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THE BOTTOM LINE

Connecting generating sites to the grid is an obstacle to the scale-up of renewable energy. Investments in transmission are often made in response to individual requests for interconnection from project developers. But isolated efforts to connect dispersed resources usually turn out to be more expensive than if the full set of planned sites had been considered up front. Only proactive planning, undertaken with a view to maximizing the efficiency of the overall network, can keep costs and connection delays to a minimum.

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Transmitting Renewable Energy to the Grid

Why is this issue important?

The growth of renewable energy places new demands on transmission planning

Many countries are scaling up their investments in renewable energy. In 2010, electricity production from renewable sources—wind, solar, biomass, biofuels, geothermal, hydropower, and ocean energy—accounted for 18 percent of global electricity supply. By early 2011, renewables made up a quarter of all installed power capacity (Madrigal and Stoft 2011). In the past five years, the number of countries that have adopted targets for the incorporation of renewables into their energy mix (or other support policies) has more than doubled, now totaling some 120 countries. But scaling up renewable resources encounters many challenges, including the increased complexity of balancing system dispatch in the short-term, and the need for a strong enabling environment for the promotion of renewables through market incentives, policies on the acquisition of land rights, and clearances on social and environmental issues.

One of the main obstacles to the scale-up of renewable energy is connecting generating sites to the grid in an efficient manner (Madrigal and Stoft 2011). Renewable energy places greater demands on the transmission network than do conventional energy sources.

First, the richest sites for solar and wind energy are often spread across multiple locations far from consumption centers or existing transmission networks. Unlike with power sources based on fossil fuels, where planners can choose where to put the generating site, the site at which energy from renewable sources is generated affects the quality of the resource. In other words, renewable energy sources are "site-constrained." For this reason, transmission networks need to be expanded to reach them.

Second, generation is subject to variability in climate conditions (such as wind speed and solar radiation). More extensive transmission is also required to smooth out the variability of renewable sources over a large geographical area so that grid operators can more easily meet demand at all times from a varied pool of energy sources.

This note focuses on the transmission implications of the dispersion of renewable energy sources, rather than on the implications of variability.

Although transmission accounts for a relatively small percentage of the final cost of electricity, that share is growing rapidly in power systems that are ramping up the share of renewable energy in their generating mix. In some subregions of the United States and countries in Europe that are pursuing renewable energy options, the requirements for investment in transmission already approved by regulators (or forecasted by transmission companies) are double or quadruple recent investment trends. Developing countries face a similar situation. In Brazil the investment needs for renewable energy in some regions surpass the asset value of the distribution utilities closest to the renewable sites.

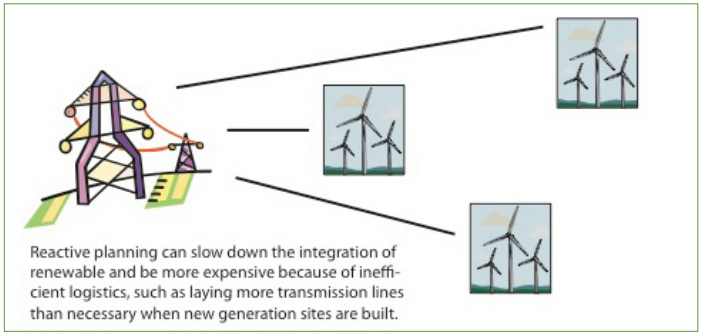
What has been the conventional wisdom?

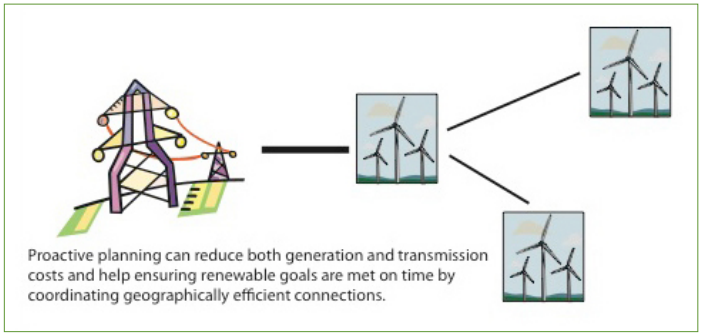
The planning process has traditionally been reactive

Traditionally, transmission needs have been an after-thought to investments in renewable energy plant. Investments in transmission typically have been made in response to individual requests for interconnection from project developers. Furthermore, the costs of extending and reinforcing the transmission network are not always split between consumers and providers in a way that supports renewable energy development while also protecting consumers;

"Traditionally, transmission needs have been an after-thought to investments in renewable energy plant."

Figure 1. Reactive and proactive planning approaches





costs are typically borne by the developers. As a result, the traditional approach to transmission expansion is not well suited for scaling up renewable energy:

- First, a planning process driven by interconnection requests will significantly clog transmission providers' processes and absorb scarce human resources, leading to delays in the process of scaling up and connecting to renewable energy grids. This is particularly true given that, for technical reasons, the deployment of renewable energy projects is typically faster than that of conventional energy and transmission projects.
- Second, isolated efforts to connect dispersed resources usually turn out to be more expensive than if the full set of planned sites had been considered up front (figure 1) and if incremental costs had been borne by both developers and consumers.

