Siting Difficulty and Transmission Investment

By Shalini P. Vajjhala*

Efforts to find locations for new energy facilities are often associated with the now familiar term NIMBY (not in my backyard) and even more extreme phrases like BANANA (build absolutely nothing anywhere near anything). These acronyms capture some of the problems associated with siting new power plants and power lines, but the issue as a whole is more complex than these expressions suggest. The term siting difficulty, as used here, is defined as any combination of obstacles to the process of finding locations for new facilities, including public opposition; environmental, topographic, and geographic constraints; interagency coordination problems; and local, state, and federal regulatory barriers to permitting, investment, and/or construction. Given the scope of the constraints affecting new projects, siting difficulty is a broad, complex problem for which solutions are not obvious or well understood.

Siting problems are not unique to energy and electricity facilities, but the siting difficulties associated with these projects can be particularly complex, especially in the case of transmission lines. Transmission projects can span states and regions and usually involve highly visible overhead lines regulated by multiple agencies. Moreover, deregulation and the transition to competitive markets have further complicated transmission ownership, financing, and management. Although the United States has one of the most reliable electricity systems in the world, electricity transmission expansion has not matched growing demand. Since the California electricity crisis and the 2003 Northeast blackout, the grid has been the subject of intense scrutiny. A variety of policies and programs have been initiated to boost transmission capacity. One of the most recent examples of these efforts is a mandate in the Energy Policy Act of 2005 to establish federal energy corridors and National Interest Electric Transmission Corridors (NEITC) to streamline siting and permitting of new power lines in critical areas and congested regions across the United States.

This process has been highly controversial, however, highlighting three major hurdles facing individual transmission projects: environmental barriers, regulatory roadblocks, and public opposition. Together these elements of siting difficulty have the potential to significantly impact investment in the grid by prolonging project timelines and adding uncertainty to already complex financing processes. Although corridor designations are intended to alleviate regulatory redundancy and to ensure timely permitting and review of new project applications, the process of siting corridors has itself has faced opposition on environmental and equity grounds. This Catch-22 or the conflicting demands exemplified by the corridor siting process, demonstrates the need for better characterizing variations in siting difficulty across states and regions to inform proposals and strategies for improving both transmission and generation investment.

Quantifying Siting Difficulty

In a recent article in *Energy Policy*, Vajjhala and Fischbeck (2007) develop a measure of transmission line siting difficulty for the continental United States. This measure is based on a carefully constructed set of indicators, including economic variations of the cost of electricity generation within states, proximity of residents to power plants in different states, comparisons of generation and transmission construction rates and capacity additions over time, and perceptions of siting difficulty, gathered through a survey of industry siting experts. These resulting four quantitative indicators of siting difficulty (economic, geographic, construction, and perception) are compiled at the state-level to provide a first-pass analysis of siting issues.

Each of these indicators is 1) separate from the local causes and effects of siting problems, 2) large-scale to avoid results that are driven by individual case studies, and 3) focused on a different aspect of the siting problem. Because of the numerous feedback loops and interactions among the causes and effects of siting difficulty, no single cause or effect adequately represents the overall problem. For example, one possible measure of transmission siting difficulty is the difference between generation and transmission capacity additions; however, this metric could conceivably mask underinvestment in both types of facilities caused by common siting constraints.

By bringing together different datasets representing complementary metrics, this research establishes a framework for characterizing and quantifying siting difficulty that evaluates and aggregates multiple impacts. The selected metrics were combined using principal component analysis to construct the economic, geographic, construction, and perception indica-

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See footnotes at end of text.

