer must pay all the costs ("Direct Assignment" in the United States; "deep costs" in the EU), they face the same first mover disincentives as their European counterparts.[125] Just as in Europe where some TSOs have experimented with building transmission ahead of generation, the Tehachapi project in Southern California is an experiment in tariff-based cost recovery that attempts to resolve this first mover challenge. The

TABLE 6. COMMON U.S. COST ALLOCATION METHODS	
COST ALLOCATION METHOD	**BRIEF DESCRIPTION**
License Plate	Each utility pays the costs of its own transmission investments.
Beneficiary Pays	Costs are allocated to the transmission organizations that benefit from a project.
Postage Stamp	Costs are spread uniformly across all customers or transmission organizations in the market area, regardless of whether they directly benefit from the transmission infrastructure.
Direct Assignment	Entities requesting transmission must pay (the equivalent of "deep" charges in the EU context).
Merchant Cost Recovery	Costs fall on specific customers—mostly applies to DC lines where transmission can be controlled.
Highway/Byway	Costs are allocated differently for different size lines, using Postage Stamp for very large lines and something closer to Merchant Cost Recovery for local lines. The Postage Stamp approach has been problematic in this model.

Note: J.P. Pfeifenberger, P.S. Fox-Penner, and D. Hou, "Transmission Investment Needs and Cost Allocation: New Challenges and Models," (The Brattle Group, Inc., December 1, 2009), available at: http://www.brattle.com/_documents/UploadLibrary/Upload823.pdf (accessed August 3, 2010).

transmission owners pay the transmission costs upfront and generators pay pro-rata shares of the costs as their energy comes online.[126] As in Europe, this spreads the risk that the transmission infrastructure will go unused across the customer base while giving RE project developers certainty that transmission will be available. California regulators are split about whether to allow this approach. Some argue the project is necessary for the utility to meet its obligations for renewable energy and thus is a reasonable cost to charge customers, while others disagree on the need and prioritize meeting new demand and grid reliability above adding the RE capacity.[127] A decision is expected in 2011.

However, when a "shallow" cost allocation method is used in the United States and more costs are imposed on the transmission companies than the generator, conflict is even more likely to doom the transmission extension altogether. When a transmission improvement or extension crosses jurisdictional lines, the process of allocating costs is significantly more complicated. There is no standard rule for allocating costs across multiple utilities and their customers (the entities receiving electricity through the transmission infrastructure).[128] Those who see only a small or difficult to quantify benefit from a project want to avoid paying altogether and all the parties are motivated to limit their share. This is particularly problematic with the Postage Stamp cost allocation method (see Table 6), because it spreads costs evenly across the entire network. This was somewhat acceptable or justifiable when a planning area was fairly small or there was a single utility or single state involved. When several utilities belong to RTOs or ISOs across multiple states, spreading the cost equally across all the members when a project will only benefit a portion has become extremely contentious. Endless negotiations and litigation hold up transmission upgrades of all sorts. No regulator wants to require customers to pay for transmission projects that do not have a very clear benefit to those specific consumers. The utilities are concerned their regulators will not allow them to pass the costs on to their consumers to recoup their expenses. Driven in part by a 7th Circuit Court decision in August 2009 on this issue,[129] FERC has recently proposed to change cost allocation rules in the United States and embrace a more explicit beneficiary pays policy (Docket No. RM10-23-000[130]), a position that faces deep divisions in the industry.[131]

Reaching agreement on using a particular cost allocation method is directly dependent on how the different parties determine the benefits of a particular project. Regulators and utilities are limited, often by law, in the benefits they can consider for a project. Reliability is a top priority for everyone involved in the industry, so cost allocation is less contentious for reliability-driven regional projects. Even the Postage Stamp cost allocation method is easier to justify with reliability improvements, since faults can cascade throughout the network very quickly. However, "economic" projects (those that yield a net economic benefit to the region through decreased costs or greater revenues to producers) prove much more difficult to settle.[132] For example, many regulators are not allowed to consider reducing costs to customers through reduced congestion outside their narrow jurisdiction as part of their cost/benefit evaluation. Similarly, most regulators cannot consider the larger social benefits of reduced pollution through increased use of RE.[133] Adding to the complexity, these more disperse benefits are difficult to quantify and demonstrate for customers, even if they can be considered. As a result, allocating the costs across different transmission operators and their customers becomes a very hard fought, parochial negotiation. Larger social benefits, national goals, or even regional goals have no seat at the table and there is no certainty that transmission builders will be allowed to recoup their costs.

