Renewable Energy 35: *How has the dispatch of renewable generation changed since the implementation of MISO's Dispatchable Intermittent Resource (DIR) tariff? How has dispatching of renewable energy impacted rates in Michigan?*

Executive Summary

1. Intermittent resources, such as wind energy, have unique characteristics that affect the operations and economics of the electric grid.
2. MISO introduced a new Dispatchable Intermittent Resource (DIR) tariff to treat wind energy on a more level playing field with other generators in the market, increase operational and market efficiency, and reduce the need for manual curtailment of intermittent resources.
3. Manual curtailment of wind has decreased with the DIR tariff allowing more efficient dispatch of resources in the MISO market.
4. The impact of dispatching renewable energy on rates in Michigan has not been quantified, but in theory MISO's DIR tariff may lessen the integration costs attributable to new intermittent resources (i.e., wind) in Michigan's electric rates.

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1. Intermittent resources, such as wind energy, have unique characteristics that affect the operations and economics of the electric grid.

Utilities and grid operators such as the Midwest Independent Transmission System Operator (MISO) manage electric generation facilities of all kinds (e.g., nuclear, coal, natural gas, wind, and hydro) so that the sum of all generation output equals electricity demand (load) at each moment. Operators account for the specific operating and economic characteristics of each type of generation when determining which units operate at any specific moment in time.

For example, peaking units are designed to increase or decrease output rapidly but have relatively high marginal costs of operating so they are used sparingly to handle peak periods when consumption is high. In contrast, baseload coal and nuclear plants have low marginal costs and are designed to operate most efficiently under fairly constant output. Wind and other intermittent resources such as solar are different in that they have little to no marginal cost (no fuel) and wind and solar output is variable and generally cannot be directly controlled or "dispatched" to increase or decrease production like a conventional power plant. Wind generation can displace conventional generation that has higher marginal costs. During certain periods, other generators must then be dispatched to increase or decrease their output to manage not only the variability in load, but also the output of intermittent resources such as wind.

Exhibit 1 illustrates how load (demand) and wind energy generation can vary over a one-week period. Grid operators are trying to select the right mix of generation to serve the "net load"—that is, load minus the wind energy, at each point in time. This exhibit also shows instances where wind generation is low and load is relatively high (hour 1240) and, conversely, when wind generation is high and load is low (hour 1340). When the latter occurs and there is a large amount of wind energy relative to the overall demand for electricity, conventional power plants can be instructed to be turned off or to reduce output to avoid system disturbances and wind generators can be manually curtailed. This is necessary because having too much electricity can create reliability problems, just like electricity shortages can. This leads to inefficiencies since generators are not running at their optimal level of production from an economic or operational standpoint. These inefficiencies are most pronounced in the periods where the load may be increasing and the wind is decreasing or where the load is decreasing and the wind is increasing.

