This document summarizes PJM Requirements for wind resources to be dispatchable and receive Lost Opportunity Cost credits. The key takeaways:

1. PJM wind generation facilities shall provide SCADA capability to transmit data and receive instructions from PJM.
   a. Data transmitted to PJM includes 1) generator net-MW and MVAR output and 2) meteorological data (e.g., wind speed, and wind direction).
   b. Data received from PJM includes SCED Desired MW Basepoint and Curtailment Indicator.

2. PJM wind generation facilities must submit dispatchable offers with an Economic Minimum in the real-time energy market no greater than the resource’s physical minimum operating level or the level of its Capacity Interconnection Rights (CIR).

3. Pool-scheduled or self-scheduled wind generators are only eligible for Lost Opportunity Cost credits if they operated the resource according to PJM Manual requirements for wind resources.
PJM Open Access Transmission Tariff (OATT) Requirements

1. Schedule H, Interconnection Requirements for a Wind Generation Facility (pg 2184):

   iii. Supervisory Control and Data Acquisition (SCADA) Capability
   The wind generation facility shall provide SCADA capability to transmit data and receive instructions from the Transmission Provider to protect system reliability. The Transmission Provider and the wind generation facility Interconnection Customer shall determine what SCADA information is essential for the proposed wind generation facility, taking into account the size of the facility and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability in its area.
   Effective Date: 9/17/2010 - Docket #: ER10-2710-000

2. Part IV, Interconnections with the Transmission System, Section 36.1.1, Interconnection Services for Generation (page 267)

   Consistent with Section 1.7.4(i) of Schedule 1 to the Operating Agreement, to the extent its generating facility is dispatchable, an Interconnection Customer shall submit an Economic Minimum in the real-time market that is no greater than the higher of its physical operating minimum or its Capacity Interconnection Rights.

   Note – in the compliance filing transmittal letter dated October 13, 2010 PJM wrote:

   On July 13, 2010, PJM submitted proposed PJM Tariff and OA revisions to ensure that PJM is able to economically dispatch energy-only resources prior to being required to initiate emergency procedures. PJM explained it was concerned about the need to declare emergency procedures and issue verbal dispatch instructions to reduce output from a resource, where all or a portion of the resource is energy-only, when resolving transmission constraints. Further, PJM explained that redispatch for transmission constraints involves the possibility that some generating units will be dispatched up, while other resources will be dispatched down in order to maintain transmission facilities within established reliability limits. To address this issue, PJM proposed adding language to the PJM Tariff and the OA to require generators to submit an economic minimum bid in the real-time energy market that is no greater than its level of capacity interconnection rights (“CIRs”) that are included in its interconnection agreement or wholesale market participation agreement. PJM explained that certain generating facilities have CIRs that are less than the facilities’ maximum facility output, such as wind and solar generation.
The intent of the filing was to require wind and solar to be dispatchable and follow PJM electronic dispatch instructions.

3. Section 3.2.3(f-4) of Schedule 1, Accounting and Billing, Operating Reserves, LOC for Wind (page 1782)

(f-4) A Market Seller’s wind generating unit that is pool-scheduled or self-scheduled and operating as requested by the Office of the Interconnection, the output of which is reduced or suspended at the request of the Office of the Interconnection due to a transmission constraint or other reliability issue, and for which the hourly integrated, real-time LMP at the unit’s bus is higher than the unit’s offer corresponding to the level of output requested by the Office of the Interconnection (as indicated either by the desired MWs of output from the unit determined by PJM’s unit dispatch system or as directed by the PJM dispatcher through a manual override), shall be credited hourly in an amount equal to 
\[(LMP_{DMW} - AG) \times (URTLMP - UB),\]

where:

LMP_{DMW} equals the lesser of the PJM forecasted output for the unit or level of output for the unit determined according to the point on the scheduled offer curve on which the unit was operating corresponding to the hourly integrated real time LMP, and shall be limited to the lesser of the unit’s Economic Maximum or the units Maximum Facility Output;

AG equals the actual hourly integrated output of the unit;

URTLMP equals the real time LMP at the unit’s bus;

UB equals the unit offer for that unit for which output is reduced or suspended, determined according to the real-time scheduled offer curve on which the unit was operating, unless such schedule was a price-based schedule and the offer associated with that price schedule is less than the cost-based offer provided for the unit, in which case the offer for the unit will be determined from the cost-based schedule; and

where URTLMP - UB shall not be negative.

