Executive Summary of Renewable Integration Study for PJM

Introduction

The integration of renewable energy into the PJM Interconnection system has increased steadily in the past several years primarily as a result of renewable energy goals in most of the states within the PJM footprint. At the request of its stakeholders, PJM commissioned a study in May 2011 to understand the impacts to grid operations if renewable energy goals over the next 15 years are achieved or exceeded. An Executive Summary for the study is now available on the PJM web site.

The study team was headed by GE Energy along with AWS Truepower, EnerNex, Exeter Associates, Intertek Asset Integrity Management and PowerGEM. The team used a combination of publicly available and confidential data to model the Eastern Interconnection, PJM and the generating plants within PJM. Ten scenarios were chosen, ranging from a business-as-usual reference case with wind and solar resources at 2011 levels, to a scenario with 30-percent of energy over a year provided by wind and solar resources.

The study explored the characteristics of load, wind and solar profiles; regulating and operating reserves; transmission system upgrades; the impact of renewables on annual PJM operations; sub-hourly operations and real-time market; capacity value of wind and solar; the impact of cycling duty on Variable Operation and Maintenance (VOM) costs; power plant emissions; industry practices and experience on renewables integration; and methods to improve system performance. Conclusions and recommendations were presented, and topics for future study were identified.

The study assumed that the penetration of renewable resources would increase and investigated how the PJM system would be affected. The economics of renewable resources and quantifying the capital investment required to install additional wind and solar infrastructure were beyond the scope of this study and were not investigated. Similarly, the study did not evaluate distribution system impacts, potential voltage and frequency control issues, and costs to maintain resource adequacy (reserves).

Key Findings

- The study's main conclusion is that the PJM system, with adequate transmission expansion (up to $13.7 billion) and additional regulation reserves (up to an additional 1,500 MW), would not have any significant reliability issues operating with up to 30 percent of its energy (as distinct from capacity) provided by wind and solar generation. PJM has long held that ISOs and RTOs are better able to integrate variable energy resources because of their organized markets and regional infrastructure planning processes, but the study found that PJM's large geographic footprint also provides significant benefit for integrating wind and solar generation because it greatly reduces the magnitude of variability-related challenges.

- Every scenario examined resulted in lower PJM fuel and VOM costs as well as lower average Locational Marginal Prices. The lower LMPs, when combined with the reduced capacity factors, resulted in lower gross and net revenues for the conventional generation resources.

- The renewable generation increased the amount of cycling (start up, shut down and ramping) on the existing fleet of generators, which will result in increased VOM costs on these units. However, these increased costs were small relative to the value of the fuel displacement.

Recommendations / Suggestions for Further Study

The study makes a few recommendations:

- *Determining Reserve Requirements* - It is recommended that PJM develop a method to determine reserve requirements based on forecasted levels of wind and solar production.

- *Intra-Day Unit Commitment* - It is recommended that PJM consider intra-day unit commitment using such a mid-range forecast in real-time operations to update the commitment of intermediate units (such as combined cycle units that could start in a few hours).

- *Improving Resource Flexibility* - It is recommended that PJM explore the reasons for ramping constraints on specific units, determine whether the limitation are technical, contractual, or otherwise, and investigate possible methods for improving resource flexibility.

The study also suggested a few topics for further study:

- *Impacts of Reduced Energy Revenues for Conventional Power Plants* - The study results show that as renewable penetration increases, energy market revenues for conventional generation resources will decline significantly. To remain economically viable, these plants would either need to receive a larger share of their revenues from a capacity market or perhaps increase energy prices to help cover fixed costs. It is suggested that PJM investigate the potential consequences of reduced energy market revenues on its conventional generation fleet.

- *Flexibility Improvement for Conventional Power Plants* - It is suggested that PJM investigate possible methods for increasing the flexibility of power plants with limited ramping or cycling capabilities that have been traditionally operated as baseload units.

- *Active Power Controls on Wind and Solar Plants* - Another potential source of system flexibility is from wind and solar plants. In the past decade, manufacturers have made significant advancements in control methods that can make plant power output responsive to grid-level controls, including frequency response and down-regulation. It would be prudent for PJM to investigate how wind and solar plants could contribute to frequency response and work towards interconnection requirements that ensure PJM will continue to meet its grid-level performance targets.

The recommendations and suggestions for future study will be presented to PJM stakeholders for their review and consideration.