Expanded Written Opening Remarks of Brian Parsons
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Operational Challenges and Innovative Solutions Panel

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My name is Brian Parsons and I am a group manager and project leader for grid integration at the National Renewable Energy Laboratory (NREL) in Golden, Colorado. My group at NREL has been primarily funded by the U.S. Department of Energy (DOE) Wind and Hydropower Technology Program to examine grid interconnection, operations, and planning impacts due to the variable and uncertain nature of utility-scale wind power.

My remarks today are based on results from numerous technical studies involving grid operators and utilities across the United States and from interaction and collaboration with international researchers.

Thank you for the opportunity to address these electric power system issues that are raised by grid, state, and federal leaders' interest in increased use of clean renewable energy.

Integration is all about the most economic means of balancing load and generation due to the increased variability and uncertainty added by renewables. For example, a Minnesota-wide study examined wind penetration of 25% energy (5.7 gigawatt (GW) nameplate capacity of wind in a 16.7 GW peak demand system), and found there was need for additional operating reserves to accommodate wind changes. However, the total increase in all reserve types needed due to the additional wind was a maximum of 430 megawatts (MW) on top of a base reserve of 1050 MW.

With a time-varying reserve strategy that holds less reserve when wind output is low, the annual average "integration cost" was found to be $3 to $4.50 per megawatt-hour of wind energy produced. This cost is in line with many other studies that examined large balancing areas with developed competitive market structures.

Grid operators use a variety of means to keep the system in balance. Additional flexibility can be provided through a variety of sources and mechanisms, including:

- Fast response, flexible generators including gas-fired and hydro resources
- Coordinated regional grid operations for improved reliability, efficiency, and ability to meet renewable energy objectives
- Balancing area cooperation through examples such as the ACE Diversity Interchange program and Joint Initiative advances on dynamic scheduling

- Market scheduling closer to the operating hour, rapid update of sub-hourly schedules, and ancillary service markets.
- Strong transmission interconnections
- Wind plant geographic diversity
- Operational wind forecasting integrated into the control room
- Use of demand response that is triggered by grid needs, including dispatchable or curtailable loads and future off-peak loads including electric and plug-in hybrid vehicles
- Selective wind power curtailment procedures, and
- Expanded deployment of conventional or advanced storage projects, including storage associated with concentrating solar-thermal power plants.

Significant flexibility already exists, but is sometimes not accessible due to institutional constraints. At higher penetrations, more flexibility is needed. Designing the grid of the future to operate reliably and economically while including large amounts of variable renewable resources (wind and solar) will require a re-thinking of conventional processes and procedures, as well as a very different use of conventional generation resources.

I would like to focus on wind forecasting for a moment, responding to the questions posed by the Commission. The use of renewable resource forecasting is becoming a critical component in the operation of the grid as more renewable energy is added. Just as load forecasting has different purposes for different time frames, the forecasting of renewable resources has different applications. In the day-ahead time frame, these forecasts can assist in making the most economic selection of units to reliably meet load and reserve obligations. In real-time, forecasts are used to assist control area operators in anticipating significant events. Some grid operators are seeing a need to forecast the extreme ramping events that can impact the reliability of the system. If these ramp events are not adequately forecast, they may prove a challenge to the scheduled reserve capacity, particularly in more isolated grids with geographically concentrated, high penetrations of variable renewable resources.

Many wind power integration studies calculate savings from the use of wind power forecasting. Studies in New York and California examining 10 to 20% wind penetrations show savings in the neighborhood of $100 million per year by using current state-of-the-art wind forecasting in operations. One of the most important factors in providing the most accurate forecasts is the quality of input data. Factoring in power output, wind measurements, and other detailed data can result in a significant improvement of forecast accuracy and uncertainty. Something as simple as knowing how many wind turbines are undergoing maintenance is currently problematic in many locations.

Private industry forecasters are providing operational wind forecasts and are working to continually improve accuracy and usability. National weather agencies are gearing up for improvements in atmospheric modeling targeting wind power forecasting. Anticipation of extreme ramps, use of probabilistic forecasts, grid operator user interfaces, and situational awareness tools are rapidly advancing aspects of wind power forecasting.