The end result is that exorbitant transmission costs threaten the economic feasibility of renewable development.

What is the new evidence?

Worldwide experience points to the benefits of planning generation and transmission in tandem

Developing efficient transmission networks for renewable energy requires a new vision. Planning that includes all stakeholders and takes into account the future development of renewable energy and its associated costs and benefits is emerging as the best way to proceed.

Planning can take different forms. It can be performed by a central authority or in a decentralized way. In a decentralized system, policy makers can facilitate negotiation or structure competition to ensure that investment decisions incorporate the costs of transmission. Either way, building transmission costs into plans will ensure that investments in generation minimize overall long-term costs.

- Anticipatory planning will design transmission solutions for sets of projects in specific geographical areas, thereby reducing costs and improving efficiency.
- Proactive planning goes one step further and uses information on combined transmission and generation costs to ensure that the most cost-effective solution is exploited first to achieve renewable energy goals efficiently. This approach builds into the planning process the trade-off between spending more on transmission and accessing high-quality but remote sites.

In addition to planning, proper allocation of the costs of transmission and sensible network pricing policies have been critical for the fulfillment of renewable energy goals. Cost-allocation policies and practices have a direct financial implication on renewable energy projects and can make them more or less attractive. Transmission pricing should be used to send the appropriate signals to generators so that the results mirror, to the extent possible, an optimum generation and transmission plan. Overall, allocation and pricing policies should be designed to address the specific transmission challenges and setting in each country. Details on network pricing and the allocation of transmission costs can be found in Madrigal and Stoft (2011).

"Transmission pricing should be used to send the appropriate signals to generators so that the results mirror, to the extent possible, an optimum generation and transmission plan."

How does this experience affect our thinking?

Proactive planning and transmission pricing are critical in scaling up renewable energy

Based on the experience being accumulated around the world, countries that are contemplating a significant scale-up of renewable energy should consider the following recommendations when making transmission policy:

Only proactive planning can keep costs and connection times to a minimum. In proactive planning, transmission lines are plotted as if the planner had full control of both generation and transmission investments, with a view to maximizing the efficiency of the overall network. An intermediate step is to undertake anticipatory planning for specific areas where there is potential for multiple renewable energy developments, with the more limited objective of minimizing the costs of opening up these areas.

Extra transmission is often worth the cost, but the planning process must be grounded in rigorous analysis. Transmission planning needs to be grounded in economic analysis that balances the full costs and benefits of renewable energy development, including both generation and transmission costs. This requires that policy makers determine an explicit value for renewable energy. While the value of renewable sources may well compensate for the incremental costs of transmission, full recognition of those costs could alter the ranking of available power supply options. For example, it may be worthwhile to connect first to a superior site farther from the grid than to many inferior sites closer to the grid, because the value of the energy supplied by the more distant site may justify the higher transmission costs.

Improved tools for planning are increasingly helpful in implementing proactive transmission. These include traditional approaches, such as robust or scenario-based planning, as well as innovative tools that use geographic information systems to incorporate spatial datasets into the planning process.

Transmission pricing is critical to the efficient fulfillment of renewable energy goals and must be used to ensure (i) that the best resources are developed first and (ii) that excess profits are reduced. If transmission is not planned at the least cost and, furthermore, if renewable energy generation projects receive transmission services at no cost, the combined transmission and generation cost could well exceed the cost of alternatives, to the detriment of consumers, the public purse, and the economy as a whole.

Uncovered transmission costs must be allocated broadly. Given the importance of ensuring that the transmission operator remains financially sustainable, any shortfall in transmission costs not recovered by suppliers of renewable energy should be made up by increases in tariffs to end-consumers of electricity. Consumers, who understand the benefits and costs of improved service, will also understand the need to pay appropriately for it. Some of the benefits of renewable energy do not derive from the energy itself, but rather from avoiding the effects of using fossil fuels. It is not fair to charge only those who use renewable energy for these wider social benefits. Consequently, it is logical that some of the additional transmission costs necessitated by renewable energy should be recovered across a broader base of consumers .

Adhering to these general principles by setting up a well-structured proactive planning process and clear and stable cost-recovery rules greatly facilitates the introduction of private sector investment and participation in the transmission sector. This will be especially helpful if public funds are scarce and renewable scale-up plans require increased amounts of investment in transmission. The planning process should emphasize the collaboration of regulators, transmission operators, and generators, and should facilitate and maximize the ability to readily connect new sites in a cost-effective way.

References

Madrigal, Marcelino, and Steven Stoft. 2011. "Transmission Expansion for Renewable Energy Scale-Up: Emerging Lessons and Recommendations." SEGEN Paper 26, World Bank, Washington, DC. June.

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