memo

To: New England Stakeholders

From: Eric Wilkinson, External Affairs

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Subject: Summary of Wind Power and Curtailment in New England

Introduction

Wind power is a growing source of energy in New England and this growth is being driven, in part, by state policies that support the development of renewable sources of energy. Wind plants supply electricity to the transmission or distribution system (depending on how they are interconnected) when there is adequate wind to power these facilities. When they operate, wind resources generally displace other sources of energy that are dispatched by ISO New England in the region's wholesale electricity market. However, there are times when the ISO, local transmission service providers, or wind plant operators themselves must reduce or "curtail" the amount of power that these resources provide to the system.

Curtailments generally arise when the maximum potential output of a resource would exceed the capacity of the existing transmission system. Resources that are most-often subject to curtailment produce electricity based on the availability of their primary source of energy (e.g., wind). This output may not correlate well with system needs or commitments. Grid operators currently have limited ability to dispatch wind resources, except to dispatch them down, or curtail them. Grid operators utilize curtailments to prevent transmission facilities from being overloaded by issuing instructions that limit the output of resources to a level that can be reliably accommodated by the system.[1] This summary looks at the underlying factors that result in curtailments and highlights some potential enhancements to minimize curtailments in the future.

Wind Background

At the start of 2013, there were about 700[2] megawatts (MW) of nameplate wind capacity installed in the six New England states,[3] up from approximately 2 MW in 2005.[4] In 2012, wind provided

[1] See: http://www.iso-ne.com/regulatory/ferc/filings/2012/sep/er12-2690-000_9-26-2012_wind_dispatch_rules.pdf

[2] See: http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/mtrls/2013/may222013/a4_wind_energy_update_052213.pdf

[3] The total capacity of New England's generation fleet is currently about 37,000 MW.

[4] See http://www.iso-ne.com/trans/sys_studies/rsp_docs/rpts/2005/102005_RSP05_App_Final.pdf

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about 1% (1,172 GWh)[5] of the energy produced in New England. More wind resources are on the interconnection horizon. As of April 1, 2013, 28 wind projects were in the ISO's generator interconnection study queue totaling about 2,053 MW, or nearly half of the nameplate capacity in the queue. In New England, most of the commercially operating wind resources are located in Maine, New Hampshire and Vermont. They tend to be located in rural areas, far from concentrations of customers, and notably, in areas with the least robust transmission facilities. The transmission resources in these parts of New England were built to serve the native load, but not designed to accommodate the addition of generation sources or the movement of large amounts of power.

Causes of Curtailments

Wind resources have low operating costs and, therefore, it is almost always economic[6] for the region to have them operate to the maximum extent that wind conditions allow. This is true except when that maximum output level would jeopardize reliable operation of the system. Resources are less susceptible to curtailment if they interconnect in areas with particularly strong transmission infrastructure (generally closer to the load), or elect to install upgrades to the grid.

When the output from any resource, including wind, jeopardizes reliability, curtailment may be necessary. The ISO, at times, needs to curtail wind resources to ensure that the bulk power system and/or sections of the system are not overloaded, and service to customers is maintained. Several factors can contribute to the need to curtail wind resources. These include: transmission constraints; interconnection choices; and the technologies associated with wind generators.

- *Transmission Constraints*

Transmission constraints are physical limitations on the amount of power that can flow across the transmission system. Transmission constraints, both at the regional and local levels are the most significant cause of curtailments. Regional constraints occur in broader areas of the system and may act to constrain the operation of larger groups of generators. Local transmission constraints occur in smaller areas of the system and may constrain individual or small groups of generators. Local constraints may be located behind other constraints, particularly regional constraints.

- *Interconnection Choices*

Many wind resources choose to connect to the weaker parts of the New England bulk power system that were not originally designed to integrate large amounts of additional power supply. These sites often have the best potential for wind power, but are usually found on portions of the transmission system with long stretches of 115 kV lines, or on lower voltage transmission facilities. The addition of wind farms in these areas can result in transmission constraints.

Pursuant to Federal Energy Regulatory Commission (FERC) orders,[7] wind resources generally are not required to provide the same basic voltage support capability that is required of other types of resources, unless studies determine that this capability is needed. Often, wind resources interconnect with a bare minimum of voltage support capability, thus providing no additional

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[5] See http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/mtrls/2013/apr242013/a3_new_england_rsp13_load_and_capacity_resource_overview.pdf

[6] Interconnecting as an energy resource allows wind plants to compete for transmission access based on their offer prices into the energy market.

[7] See FERC Orders 661 http://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=10594521 and 661A http://www.ferc.gov/EventCalendar/Files/20051212171744-RM05-4-001.pdf.

strength or improved reliability margins to the transmission system. Moreover, as wind resources tend to develop fairly close to one another, the first-in-service plants tend to exhaust any existing thermal, voltage and stability margins, resulting in the need for more significant upgrades or curtailments for subsequent generators.