TRANSMISSION IN 2020

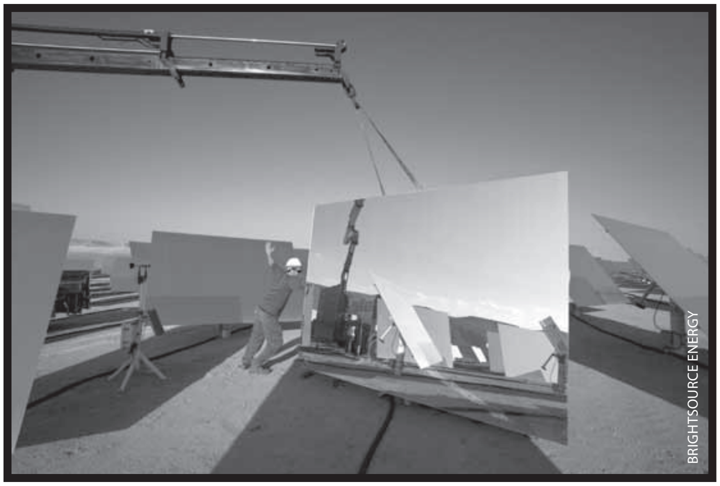
The particularly local and often parochial approach to transmission planning in the United States will likely constrain RE development in the next decade. However, improvements could be achieved by FERC or if the U.S. Congress chooses to act. There are a number of ways this can happen, and some useful history to understand as state and federal jurisdictions work out what is a complex set of legal relationships that have grown up over almost a century.

One question is the existence and extent of FERC "preemptive" powers to permit transmission line development in designated national energy corridors. The Energy Policy Act of 2005 gave FERC authority to issue permits for transmission projects in national energy corridors whenever a state has "withheld approval" of such a proposed transmission line for more than one year.[134] FERC interpreted this provision to allow it "backstop" permitting authority even when a state commission had denied a project permit outright. FERC's interpretation was reversed by a federal appeals court, which concluded that FERC could not overrule a state's decision denying a permit on reasonable grounds.[135] Several bills pending in Congress that vary in their scope and ambition would increase FERC backstop authority in transmission siting and/or effectively overturn the appeals court decision.[136] However, they are controversial and would be hard fought if they moved forward.

Environmentalists and other RE advocates are interested in creating a nationwide transmission "superhighway" for renewable energy, with onramps for new wind and solar in the Midwest and Southwest and off-ramps delivering that power to cities of the West and East.[137] Rapid construction of this system could require federal preemption of state review of transmission planning and new cost allocation models for cost-sharing between onramp and off-ramp states. Taking a very small initial step toward this, on June 17, 2010, FERC issued a proposed rule[138] on transmission line costs and planning for public comment that would require that transmission planning be handled regionally and take into account state or federal public policy mandates, such as renewable portfolio and efficiency standards.[139] FERC also proposed changing cost recovery rules so that the costs for new projects would be borne by customers "at least roughly commensurate" with the estimated benefits they receive (versus precise alignment of costs and benefits required by the Beneficiary Pays model).[140] These regulatory changes and others that FERC is considering seek to incrementally remove specific barriers to coordinated transmission investment. However, any final rule will be litigated by incumbent utilities that feel the new requirements are onerous or risk the reliability of the system.