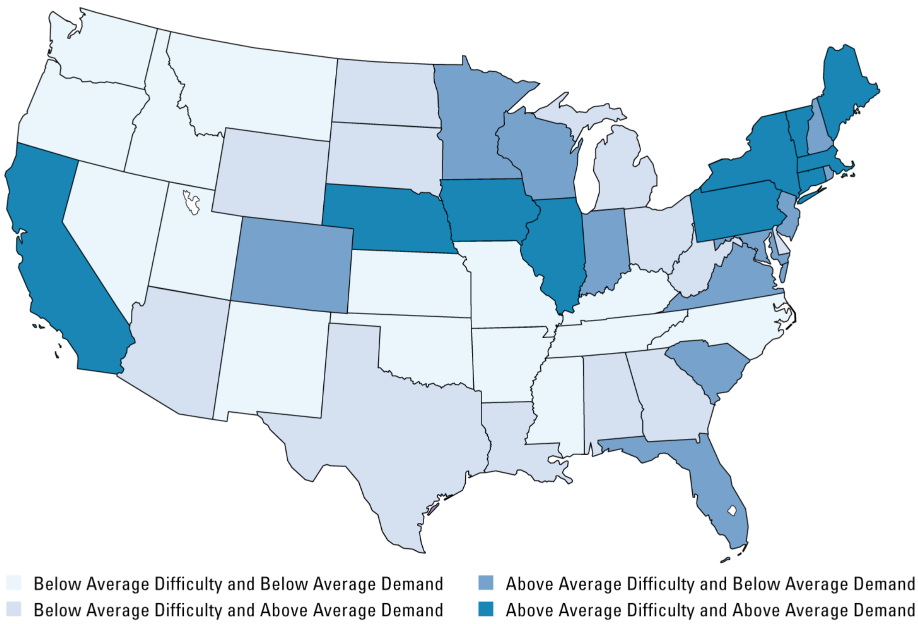

Figure 1

Map of Transmission Siting Difficulty and Demand

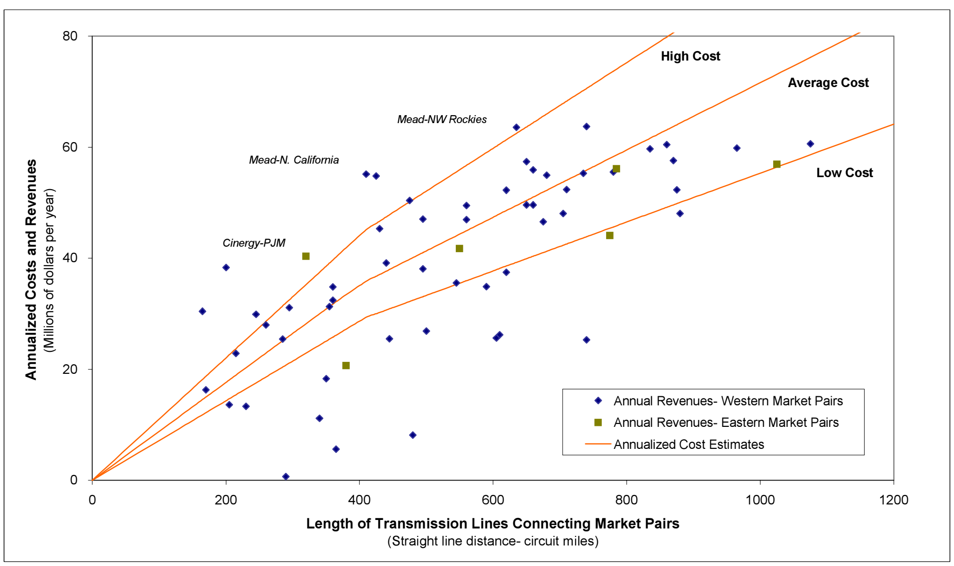

Figure 2
Estimated Revenues and Costs for Hypothetical Transmission Lines Connecting Market Pairs

tors outlined above, and the four indicators were then aggregated using factor analyses. The results of this analysis yield a two factor solution, where the first factor describes state-level siting difficulty and the second factor captures state transmission demand or the need for additional power lines.

Figure 1 illustrates the geographic distribution of these two factors. Scores for both factors range from –3 (very low) to +3 (very high), where 0 is the average demand and difficulty for all states. Transmission demand and siting difficulty are treated as related problems, where states with high need and incentive to build additional transmission capacity are understood to face a variety of constraints (of which siting difficulty is one) that have prevented them from adding lines. The map represents four categories for different combinations of above- and below-average state siting difficulty and transmission demand based on the two sets of state factor scores.

The geographic variations in siting difficulty illustrated here have significant implications for regional transmission development and investment. For example, Regional Transmission Organizations (RTO) face markedly different siting contexts, where the Southeast and Northwest regions of the country have very few states with both high demand for new transmission lines and high difficulty siting them, while the Northeast region has as many as six such states.

Barriers to Investment

Siting difficulty and transmission investment are paired problems. In order to justify construction of any new line, the market for power must provide adequate investment incentive. Policy proposals, like energy corridors, are intended to address cases where investment incentives are inadequate because of the additional costs imposed by siting difficulty. However, even in the absence of siting difficulty, opportunities for transmission investment are highly uncertain. In order to examine the further implications of state-level differences in siting difficulty for investment in the grid, the siting difficulty measure described above was evaluated alongside electricity price data from the Energy Market Reports (EMR). Together these data were used to calculate the potential revenues that could by generated by connecting all possible pairs of EMR markets with new transmission and then examining the relationship between profitability and siting difficulty.

