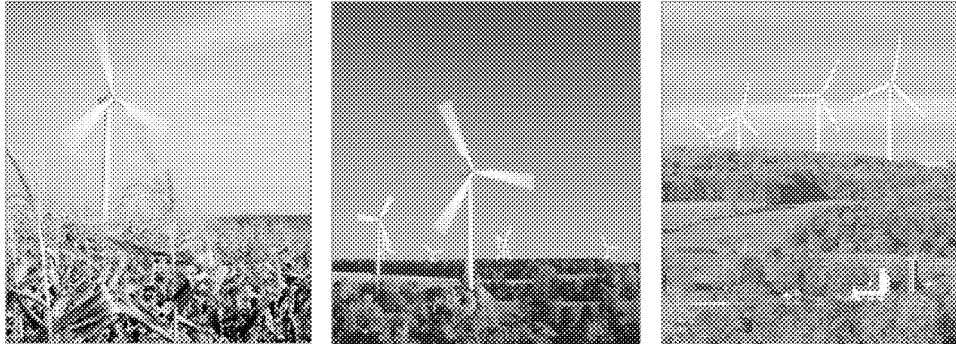




Growing Wind

Final Report of the NYISO 2010 Wind Generation Study



September 2010

Executive Summary

1. Introduction

In 2004, the New York State Public Service Commission (PSC) adopted a Renewable Portfolio Standard (RPS) that requires 25% of New York States' electricity needs to be supplied by renewable resources by 2013. The development of the RPS prompted the New York Independent System Operator (NYISO) and the New York State Energy Research and Development Authority (NYSERDA) to co-fund a study which was designed to conduct a comprehensive assessment of wind technology, and to perform a detailed technical study to evaluate the impact of large-scale integration of wind generation on the New York Power System (NYPS). The study was conducted by GE Power System Energy Consulting in fall of 2003 and completed by the end of 2004 (i.e., "the 2004 Study").

The overall conclusion of the 2004 Study was the expectation that the NYPS can reliably accommodate up to a 10% penetration of wind generation or 3,300 megawatts (MW) with only minor adjustments to and extensions of its existing planning, operation, and reliability practices. Since the completion of the 2004 Study, a number of the recommendations contained in the report have been adopted. They include the adoption of a low voltage ride through standard, a voltage performance standard and the implementation of a centralized forecasting service for wind plants.

The nameplate capacity of installed wind generation has now increased to 1,275 MW and the NYISO interconnection queue significantly exceeds the 3,300 MW that was originally studied. In addition, the PSC has increased New York State's RPS standard to 30% by 2015. As a result, the NYISO has been studying the integration of installed wind plants with nameplate ratings that total from 3,500 MW to 8,000 MW.

From an operational perspective, power systems are dynamic, and are affected by factors that change each second, minute, hour, day, season, and year. In each and every time frame of operation, it is essential that balance be maintained between the load on the system and the available supply of generation. In the very short time frames (seconds-to-minutes), bulk power system reliability is almost entirely maintained by automatic equipment and control systems, such as automatic generation control (AGC). In the intermediate to longer time frames, system operators and operational planners are the primary keys to maintaining system reliability. The key metric driving operational decisions in all time frames are the amount of expected load and its variability. The magnitude of these challenges increases with the significant addition of wind-generating resources.

Variable generation, such as wind and solar, have high fixed costs and very low marginal operating costs which tend to reduce overall production costs and marginal energy prices. However, as will be shown in this study, variable resources require additional resources to be available to respond to the increased system variability, which offsets some of the production cost savings. The primary focus of this report is on the technical impacts of increasing the penetration of wind resources. The impact on production costs, locational-based marginal prices, congestion costs and uplift are presented based on the production costs simulations that were conducted. The study did not conduct, nor did the study scope contemplate, a full economic evaluation of the costs and benefits of wind generation.

2. Technical Approach

Due to its variable nature and the uncertainty of its output, the pattern of wind generation has more in common with load than it does with conventional generation. Therefore, the primary metric of interest in assessing the impact of wind on system operations is “net load,” which is defined as the load minus wind. It is net load to which dispatchable resources consisting of primarily fossil fired generation must be able to respond. The study evaluated the impact of up to 8,000 MW of wind-generation resources on system variability. The study process consisted of the following tasks:

Task 1: Develop wind generator penetration scenarios for selected study years including MW output profile and MW load profile.