The 2009 American Reinvestment and Recovery Act went beyond providing stimulus funds for infrastructure and funded the Interconnect-Wide Transmission Planning Initiative, through which "collaboratives" with members from industry, non-governmental organizations, and federal and state governments "will develop by consensus scenarios for future electricity supplies and analyze environmental and other considerations that will be incorporated into transmission plans."[141] In December 2009, the U.S. Department of Energy (DOE) granted $60 million to six recipients for the purpose of carrying out broadly coordinated regional transmission planning efforts.[142] The goal is to develop long-term interconnection-wide transmission expansion plans. While this approach does not directly resolve the thorniest issues around siting and cost allocation, it does bring the stakeholders to the table to begin the difficult work of integrated transmission planning. The collaboratives have only just begun to meet, so any impact on policy or planning is still a few years distant.

Two congressional efforts that could alter the transmission landscape include federal climate and energy policies that would cap greenhouse gases from major sources or establish significant incentives or overt


BRIGHTSOURCE ENERGY

requirements for RE. After the summer 2010 collapse of negotiations, most observers believe comprehensive climate policy to be out of the question until after 2012 at the earliest. The 2010 midterm election makes clean energy legislation much less likely. This would leave existing transmission barriers intact with no new pressure to find resolutions.

Realistically, any assessment of the chances of making these significant changes in the current structure must consider the potentially blocking role of incumbent interests.[143] Any legislation that usurps states' final say in siting faces significant opposition from states.[144] There are more subtle efforts as well, such Senator Bob Corker's (R-TN) Amendment to Senate Bill 1462, the American Clean Energy Leadership Act, which would allow FERC to allocate costs only upon a finding that "the costs are reasonably proportionate to measurable economic and reliability benefits."[145] This runs expressly opposite to FERC's proposed rule changes that take public policy mandates into account. Should this pass, legal experts and renewable energy proponents foresee countless projects becoming bogged down in litigation haggling over the "proportionality" of "measurable" costs to benefits.[146]

Unless the key institutional and legal challenges discussed above are resolved, the limiting factors for the growth of remotely located RE project development and issues associated with intermittency and the requirement of standby reserve generating capacity will remain difficult to resolve. Only robust grid interconnections between the balancing authorities (or major advances in storage capacity) can achieve reliability without redundant standby reserve generating capacity (usually gas-fired, fast-start generators that run a limited number of days at high expense).

If the federal government does not act, local transmission siting decisions will continue to thwart an integrated, national (or even large regional) solution. However, piecemeal deployment of RE will still be possible. Support for these projects will instead reflect the supply/demand conditions of states and possibly, regions, other policy objectives such as job creation efforts, and other plans anticipating a carbon-constrained future. Contiguous jurisdictions could come together as a matter of necessity and construct strong, mutual governing bodies uniting regulatory frameworks for transmission, as exemplified by ERCOT, the California Independent System Operator (CAISO), and the Southwest Power Pool (SPP), where transmission expansion has, or likely will, stretch across long distances or between adjacent states. Success in these situations heavily depends on political will and initiative at the state and regional level.

Projects that build on existing ISO and RTO efforts will likely be closer to load points and at a smaller scale than the proposed long-range, multi-state projects envisioned in a transmission "superhighway." For example, in the absence of a national energy plan to resolve long-distance transmission, it may be more feasible to connect off-shore wind developments on the Eastern Seaboard to the large load centers in the East than it will be to import wind power from the Midwest to those same cities. In some cases, this local model may also be more cost effective, for example, in New England weighing the 20.7 cents/kWh expected cost of wind from Cape Cod against the cost of moving Midwest wind much longer distances.[147] These regional or state-level RE projects, while environmentally beneficial, will lack the ability to self-compensate for intermittency problems that a geographically broader pool of RE could solve, however, and thus will require greater investment in natural gas baseload generation to ensure reliability. Additionally, the opposition and delays seen in the Cape Wind project highlight how regional development is no guarantee of success.

In summary, if legislation or other action by the federal government reduces regulatory bottlenecks by, for example, providing FERC backstop authority, the transmission landscape could be transformed, allowing the country to capture energy based on more efficient locations and transmit it to needy load centers. However, very few transmission industry insiders or analysts expect a quick solution to such a longstanding stalemate.


