Renewable Energy Question 6: *How can reliability costs and benefits be assessed and incorporated into an analysis of renewables costs? Has any jurisdiction tried to do so, and if so, how?*

Executive Summary

1. The variability and unpredictability of the intermittent supply from renewable resources such as wind and solar have created some operational challenges and raised reliability concerns for electric system operators. Various integration studies have been conducted to address the cost of reliability associated with overcoming these operational challenges

2. Most integration studies suggest that the cost of integration for an intermittent renewable resource such as wind is in the range of $2-9 / MWh. This cost increases as more renewable generation is connected to the electric grid

3. Although the Midwest Independent System Operator has taken some measures to mitigate the challenges of integrating wind generation, the extent to which these measures will support renewable integration is still unclear

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1. The variability and unpredictability of the intermittent supply from renewable resources such as wind and solar have created some operational challenges and raised reliability concerns for electric system operators. Various integration studies have been conducted to address the cost of reliability associated with overcoming these operational challenges

The electric grid is a complex, interconnected system requiring constant balancing of supply and demand. The characteristics of electricity output from renewable resources are fundamentally different from the traditional technologies to which electric system operators are accustomed. Electricity output from wind and solar plants is constantly changing and hard to accurately predict. The combination of production variability and unpredictability makes it difficult to "fit" intermittent generation into established practices and methodologies for electric system operations and short-term planning and scheduling. As the penetration of intermittent renewable resources increases, considerable efforts are needed to accommodate and effectively manage the unique operating and planning characteristics of renewable resources so that electric system reliability can be maintained.

To quantify the additional costs of integrating the variability and unpredictability of renewable resources, especially wind, into the electric grid, market participants, system operators and research institutions have conducted a number of integration studies. The findings of the integration studies can be understood as describing the reliability costs associated with intermittent renewable resources.

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It is important to understand that these integration studies do not address transmission upgrade costs associated with interconnecting wind and other renewables to the grid. Rather, they address the costs that are needed to cope with the additional system variability as a result of renewable penetration over specific timeframes (illustrated in Exhibit 1), such as:

- Additional system variability from several seconds to 5 minutes (regulation): variability during this timeframe must be met by generation that is on-line, grid-synchronized and under automated control by the system operators. The Midwest Independent System Operator (MISO), of which both DTE Energy and Consumers Energy are market participants, mainly relies on fossil generation plants such as coal to respond to this variability. The additional variability brought by intermittent renewable resources requires these fossil plants, which are designed to optimally run at a steady level of output, to ramp up and down more often, consequently reducing plant efficiency and increasing operating and maintenance (O&M) costs.

- Additional system variability from 5-15 minutes to several hours (load following): variability during this timeframe can be met by generation that has been previously committed, or can be started quickly. In MISO, gas-fired generation plants are the main contributor to the requirement. As more renewable generation is brought on-line, more gas-fired generation plants will be needed to provide the system flexibility during this timeframe, leading to increased capital and O&M costs.

- Additional system variability from several hours to several days (unit commitment): unit commitment involves the starting and synchronizing of fossil and nuclear generation so that is it available when needed to meet expected electricity demand. More intermittent renewable generation imposes a need for more flexibility in the generation mix. Additional costs will be incurred as more flexible generation resources replace generation that is not as flexible.