Each point in Figure 2 represents a transmission line connecting a pair of markets and illustrates the potential yearly revenues annualized over a 25-year investment period for a transmission owner of a dedicated 230 kv transmission line. The lengths of the proposed lines connecting 55 pairs of western markets and 6 pairs of eastern markets are estimated as the straight-line distance in miles between market center points. The analysis assumes that the owner collects rents for a transmission line between any given market pair equal to the average annual price difference between those markets.[2]

To compare the potential revenues with possible engineering construction costs, three cost estimates for AC and DC transmission construction are overlaid on the plot. For AC lines, the estimated low cost of transmission is $650,000/circuit-mile, average cost is $800,000/circuit-mile, and high cost is $1,000,000/circuit-mile. These cost estimates are then multiplied by the length of each line, and an annualized cost estimate is calculated based on a payback period of 25 years at a 10% annual discount rate. For lines longer than 400 circuit-miles, DC transmission becomes cheaper than AC transmission; therefore, each of the cost estimate lines includes a break-even pivot point from AC to DC transmission costs at 400 circuit-miles on the graph. For DC lines, the estimated low cost is $400,000/circuit-mile, average cost is $550,000/circuit-mile, and high cost is $700,000/circuit-mile. From Figure 2, revenues exceed average construction costs for approximately 38% of all possible lines at a minimum 10% return on investment.

Based on this simple analysis, if siting costs are not considered, then there appear to be opportunities for profitable transmission investment. Note, however, that project viability in this analysis is defined based on the collective private costs and benefits that could accrue to a group of investors. Transmission ownership is rarely consolidated in the hands of a single owner who sees all the costs and revenues of a project. At a more detailed level of evaluation, these costs and benefits would be disaggregated among various investors and stakeholders, and the viability of any individual project would depend on their allocation. The analysis simply provides an important estimate or upper-bound of the potential benefits and costs of a set of plausible transmission projects.

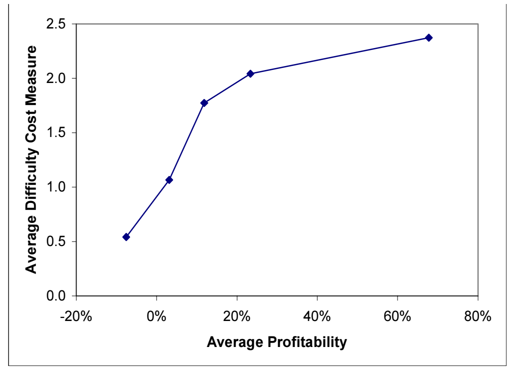

Figure 3
Relationship Between Estimated Profitability of Hypothetical Power Lines Connecting Market Pairs and Distance-weighted State Siting Difficulty Along a Straight-line Route Between Market Pairs.

Since none of the lines in this analysis were under consideration for construction at the time of this study, additional factors, such as siting costs and uncertainty, were assumed to affect total costs, making the lines unprofitable. To examine the impacts of siting difficulty, all lines were ranked by potential profits, divided into five equal groups, and the means of these groups were finally compared with a generic concave siting-difficulty cost measure. The results of this comparison reveal a monotonically increasing relationship between siting difficulty and profitability.

Figure 3 is a graph of this relationship, showing that as the potential profits from a line increase, so do the associated siting difficulty costs. This comparative analysis not only validates the results of the siting difficulty measure, it also highlights the relative importance of siting difficulty to transmission investment. This analysis does not attempt to suggest that any of these lines would be profitable given a detailed evaluation of land costs, rights-of-way, and market uncertainty; nevertheless, it provides an independent validation of the role of siting difficulty as a barrier to transmission investment.

Implications for the Grid

Growing attention to climate policy has brought investments into our energy systems into sharper focus. As a result, many alternatives and proposals for reducing greenhouse gas emissions involve new, large-scale development of facilities ranging from wind farms to coal plants with carbon capture and sequestration to fleets of new plug-in hybrid vehicles. The scale of these proposals has tremendous implications for the future of the grid.

Because many new policy initiatives hinge on the successful development and deployment of large-scale, grid-connected facilities, the difficulties associated with siting new transmission infrastructure provide an important benchmark for the siting problems facing other types of energy investments. Problems with siting new transmission are likely to both reflect siting difficulty associated with new energy development and also directly affect it. As a result, siting difficulty is at the intersection of both technical and policy solutions intended to boost energy system investment. This research makes a first step toward breaking down current siting problems into manageable pieces for evaluation and planning, while simultaneously maintaining a large-scale view of transmission and generation investments on the horizon.

(See footnotes on page 10)