Task 2: Develop and implement performance-monitoring processes for operating wind generators.

Task 3: Update the review of the European experience conducted for the 2004 study with currently existing wind plants, and review the experiences and studies for wind plants in other regions of the US and Canada.

Task 4: Study the potential impact on system operations of wind generators at various future levels of installed MW for the selected study years as it relates to regulation requirements and the overall impact on ramping.

Task 5: Evaluate the impact of the higher penetration of wind generation from a system planning perspective – including the evaluation of transmission limitations – by identifying specific transmission constraints (limiting element/contingency) for each wind project (or group of projects)

Task 6: Evaluate the impact of the higher penetration of wind generation on the overall system energy production by fuel types, locational-based marginal prices (LBMP), congestion cost, operating reserves, regulation requirements, and load following requirements.

Task 7: Identify the impact of transmission constraints on wind energy that is not deliverable (i.e., “bottled”) and identify possible upgrades for the limiting elements/transmission facilities.

The technical analysis required by the study task includes a set of sequential steps that are needed to successfully conduct a comprehensive analysis of integrating wind into the grid as a function of penetration level. In addition to the traditional planning analysis and economic assessments, the integration of a variable generation resources requires the assessment of operational issues as well. Operational analyses in conjunction with traditional planning assessments are necessary to fully understand the overall technical implication and potential cost associated with integrating variable generation resources. This process includes the following steps:

Step 1: A determination of the interconnection point of the resources and potential output

Step 2: A thorough assessment of the transmission system to determine the contingencies and constraints that could adversely impact wind

Step 3: A statistical analysis of the interaction of load and wind as measured by the net load to determine the impact of variable wind resources on overall system variability and operational requirements

Step 4: Dispatch simulation with a production cost tool to determine the amount of wind that will be constrained and the impact of wind on the overall dispatchability such as plant commitment and economics of the system

Step 5: An identification and rank ordering of the transmission constraints that impact the dispatchability of wind

Step 6: Development of transmission upgrades to relieve wind constraints for the various penetration levels of wind

Step 7: Redo Step 4 with upgrades and needed operational adjustments determined in Step 3 to determine the full impact

Step 8: Conduct a dynamic assessment to determine if the planned system with the higher levels of wind will satisfy stability criteria

Step 9: Conduct loss-of-load-expectation (LOLE) analysis to determine the impact of installed wind on system load carrying capability or reserve margin requirements.

The study spanned a period of time from the spring of 2008 to the spring of 2010 and involved an extensive review of not only the New York Control Area (NYCA) bulk power system, but the underlying 115 kV transmission system as well. It also involved significant feed-forward and feedback between the power flow analysis and the simulation of NYISO security constrained economic dispatch. This process was used to determine the impact of transmission constraints on the energy deliverability of the wind plants as well as how relieving the transmission constraints affected the energy deliverability of the wind plants. Given the study scope and the plant-by-plant analysis, this study is one of the most comprehensive assessments undertaken for evaluating wind integration for a large balancing area.

3. Study Findings

The study has determined that as the level of installed wind plant generation increases, system variability, as measured by the net-load, increases for the system as whole. The increase exceeds 20% on an average annual basis for the 8 GW wind scenario and the 2018 loads. The level of increase varies by season, month, and time-of-day. This will result in higher magnitude ramping events in all timeframes. Ramp is the measure of the change in net load over time to which the dispatchable resources need to respond. Study results are reported for the New York system as a whole and for three superzones (Western load zones A-E, Hudson Valley load zones F-I, and the New York City and Long island load zones J-K). The study resulted in the following findings with respect to system reliability, system operations and dispatch, and transmission planning.

3.1 Reliability Finding:

This study has determined that that the addition of up to 8 GW of wind generation to the New York power system will have no adverse reliability impact. The 8 GW of wind would supply in excess of 10% of the system's energy requirement. On a nameplate basis, 8 GW of wind exceeds 20% of the expected 2018 peak load. This finding is predicated on the analysis presented in this report and the following NYISO actions and expectations:

The NYISO has established a centralized wind forecasting system for scheduling of wind resources and requires wind plants to provide meteorological data to the NYISO for use in forecasting their output. *This item was approved by the Federal Energy Regulatory Commission (FERC) and implemented by the NYISO in 2008.*