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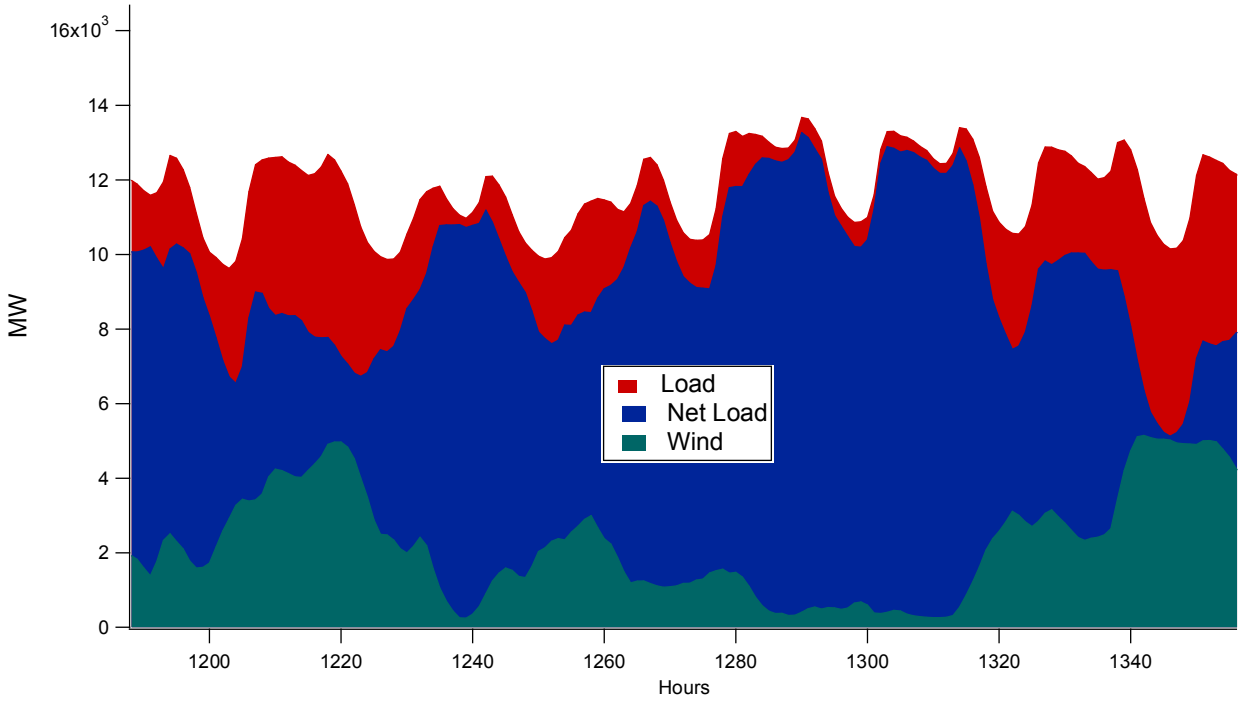
When determining which units get turned down or off, the grid operator has to make sure that there is the right mix of generation essentially on standby to be able to increase output as load increases (or wind dies down). Coal and nuclear power plants are not designed to increase or decrease output rapidly, so this "ramp" time must be considered. Hydro-electric units, such as the Ludington pumped storage facility and smaller dams, are valuable because they can typically respond very quickly in order to help balance the system.

EXHIBIT 1. Net Load (Load Minus Wind Generation) over Seven-Day Period



SOURCE: Brian Parsons, National Renewable Energy Laboratory, Grid Considerations for Variable and Uncertain Renewable Power, Presentation (2011). See also M. Milligan and B. Kirby, National Renewable Energy Laboratory, Utilizing Load Response for Wind and Solar Integration and Power, Conference Paper, June 2010. Available at: www.nrel.gov/docs/fy10osti/48247.pdf.
NOTE: The hours shown illustrate a one-week period during late winter. The hours are ordered sequentially over the year with January 1 at 12:00 a.m. as hour 1 and December 31 as hour 8760. Actual results may vary by season, wind patterns, and weather, and are location-specific.

System Reliability and Dispatch

"Dispatch" refers to the instructions by the grid operator to generate electricity or provide other support to maintain voltage or stability of the electric system. Within the MISO and other organized wholesale markets, such as PJM, dispatch is based on a "security constrained economic dispatch" model in which generators bid into the market at set intervals (e.g., every five minutes) and then units are selected based on their marginal cost while recognizing reliability or operating limits of the generation and transmission

facilities.[1] Thus, generators with the lowest marginal cost such as hydro, nuclear, and wind energy, are generally selected first, followed by those with higher marginal costs (e.g., coal and natural gas), and then finally the "peakers" during peak periods of consumption or in the event of an outage of a major generator or transmission line. The price of electricity, known as the "market-clearing price," is set by the most expensive, or marginal, unit of supply.

Recently, new technologies and improved wind forecasting have allowed wind energy to be effectively dispatched as part of the wholesale market. Wind energy forecasts can be provided to grid operators and then the output of the wind generators can be controlled to generate only up to that amount. This can reduce the need for other generators to respond to fluctuations in wind output and minimize situations where wind generators must be manually curtailed to avoid reliability problems. As discussed further in section 2 below, MISO's market rules now account for these technological and forecasting advancements in order to dispatch intermittent resources.[2] Previously, the output of a wind generator was assumed in the real-time energy market based on its historical output, and then the system operator had to balance the overall system based on the actual output. This approach created a lag in responding to changes in output, leading to inefficiencies and over/under correction of wind and other generating units to accommodate the wind generation. In addition, a manual process was used by MISO to relieve transmission congestion. This process relied on phone calls to direct the curtailment of wind generators and was not optimized. As wind penetration across MISO's multi-state footprint increased, resulting in more congestion on the transmission system, particularly in the western part of MISO (e.g., Dakotas and Iowa), operation and market inefficiencies increased.