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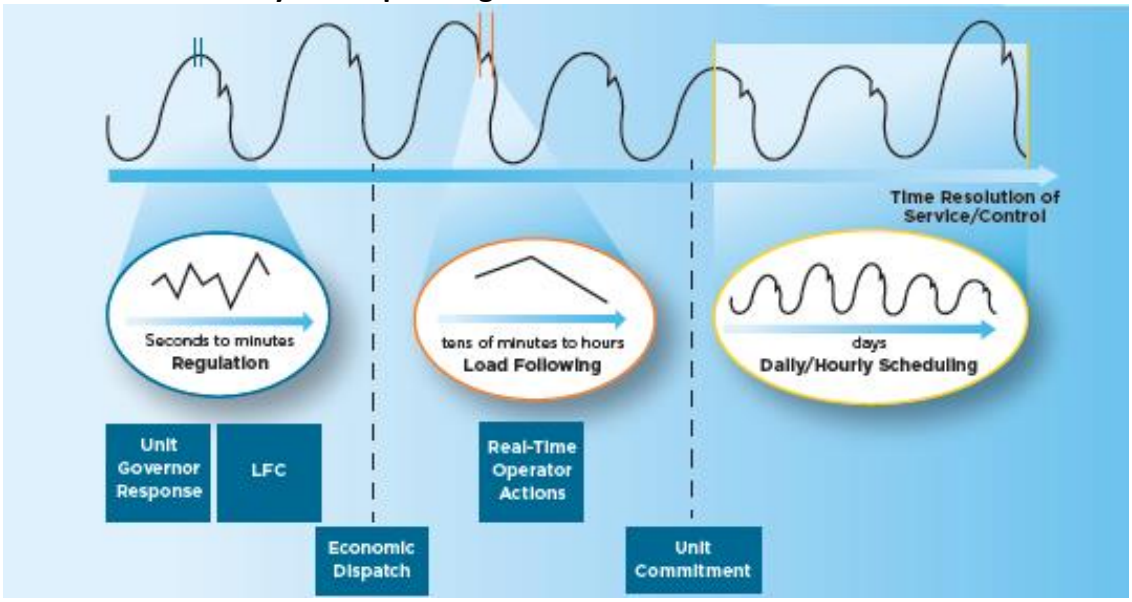
Exhibit 1 System Operating Timeframes and Control Mechanisms



Source: The Importance of Flexible Electricity Supply, U.S. Department of Energy.

2. Most integration studies suggest that the cost of integration for an intermittent renewable resource such as wind is in the range of $2-9 / MWh. This cost increases as more renewable generation is connected to the electric grid

The Eastern Wind Integration and Transmission Study (EWITS), conducted by the National Renewable Energy Laboratory (NREL) in 2010, evaluated the wind integration costs for 20% to 30% wind penetration scenarios in Eastern Interconnection. It concluded:

"With large balancing areas and fully developed regional markets, the cost of integration for all scenarios is about $5 (US $ 2009) per megawatt-hour (MWh) of wind, or about $0.005 per kilowatt-hour (kWh) of electricity used by customers."

This study result is in line with the findings of many other integration studies, as demonstrated in Exhibit 2. Most studies have concluded that there is a ~$2-9 / MWh integration cost for wind generation.

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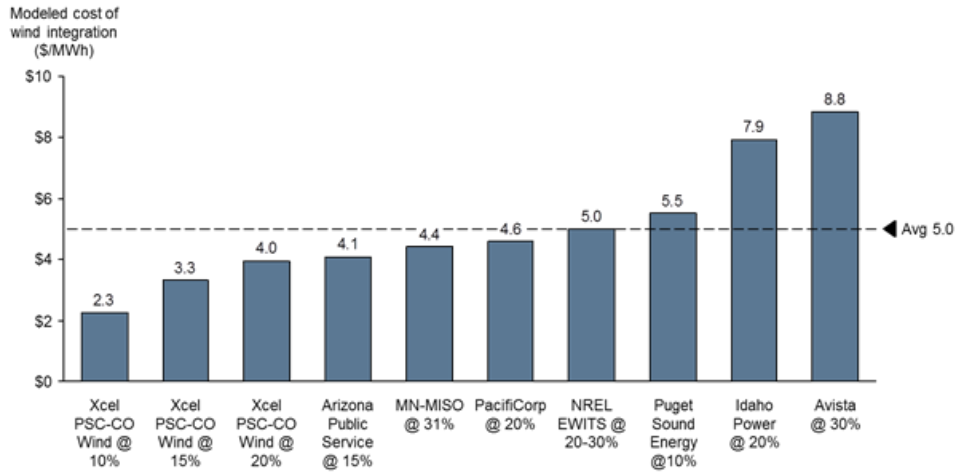
Exhibit 2 Costs of Wind Integration from Industry Studies