Under FERC policy, wind generators connect to the system using a minimum interconnection standard. However, this standard does not ensure that the resource will be able to put its full output onto the grid. Generators that do not fund additional elective upgrades to enhance their access to the transmission system, or connect to a relatively weak area of the system, are at a higher risk of being curtailed.

- *Wind Generator Technology*

Although the ISO has seen some improvements in recent years, historically wind generators have not provided significant system voltage or stability support to the grid compared to other types of energy resources. Also, the voltage control and reactive power capability of wind generators is mostly consumed within the wind farm, thus providing little transmission system support. Some of the electronic controls for wind generators do not function properly in less robust parts of the transmission system.[8] This, in combination with the factors described above, can result in wind plants being extremely sensitive to the normal variations in system operating conditions and more likely subject to curtailments than other types of resources.

Markets

ISO New England operates real-time and day-ahead energy markets. The main purpose of the day-ahead market (DAM) is to serve as a hedge against potentially volatile real-time prices. Market participants can purchase and sell energy at financially binding day-ahead prices. The DAM also serves as the starting point for initial unit commitment for the next operating day. This point is particularly important for wind resources. Because wind resources are often unsure of their ability to produce specific amounts of power the next operating day, they tend to "self-schedule" and not participate in the DAM. In contrast, other types of traditional generators can be scheduled and committed to run by the ISO. Traditional resources typically participate in the DAM and have binding offers to sell energy and can also be dispatched by the ISO in real-time. Therefore, there may be times when, despite a wind resource's availability to produce power, it is not called on by the ISO because other resources that are already committed through the DAM will be sufficient to meet demand.

How Much Curtailment Occurs on the Grid?

The ISO does not collect specific data related to the amount of time that any particular resource is curtailed. Moreover, if ordered by a local transmission service provider, or self-curtailed by the wind plant operator, the ISO may not know that the resource is being curtailed. However, the ISO has begun a process to collect indicators of curtailments related to wind generators. This data collection effort is part of the ISO's enhanced wind power forecasting project. When this project is fully operational, the ISO expects to have a better understanding of the magnitude of curtailments.

[8] See ISO presentation: Wind Development in Constrained Areas, March 21, 2013 available at: http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/ceii/mtrls/2013/mar212013/a5_wind_development_in_constrained_areas_new.pdf

Potential Enhancements
The following types of activities could help reduce the amount of curtailments of wind power.

- *Planning*

Improvements to the elective transmission expansion[9] process may help reduce curtailments by allowing more efficient identification of marginal interconnections and transmission constraints. A more efficient elective expansion process would better complement the existing generator interconnection process. Also, the interconnection study process could potentially be enhanced by the development of a more thorough study regimen that would analyze a wider range of operating conditions than current practices. The possibility and nature of potential changes to interconnection studies is currently under consideration at the ISO.

- *Operations*

Wind Power Forecast Integration Project: The ISO is currently undertaking an initiative that will incorporate wind forecasting and wind resources into ISO processes, scheduling, and dispatch services. The project will acquire external wind power forecasting services, create operator situational awareness displays, partially integrate wind into the real-time dispatch and maintain historical wind data for future use of the forecast service, auditing, and other analysis. The project is scheduled for implementation in the second half of 2013.[10]

Increased Efficiency & Automation: When system operators need to communicate dispatch instructions or other information related to the operation of a wind resource, it is done by placing a telephone call to the resource. This is in contrast to the fully automated system that ISO employs with dispatchable resources like natural gas plants.

After the wind power forecast integration project becomes operational, all wind resources will be required to provide real-time telemetry indicating current output and additional meteorological data. This information will support the ISO's short-term wind power forecast system and will greatly improve the system operators' situational awareness during changing weather conditions. The equipment necessary to provide this telemetry will also provide a critical link in the technical capability for wind resources to receive dispatch instructions electronically.

The ISO is also developing enhancements to the dispatch algorithm that will determine and communicate to each wind resource an output limit approximately every five minutes (which will be defined in the ISO Tariff as a "Do Not Exceed Dispatch Point"). A wind resource will be able to operate at any output level between 0 MW and its output limit. The "Do Not Exceed Dispatch Point" is analogous to the dispatch instruction sent to fully dispatchable resources except that it provides additional flexibility to account for variability in weather conditions. When design details are complete, the ISO plans to continue working with stakeholders to incorporate the dispatch enhancements for wind resources into the market rules. Barring unforeseen difficulties, implementation is anticipated in the first half of 2015.[11]

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[9] An Elective Transmission Upgrade is an upgrade to the New England transmission system voluntarily funded by one or more participants that have agreed to pay all the costs of the upgrade. See: http://www.iso-ne.com/trans/rsp/2012/rsp_final_110212.docx

[10] See: http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/prtcpnts/mtrls/2013/feb12013/2013_work_plan_update.pdf

[11] See: http://www.iso-ne.com/regulatory/ferc/filings/2012/sep/er12-2690-000_9-26-2012_wind_dispatch_rules.pdf