ALAN RADECKI

SECTION VI

Going Forward

KEY POINTS

- Major changes in transmission to accommodate growing contributions of renewable energy will require a transformative shift in transmission regulation or in the regional or other alliances where transmission system operators manage their balancing areas.
- RE investors should closely follow transmission policy developments in all three markets, as the political and administrative processes wrestle with the growing demands posed by policies to reduce emissions and address climate change.

The transmission challenges impacting RE investment in China, the EU, and the United States have some commonality but occur in three unique regulatory and governance landscapes that establish different incentives and roadblocks to reform. In all three cases, taking full advantage of RE resource endowments will require reforms in the way in which planning, siting, approval, and costing of transmission lines is handled, particularly for remotely located, location-constrained RE resources. Investors must stay current with policy developments in all three markets, as unlocking greater potential is highly dependent on government decisions at both the political and administrative level.

Transmission siting and construction in general may be marginally easier to approve in the EU than in the United States for the time being, should the cooperative efforts captured in ENTSO-E and ACER succeed. This will depend on whether the controlling nature of the relevant EU directives and policies prevail over local interests in practice. The EU's efforts in this regard represent a formal set of decisions that have yet to be seen in the United States.

TABLE 7. INCENTIVES DRIVING TRANSMISSION ACTION

	RE GOALS	COORDINATION EFFORTS	INNOVATIONS
European Union	EU Renewable Energy Directive (June 2009) sets goal of 20 percent power from RE sources by 2020 and mandates grid connectors to provide access to new RE to achieve EU climate policy	ENTSO-E and ACER have transmission coordinating missions	EU Priority Projects defined and assigned an EU coordinator to push the project forward
China	Renewable Energy Law (2005, 2009) obligates power grid companies to connect all RE generation sites that fall in their grid coverage	Renewable Energy Law Amendments (2009) require coordinated RE and transmission planning	Development of UHV infrastructure with $59.7 billion in investment
United States	Thirty-one state Renewable Portfolio Standards	Federal efforts encourage regional transmission planning, though there are no requirements	Innovative cost allocation resolutions such as the Tehachapi and Southwest Power Pool projects

TABLE 8. ROADBLOCKS TO SUFFICIENT TRANSMISSION ACTION

	LOCAL INTERESTS	COSTS
European Union	Transnational coordination and enforcement powers of EU institutions remain unproven while local opposition to large-scale infrastructure projects is significant in some areas	Transmission investment will be difficult in an era of austerity and slow economic growth
China	Disagreement between the grid operators and wind developers on technology standards and planning complicate RE generation connection	Vast distances between generation and load sites and chronic grid congestion necessitate massive transmission expansion
United States	Weak jurisdictional coordination in the transmission siting and approval process slows or stops transmission projects	Transmission cost allocation issues remain largely unresolved or are resolved at local level, reflecting narrow local interests

The potential generation that could be unlocked through transmission expansion in the United States and China may, however, be relatively greater, due to the large domestic tracts of land with significant RE generation potential that are currently inaccessible because of transmission constraints. Again, these opportunities may prove more difficult to capture in the United States as a result of difficult-to-resolve regulatory and political uncertainties and philosophic differences about the roles of federal versus state and local governments. China's future market depends on its ability to overcome the resistance of grid companies in a more opaque decision and regulatory environment than is found in the United States or EU.

In the short run, investors may be inclined to focus their efforts on the EU on the assumption that the political structure and culture is more conducive to RE integration despite the relatively lower market expansion potential than the United States and China. Decisions over the next decade to address transmission roadblocks will largely determine whether these opportunities open up to investors or remain infeasible.

If reform efforts bring greater certainty to the United States and simplify the approval process for transmission siting, investors will be able to respond and shape RE projects accordingly. Even if not all roadblocks are addressed with legislation, any increase in certainty regarding transmission siting coordination, cost allocation, and national energy policy would unlock new potential in the United States. But even the status quo leaves open the possibility of smaller projects with higher backup generation costs that stay within single jurisdictions. This is a smaller market overall, though, as many load centers have poor RE resources.