The NYISO is the first grid operator to fully integrate wind resources with economic dispatch of electricity through implementation of its wind energy management initiative. If needed to maintain system security, the NYISO system operators can dispatch wind plants down to a lower output. *This item was approved by the Federal Energy Regulatory Commission (FERC) and implemented by the NYISO in 2009.*

The NYISO's wind plant interconnection process requires wind plants: 1) To participate fully in the NYISO's supervisory control and data acquisition processes; 2) To meet a low voltage ride through standard; and 3) conduct voltage testing to evaluate whether the interconnection of wind plants will have an adverse impact on the system voltage profile at the point of interconnection. In addition, the NYISO will continue to integrate best practice requirements into its interconnection processes.

The NYISO's development of new market rules assist in expanding the use of new energy storage systems that complement wind generation. *This item was approved by the Federal Energy Regulatory Commission (FERC) and implemented by the NYISO in 2009.*

The NYISO's installed resource base will have sufficient resources to support wind plant operations. As described in this report, the overall availability of wind resources is much less than other resources and their variability (changing output as wind speed changes) increases the magnitude of the ramps. For a system that meets its resource adequacy criteria (e.g., the 1 day in ten years), the additions of 1 MW of resources generally means that 1 MW of existing resources could be removed and still meet the resource adequacy criteria. However, the addition of 1 MW of wind would allow approximately 0.2

MW to 0.3 MW of existing resources to be removed in order to still meet the resource adequacy criteria. The balance of the conventional generation must remain in service to be available for those times when the wind plants are unavailable because of wind conditions and to support larger magnitude ramp events.

3.2 Operation and Dispatch Simulation Findings:

Analysis of the wind plant output and dispatch simulations resulted in the following findings for the expected impact of wind plant output on system operations and dispatch:

Finding One - Analysis of five minute load data coupled with a ten minute persistence for forecasting wind plant output (i.e., wind plant output was projected to maintain its current level for the next five minute economic dispatch cycle) concluded that increased system variability will result in a need for increased regulation resources. The need for regulation resources varies by time of day, day of the week and seasons of the year. The analysis determined that the average regulation requirement increases approximately 9% for every 1,000 MW increase between the 4,250 MW and 8,000 MW wind penetration level. The analysis for 8 GW of wind and 2018 loads (37,130 MW peak) resulted in the overall weighted average regulation requirement increasing by 116 MW. The maximum increase is 225 MW (a change from a 175 MW requirement up to 400 MW) for the June-August season hour beginning (HB) 1400. The highest requirement is 425 MW in the June-August season HB2000/HB2100.

Finding Two - The amount of dispatchable fossil generation committed to meet load decreases as the level of installed nameplate wind increases. However, a greater percentage of the dispatchable generation is committed to respond to changes in the net-load (load minus wind) than committed to meet the overall energy needs of the system. The magnitudes of ramp or load following events are reduced when wind is in phase with the load (i.e., moving in the same direction). However, for many hours such as the morning ramp or the evening load drop, wind is out of phase with the load (i.e., moving in the opposite direction). These results in ramp or net-load following events that are of higher magnitude than those that would result from changes in load alone. It is these ramp or load following events to which the dispatchable resources must respond.

Finding Three - Simulations with 8 GW of installed wind resulted in hourly net-load up and down ramps that exceeded by approximately 20% the ramps that resulted from load alone. It was also determined from the simulations the NYISO security constrained economic dispatch processes are sufficient to reliably respond to the increase in the magnitude of the net-load ramps. This finding is based on the expectation that sufficient resources will be available to support the variability of the wind generation. For example, the data base used for these simulations had installed reserve margins which exceeded 30%.

Finding Four - Simulations for 8 GW of wind generation concluded that no change in the amount of operating reserves¹ was needed to cover the largest instantaneous loss of source or contingency event. The system is designed to sustain the loss of 1,200 MW instantaneously with replacement within ten minutes where as a large loss of wind generation occurs over several minutes to hours. The

¹ Operating reserves is the amount of resources that are needed to be available for real-time operations to cover the instantaneous and unexpected loss of resources. The New York power system is operated to protect the system against the sudden loss of 1,200 MW of resources. Operating reserve as stated is an operational concept while the reserve margin discussed in section 3.3 is a planning concept. The required reserve margin is designed to maintain, at an acceptable level, the risk of not having sufficient resources to avoid an involuntary loss-of-load event.