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Estimating the value of additional wind and transmission capacity in the rocky mountain west

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ABSTRACT

The expansion of wind-generation in the United States poses significant challenges to policy-makers, particularly because wind's intermittency and unpredictability can exacerbate problems of congestion on a transmission-constrained grid. Understanding these issues is necessary if optimal development of wind energy and transmission is to occur. This paper applies a model that integrates the special concerns of electricity generation to empirically consider the challenges of developing wind resources in the Rocky Mountain region of the United States. Given the lack the high frequency data needed to address the special problems of intermittency and congestion, our solution is to create a dispatch model of the region and to use simulations to generate the necessary data, then use this data to understand patterns that have occurred as wind resources have been developed.

Our results indicate that the price effects caused by changes in power output at intermittent sources are strongly dependent on supply conditions and the presence of market distortions caused by transmission constraints. Peculiarities inherent in electric grid operation can cause system responses that are not always intuitive. The distribution of the rents accruing to wind generation, particularly in unexpectedly windy periods are strongly dependent on the allocation of transmission rights when congestion occurs, which impacts potential returns to developing wind

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resources. Incidents of congestion depend on the pace of development of wind and transmission capacity. Not accounting for such distortions may cause new investment to worsen market outcomes if mistaken estimates of benefits or costs lead to sub-optimal development of wind and transmission facilities.

1. Introduction

The expansion of wind-generation in the United States poses significant challenges to policymakers. Of primary concern is how to incorporate wind and other renewable resources into the existing electricity-grid while maintaining power supply at low cost and high reliability. On the supply side, adding generation with the unique characteristics of wind and solar power to the grid presents significant reliability and cost challenges. Electricity cannot easily be stored and the intermittency and unpredictability of these sources can make scheduling electricity in a reliable but efficient way difficult. Transmission capacity and network congestion also complicate these efforts (see Green and Vasilakos, 2010; DOE, 2009; NREL, 2010 as examples). On the demand side, electricity demand is unresponsive to cost change, lacking both the information to react to cost conditions and changes, and the short-run flexibility to meaningfully change an inelastic demand. Given supply must always equal demand on an electricity system and that demand does not respond to changes in the availability of wind energy, sudden increases in windpower can cause significant economic changes as well as operational problems on the electricity grid. This paper attempts to illuminate some of these problems and their interrelationships with a simulated model of the Rocky Mountain Power Area.

Among renewable sources, wind power poses the most serious challenge to electricity network planners and regulators due to the intermittency of the resource. While back-up sources can be added to the grid for use when wind or other renewable resource availability is low, these large fixed capital investments are costly and their use as a backstop ensures lower capital return and higher system costs than when the same technologies are used as primary generators. The determination of optimal diversity of generation sources, along with the spatial location of wind generating sources could reduce the potential intermittency of total generation, and reduce the fixed costs of back-up sources necessary to ensure system reliability.

Location of wind resources, however, often requires transmission capacity to deliver power to market when it is available. Since intermittency exists, the coordination of wind generation to total demand on a fixed transmission system can be difficult and result in problems of congestion. Congestion may occur due to demand spikes in one portion of the grid requiring delivery of additional power using the transmission network, or from unexpected increases in renewable generation, which strains the transmission system capacity to deliver this low-cost power to load. When such congestion events occur, local rents can be created for generators, in areas where congestion constrains deliverable energy, as the value of energy on the downstream side of any constraint rises relative to uncongested conditions. Significant rents may not only be created for generators within the areas affected by constrained delivery capacity, but they may also be created for the holders of transmission rights able to deliver to such areas. Understanding the stochastic nature of wind energy and the grid-cost dynamics of this resource also requires an understanding of system-wide transmission outcomes and the associated economic rents generated by wind installations. This requires a modeling framework that mimics the special nature of electricity markets, the problems posed by inelastic demand and lack of inventory or storage.

A challenge to the empirical study of renewable energy integration is a lack of data, specifically high frequency (hourly or higher frequency) wholesale electricity price data that describe market outcomes. Spot prices for electricity are not available in many areas as spot markets do not exist. Where such markets exist, prices are often reported as an index of average prices representing lower frequency intervals. The nature of demand, renewable generation changes, as well as transmission congestion on an electricity system is that they are intermittent. Congestion can occur for only minutes or for several