Perhaps the market most likely to remove transmission barriers is China, as the central government methodically works to reform transmission to support its national renewable energy goals. China primarily faces technical and capacity barriers, rather than the paralyzing political debate seen in the United States.


LAND ROVER

Notes

1. Transporting RE from remote locations to demand or load centers is not the only low-carbon scenario. Energy efficiency, demand response, and distributed renewable energy could all reduce the need for large-scale, centralized RE and thus transmission. However, some centralized RE will be necessary and it is more likely to be cost competitive with fossil fuel generation than other options in the near term. Even low-carbon scenarios with less centralized RE require significant transmission additions (P. Fox-Penner, *Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities*, [Washington, D.C.: Island Press, 2010]).
2. This paper does not address distribution. "Distribution" refers to sending power through local networks to end-users after it has been stepped down in voltage in regional sub-stations.
3. International Energy Agency (IEA), "Energy Technology Perspectives 2010: Scenarios and Strategies to 2050," (Organization for Economic Co-operation and Development (OECD)/IEA: 2010), available at: http://www.iea.org/techno/etp/index.asp, p. 106–11, 142–43 [hereinafter "IEA 2010"].
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5. B. Shively, and J. Ferrare, *Understanding Today's Electricity Business*, (San Francisco: Energy Dynamics, 2008) [hereinafter "Shively and Ferrare 2008"].
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7. "Distribution" refers to sending power through local networks to end-users after it has been stepped down in voltage in regional sub-stations. Distribution will not be covered in this paper.
8. P. Fox-Penner, *Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities*, (Washington, D.C.: Island Press, 2010) [hereinafter "Fox-Penner 2010"].
9. IEA 2010; Federal Smart Grid Task Force, "The U.S. Electric Power Industry Today" (May 18, 2010), available at: http://www.smartgrid.gov/history/today (accessed August 3, 2010); National Energy Technology Laboratory, "The Transmission Smart Grid Imperative," (Office of Electricity Delivery and Energy Reliability, U.S. Department of Energy, September 2009), available at: http://www.smartgrid.gov/sites/default/files/pdfs/the_transmission_smart_grid_imperative_10-2009.pdf (accessed August 3, 2010), p. 4–5.
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11. D. Cyranoski, "Renewable Energy: Beijing's Windy Bet," *Nature*, 457 (2009), available at: http://www.nature.com/news/2009/090121/full/457372a.html (accessed November 9, 2010), p. 372–374.
12. In the United States, the grid is divided into over 100 control areas where coordinating, controlling, and monitoring the grid is discretely managed. These areas might be managed by a regional transmission organization (RTO), an independent system operator (ISO), or a local utility or group of utilities. TSOs in Europe are responsible for coordination and crossstate and provincial borders like RTOs do in the United States. In China, the two state-owned grid companies fulfill these responsibilities.
13. Shively and Ferrare 2008, p. 72.
14. Stoel Rivers, LLP, "Renewable Energy Law Alert: Pledging to Veto SB 14 and AB 64, Governor Schwarzenegger Pursues Alternative Path to 33 Percent RPS," (September 18, 2009), available at: http://www.stoel.com/showalert.aspx?Show=5888 (accessed July 28, 2010).
15. *Sacramento Bee*, "Editorial: Time to End Fight Over Renewables," (Editorial, *The Sacramento Bee*, July 24, 2010), available at: http://www.sacbee.com/2010/07/24/2911468/time-to-end-fight-over-renewables.html (accessed July 28, 2010).
16. K. Alltucker, "Ariz.-Calif. Power Line Mulled," (*The Arizona Republic*, May 19, 2006) available at: http://www.azcentral.com/arizonarepublic/business/articles/0519biz-devers0519.html (accessed August 6, 2010); Southern California Edison, "Company Overview," (Edison International, 2010), available at: http://www.sce.com/AboutSCE/CompanyOverview/ (accessed August 6, 2010).
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