2. MISO introduced a new Dispatchable Intermittent Resource (DIR) tariff to treat wind energy on a more level playing field with other generators in the market, increase operational and market efficiency, and reduce the need for manual curtailment of intermittent resources.

On March 1, 2013, MISO completed a two-year transition to register and treat intermittent resources as dispatchable under the operating guidelines of MISO's new Dispatchable Intermittent Resource (DIR) tariff. The tariff was developed with stakeholder input and approved by the Federal Energy Regulatory Commission. Since the first DIRs began operating under the new tariff on June 1, 2011, 9,544 MWs of wind generators have registered as DIRs. This represents 78% of the 12,238 MWs of wind generation registered in MISO.

Under the DIR tariff, intermittent resources are dispatched as part of the real-time energy market, comparable to conventional generators. Wind generators will supply data including forecasted output, ramp rates, and pricing, similar to what is provided by conventional power plants. A key part of the DIR tariff requires the wind generator (or MISO) to forecast the wind available over the next 10 minutes. The wind generators are then restricted from producing more than the forecasted amount (even though actual wind could allow for greater production), and are held accountable with penalties if they do not produce the forecasted output. This provides strong incentive for wind generators to accurately forecast their output, and it helps MISO better match wind energy and load, thereby reducing inefficiencies resulting

[1] FERC has defined security constrained economic dispatch, or SCED, as "the operation of generation facilities to produce energy at the lowest cost to reliably serve consumers, recognizing any operational limits of generation and transmission facilities." See FERC Docket No. No. AD05-13-000, Joint Board on Security for the South Region, *Study and Recommendations Regarding Security Constrained Economic Dispatch*, July 11, 2006. Available at: www.ferc.gov/industries/electric/indus-act/joint-boards/south-recom.pdf.

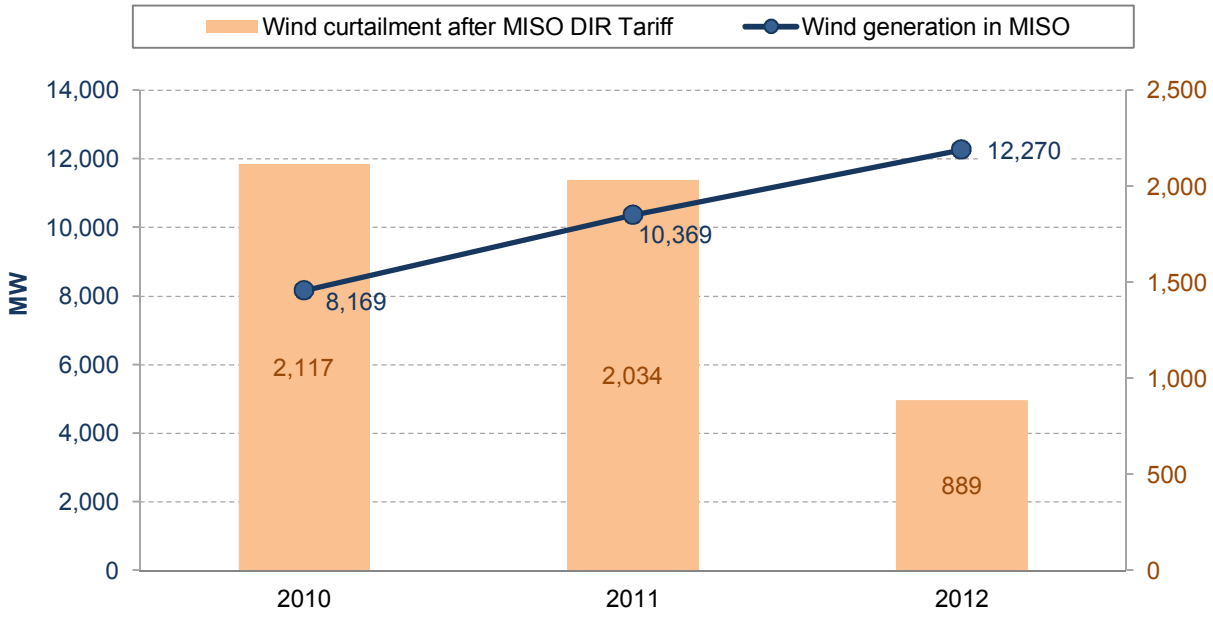
[2] Like PJM and other regional transmission organizations, MISO operates both a real-time and day-ahead energy market.

