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Quantifying siting difficulty: A case study of US transmission line siting

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Abstract

The worldwide demand for new energy infrastructures has been paralleled in recent years by the increasing difficulty of siting major facilities. Siting difficulty is the subject of widespread discussion, but because of the complexity of the problem, potential solutions are not obvious or well understood. This paper presents a two-step policy-level framework that first develops an empirical measure of siting difficulty and then quantitatively assesses its major causes. The approach is based on the creation and aggregation of four siting indicators that are independent of the common causes and localized effects of siting problems. The proposed framework is demonstrated for the case of US transmission line siting. Results of the analyses reveal significant variations in state siting difficulty and industry experts' perceptions of its dominant causes, with implications for the long-term success of Regional Transmission Organizations (RTOs) and knowledge transfer among siting professionals in the deregulated industry.

Keywords: Facilities siting; Electric transmission lines; Public opposition

1. Introduction

Recent decades have seen a growing worldwide demand for new energy infrastructures, including power plants, wind farms, electric transmission lines, liquefied natural gas terminals, and petroleum refineries, among other major projects. Siting such energy facilities, however, has become increasingly difficult (Casper and Wellstone, 1981; Halvorsen, 1999; Inhaber, 1998). Because of their large scale and technical complexity, many projects involve disparate risks, costs, and benefits for stakeholders, affected populations, and surrounding environments (Keeney, 1980). This asymmetric distribution of project impacts has often fueled intense local opposition and compounded already complex engineering and economic considerations and project constraints.

Siting difficulty is now frequently associated with the familiar acronym NIMBY (not in my backyard) and even more extreme acronyms like BANANA (build absolutely nothing anywhere near anything) (Fialka, 2001; Halvorsen, 1999; Maize and McCaughey, 1992); however, the problem as a whole is more complex than these expressions suggest. The term siting difficulty, as used here, is defined as any combination of obstacles in facilities planning and siting processes, including public opposition; environmental, topographic, and geographic constraints; interagency coordination problems; and local, state, and federal regulatory barriers to permitting, investment, and/or construction. Siting difficulty is thus a broad and complex problem, affecting a variety of industries, for which solutions are not obvious or well understood.

The lack of substantial data is another major obstacle to understanding the problem. Most academic research and industry trade publications focus on either individual *causes* of siting difficulty, such as public opposition, or localized *effects*, such as transmission grid congestion. These analyses are advanced in the absence of any clear empirical reference level for difficulty as a whole, and as a result, many of these studies have limited practical application and policy relevance.

To bridge that gap, this paper develops a policy-level framework for assessing siting difficulty, based on several datasets and statistical analyses. The next section outlines

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our approach and methods and organizes the sections to follow.

2. Framing the problem

The analytical approach developed in this paper is based on a two-step structure. The first step focuses on answering the question "How difficult is siting?" using a collection of siting indicators. The second step then builds on the resulting measure of siting difficulty to address the question "What makes siting difficult?"

Our formulation is similar to that of current climate change research, where some researchers are looking for "indicators" to determine whether climate change is happening, where it is taking place, and to what extent; and others are examining possible contributing causes and mitigation strategies. Until the significance of the change has been robustly characterized, evaluations of contributing causes (and their interactions) remain out of context. Similarly, for facilities siting, a quantitative measure of difficulty must first be created and verified, and only then can the causes of siting difficulty be analyzed in context.

Fig. 1 diagrams our framework and highlights the general relationships among our selected siting indicators and the typical causes and effects of siting problems for the case of electric transmission line siting. This diagram illustrates how multiple causes of siting difficulty, such as public opposition, environmental barriers, and regulatory roadblocks, could collectively lead to an underinvestment in infrastructure. The resulting lack of capacity then triggers industry-level economic, physical, and perceptual impacts, such as variations in the cost of electricity generation and changes in capacity additions. These types of large-scale impacts form the basis for the siting indicators in the analyses to follow.

The four indicators in Fig. 1 are neither direct causes nor effects. 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 line siting difficulty is the difference between generation and transmission capacity additions; however, this metric could conceivably mask underinvestment in both generation and transmission caused by shared siting constraints. As a result, siting difficulty needs to be quantified based on a careful evaluation and aggregation of multiple impacts.

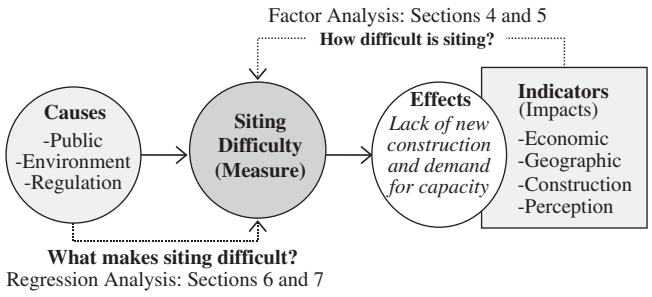

Fig. 1. Diagram of causes, effects, and indicators of siting difficulty.

Section 3 characterizes the transmission problem, with a brief literature review. In Section 4 we develop a single quantitative measure of siting difficulty by combining four indicators—economic, geographic, construction, and perception; in Section 5 we test and validate this measure using real-world electricity market data. We then use the measure to analyze the causes of siting problems in Section 6, and in Section 7 we place these results in the context of prevailing industry perceptions, obtained from a survey of siting professionals. Finally, Section 8 concludes with a brief discussion of the policy implications of our analyses and results for other industries facing siting problems.

3. Characterizing the grid

Transmission line siting is one of the most extreme examples of siting difficulty today (Casper and Wellstone, 1981; Henshaw, 2001; Pierobon, 1995). Although the United States has one of the most reliable electricity systems in the world, electricity transmission expansion has not matched growing demand (CECA/RF, 1990; DOE, 2002; EEI, 2002; Hirst and Kirby, 2001). In August 2001, Spencer Abraham, US Secretary of Energy, noted, "The shortage of transmission lines is nationwide and will worsen as the demand for electricity grows if corrective steps are not quickly taken" (EEI, 2001b).

Siting problems are not unique to the electricity industry; however, siting difficulties associated with transmission lines are especially complex. Transmission projects can span states and regions and usually involve highly visible overhead lines regulated by multiple agencies (Smead, 2002; Smith, 2002). Moreover, deregulation of the electricity industry and the transition to competitive markets have further complicated transmission ownership, financing, and management (Krapels, 2002; Joskow and Tirole, 2005; Krellenstein, 2004).

To place our empirical analyses of siting difficulty in context, we next review two specific challenges facing the electricity industry—changes in the siting process, and the complexities of the regulatory environment—and discuss the industry's response to mitigating siting difficulty.

3.1. The siting process

Building major infrastructures like transmission lines involves a dynamic series of technical, economic, regulatory, and social decisions. Until the 1990s, this decision-making process was largely internal to vertically integrated utilities. Siting divisions assessed the need for new lines, possible alternatives, cost–benefit considerations, technical design options, and permitting requirements in an established sequence, typically unimpeded by external influences (Houston, 1995). Traditionally, practitioners relied on a "decide-announce-defend" approach (Beierle and Cayford, 2002). With electricity deregulation and mounting