NREL is coordinating and DOE providing funding for two large regional wind integration studies. Previous integration studies have focused on single markets, balancing areas, or states. In contrast, the Western Wind and Solar Integration Study (WWSIS) and the Eastern Wind Integration and Transmission Study (EWITS) both span several states and sometimes markets. Grid and utility entities in the regions are members of study technical review committees and stakeholder processes bring together broad regional representation to ensure accuracy and relevancy.

These regional studies can help look at broader issues beyond just the cost and operating impact of wind and solar resource variability and uncertainty. These studies investigate the value of broad geographic diversity and the potential for balancing area cooperation, tradeoffs between long-distance transmission and local resources or tradeoffs between on-shore and off-shore wind, and how wind forecasting and reprioritizing hydro can help with integration. These studies are examining 20% and 30% wind penetration by energy, and in the Western Study, up to 5% from solar. The Eastern Study is closely integrated with the Joint Coordinated System Plan (JCSP) transmission expansion effort for much of the Eastern Interconnection. The Eastern Study may also look at additional scenarios besides the JCSP, pending suitable funding. Attaining a 20% penetration of wind energy in the Eastern Interconnection requires either a significant transmission build-out to bring large amounts of Midwest wind power to the east, or significant offshore wind development. Attaining a 30% wind energy penetration requires both.

The implications of these ongoing studies of high penetrations of renewables are challenging. Thirty-five percent wind and solar average energy penetration in the Western Study means a renewable nameplate capacity equivalent to more than 150% of the minimum load. While all of the wind plants would not produce full output at minimum load hours, early simulation results find 25 hours in one year where the instantaneous wind power output, if uncurtailed, is greater than 100% of the projected load. Interestingly, in the Western Study, simulations show increased use of existing pumped hydro storage with 35% renewables, but not enough of an increase to indicate that the existing pumped hydro is inadequate or that more pumped hydro storage is necessary. This is consistent with results from other high penetration studies from Ireland, Minnesota, and California. These large footprint studies managed by NREL are expected to be completed and publically available by end of 2009 for the Western Study, and by September 2009 for the Eastern Study.

In addition to examining operational issues, these grid studies examine transmission expansion. Complementary efforts in renewable energy zone designation will likely be discussed in other sessions of this conference. However, it is worth pointing out that both operational and transmission analyses rely on a good understanding of renewable resource variability characteristics. NREL maintains a database of temporal profiles of historic measured wind and solar project power-flow. Analyses also rely heavily on projections from mesoscale weather model “back-casts” of historic weather years to correctly capture coincident power and geographic diversity effects. Significant new and continuing effort to improve and validate tall-tower wind projections and to simulate recent historic years is needed.

Issues do remain because costs and benefits are system specific, and challenges become more pronounced with higher penetrations of wind and solar electricity. However, as highlighted in the DOE "20% Wind Energy by 2030" report (http://www1.eere.energy.gov/windandhydro/pdfs/41869.pdf) issued in May 2008, there are no fundamental technical barriers to the integration of 20% wind energy into the nation's electrical system, should that be desired. But if so, there needs to be a continuing evolution of transmission planning and system operation policy, and market development for this to be most economically achieved.

Grid entities and power system professionals have varying levels of experience with these emerging issues. The NREL program works closely with the Utility Wind Integration Group (UWIG) to understand and disseminate information on wind integration issues. With over 150 members, including system operators, investor owned utilities, and public power entities, UWIG provides a forum for the critical analysis of wind power in grid applications.

UWIG, DOE's Wind Program, and the national laboratories' technical efforts are available to inform FERC and other interested bodies. Based on the large body of literature and present understanding of the key integration issues, increasing amounts of wind energy can be furthered by:

- Increasing data availability for integrating wind plant output forecasting into operations planning and situational awareness,
- Aggregating wind plant output across broad geographical areas and increasing broad grid cooperation on operations, and generation and transmission expansion,
- Accessing existing grid flexibility, including hydro, through expanded transmission, smart grid applications, scheduling closer to the operating hour, and updating dispatch schedules on a sub-hourly basis, and
- Factoring flexibility needs into future resource acquisitions and transmission expansion.

This concludes my written submitted comments, but I hope the Commission and staff will feel free to ask questions during the workshop, or to contact NREL and DOE in the future regarding the technical analyses we have been involved with through the past several years.

Thank you.

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