from other generators having to accommodate the fluctuations. MISO expects the tariff will improve operational efficiency by reducing the number of manual curtailments, minimizing over-curtailments (thus maximizing the use of low cost energy from wind generation), and selecting the most efficient resources to meet customer demand while recognizing reliability limits of the system.

3. Manual curtailment of wind has decreased with the DIR tariff allowing more efficient dispatch of resources in the MISO market.

There are situations when there is too much generation on the system relative to the load, even with the DIR tariff in place. In these cases, wind generators can be manually curtailed and other generators can also be shut off or turned down to their minimum levels. In 2012, the first full year under MISO's DIR tariff, there were 889 wind curtailments in MISO. This is a significant decrease from the 2,117 curtailments in 2010 and the 2,034 curtailments in 2011, even as wind generation in MISO increased during this time frame (see Exhibit 2).[3] Similarly, the hours of curtailment decreased from 19,951 in 2011 to 10,430 in 2012. This trend should continue in 2013, as a number of wind generators registered under the DIR shortly before the March 2013 deadline; these generators represented 3,400 MW, or about one-third of all the DIR registered generation.

EXHIBIT 2. Wind Curtailment and Generation in the MISO Market



SOURCE: Public Sector Consultants, Inc. using data from MISO, Growth of Wind Capacity, https://www.midwestiso.org/WhatWeDo/StrategicInitiatives/Pages/GrowthofWindCapacity.aspx.

[3] MISO, Growth of Wind Capacity, https://www.midwestiso.org/WhatWeDo/StrategicInitiatives/Pages/GrowthofWindCapacity.aspx (accessed 4-9-13).

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4. **The impact of dispatching renewable energy on rates in Michigan has not been quantified, but in theory MISO's DIR tariff may lessen the integration costs attributable to new intermittent resources (i.e., wind) in Michigan's electric rates.**

Electricity rates for Michigan's regulated electric utilities are highly dependent on the efficient dispatch and operation of the utilities' generation fleet. Historically, Consumers Energy and DTE Energy operated a power pool that dispatched their combined fleet of generation to minimize the cost of generation. With the advent of the MISO energy markets, this function transitioned from the utilities to MISO where the security constrained economic dispatch model is used to perform the same function for the entire MISO energy market, as discussed further above.

Under both the historic Michigan power pool and under the MISO energy market, generation is dispatched on an economic order basis. Historically, if the power pool could have purchased a MWh of energy from an out-of-state utility at a lower cost than the marginal cost of producing that MWh from one of the utility's generating units, the power pool would back down the power pool's generation and make the purchase from the out-of-state utility. Similarly, in the MISO energy market, MISO is rank ordering generation and dispatching the next most economic generation for a change in load.

The introduction of significant amounts of intermittent wind resources has affected MISO's efficient operation and dispatch of resources. Without the ability to dispatch intermittent resources, MISO had been required to dispatch other resources at less than the optimal output to provide a buffer for changes in wind and load. This inefficiency is generally referred to as integration costs, which are discussed in more detail under Renewable Energy Question 6.

MISO's DIR tariff was developed to reduce these inefficiencies and related costs of integrating wind energy, put wind on a more level playing field compared to other generators, and reduce manual curtailment of wind energy. While impacts have not been quantified, the tariff is expected to lessen integration costs. As the Department of Energy's 2011 Wind Technologies Market Report suggests, developing a reliable centralized wind energy forecasting system is a key prerequisite to the integration of wind into electric system operations.[4] However, given the fact that integration costs increase as penetration of intermittent resources increase, the extent to which the measures will impact rates and overall integration costs is still unclear.

[4] U.S. Department of Energy, 2011 Wind Technologies Market Report , August 2012. Available at: www1.eere.energy.gov/wind/pdfs/2011_wind_technologies_market_report.pdf.