Source: 2009 ScottMadden report "Wind Energy: Grid Integration Challenges", Public Service Commission of Colorado 2 GW and 3 GW Wind Integration Cost Study, NREL Eastern Wind Integration and Transmission Study

Furthermore, the 2009 ScottMadden report "Wind Energy: Grid Integration Challenges" suggested integration costs increase as wind penetration rates increase:

"As more wind generation is introduced to an electric system, variability and uncertainty increase on a system-wide basis. This creates the need for additional operational flexibility in the form of increased reserves and leads to higher integration costs. "

Results from integration studies at various levels of wind penetration rates demonstrate the same point, as shown in Exhibit 3.

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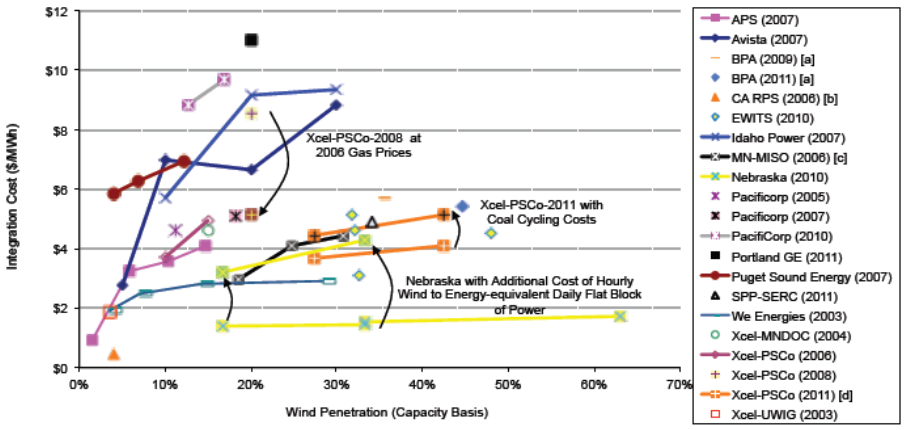
Exhibit 3 Integraton Costs at Various Levels of Wind Power Capacity Penetration



Source: R. Wiser and M. Bolinger, 2011 Wind Technologies Market Report, Lawrence Berkeley National Laboratory
Note: Because methods vary and a consistent set of operational impacts has not been included in each study, results from the different analyses of integration costs are not fully comparable

3. Although the Midwest Independent System Operator has taken some measures to mitigate the challenges of integrating wind generation, the extent to which these measures will support renewable integration is still unclear

In the past several years, the Midwest Independent System Operator (MISO), of which DTE Energy and Consumers Energy are market participants, has adopted some measures to mitigate the challenges of integrating wind generation.

Dispatchable Intermittent Resources (DIRs): MISO introduced the DIR system in June 2011 to enable more timely control over its wind resources by allowing them to be dispatchable (i.e. to respond economically to dispatch instructions). This takes advantage of advances in wind technology and allows wind resources to fully participate in the energy markets.

Wind Energy Forecasting System: MISO has been actively forecasting wind resource output at intervals ranging from the next 5 minutes to the next operating day. As the 2011 Wind Technologies Market Report[1] suggested, developing a reliable centralized wind energy forecasting system is a key prerequisite to the integration of wind into electric system operations.

However, given the fact that integration costs increase as renewable penetration rates increase, the extent to which the measures will support renewable integration is still unclear.

[1] R. Wiser and M. Bolinger. 2011 Wind Technologies Market Report. Lawrence Berkeley National Laboratory. http://emp.lbl.gov/publications/2011-wind-technologies-market-report. Accessed Mar 12, 2013