In the event the Office of the Interconnection experiences a technical problem or malfunction with its wind forecasting tool that results in an erroneous forecast for a wind resource during a period of time for which the wind resource is eligible for lost opportunity cost, the Office of the Interconnection and the Market Seller will attempt to reach a mutually agreeable forecast value for settlement purposes. If the Office of the Interconnection and the Market Seller do not come to mutual agreement on an acceptable forecast value, the Office of the Interconnection shall utilize the forecast value that it determines is appropriate.
Requirements for PJM Wind Resources

PJM Manual Requirements

1. Manual 28 – Operating Agreement Accounting, Section 5.2.6 – Credits for Resources Reduced or Suspended due to a Transmission Constraint or for Other Reliability Reasons. Revision 52 on 6/1/2012 updated Section 5.2.6 to incorporate lost opportunity cost credit details for wind units per FERC Docket #ER12-1422.

“Pool-scheduled or self-scheduled wind generators whose output is reduced or suspended at the request of the Office of the Interconnection and the hourly integrated, real-time LMP at the unit’s bus is higher than the unit’s offer corresponding to the level of output requested by PJM are credited hourly in an amount equal to: (Desired MWh – Actual MWh) * (Real-time LMP – Incremental Offer Rate at Actual MWh). The Desired MWh used in this calculation is the lesser of the point on the unit’s offer curve corresponding to the hourly integrated real-time LMP at the generator’s bus adjusted for effective regulation or synchronized reserve assignments or the PJM forecasted output for the unit.

Pool-scheduled or self-scheduled wind generators are only eligible for the above-referenced credit if they:

- Operated the resource according to PJM Manual requirements for wind resources

If a technical issue (e.g. computer system failure or disruption or failure of communications equipment) occurs resulting in an erroneous forecast, PJM and the market participant will determine a mutually agreeable settlement value. Recommendations for reconciliation include but are not limited to:

- Using the average forecast values as determined by PJM wind forecasting tool from before and after the technical issue to determine forecast value during the issue

- Using the forecast value as determined by PJM wind forecasting tool from before the technical issue for the first half of the duration of the technical issue and forecast value from after the technical issue for the latter half of the duration of the technical issue

- Using Market Seller’s forecast value during the technical issue"
2. **Manual 14D** - Generator Operational Requirements, Section 8: Wind Farms requirements

8.1 Computer System Data Exchange

The PJM SCADA system allows PJM to communicate directly with individual generators or smaller Control Centers. A data concentrator (e.g. Remote Terminal Unit, Generator Control System, etc.) is located at the Member's site, and, after collecting data from the industrial metering equipment, communicates with PJM's SCADA system using either DNP 3.0, Level 2 (Distributed Network Protocol) or ICCP (Inter-Control Center Protocol) consistent with PJM Control Center Requirements Manual (M01).

Every Generator interconnected with and synchronized to the transmission system must at all times coordinate operation with PJM and the Local Control Center, providing all necessary and requested information and equipment status, to assure that the electrical system can be operated in a safe and reliable manner. Attachment L defines coordination models that are considered acceptable PJM Wind Farm Communication Models.

**This coordination includes, but is not limited to:**

- Supplying low side generator net-MW and MVAR output.
- **Supplying meteorological data (wind speed, wind direction, temperature, pressure and humidity).** Wind speed and direction required.
- Scheduling the operation and outages of facilities including providing advanced notification.
- Coordinating the synchronization and disconnection of the Wind Farm with PJM and Transmission Owner.
- Coordinating the dispatching of a generation unit utilizing the Wind “Curtailment Indicator.”
- Providing data required to operate the system and to conduct system studies.
- Providing documented start-up and shutdown procedures including ramp-up and ramp-down times.
- Following PJM-directed plant operation during emergency and restoration conditions.

- Following PJM-directed operation during transmission-constrained conditions.

All data items, regardless of type, are collected and disseminated at a frequency of 10 seconds or less.

Each PJM Member is responsible for determining data-quality indicators for all data transmitted to PJM. Both failed individual values and any value calculated using a failed point must be flagged. When a point fails for an extended period, a manual update of the point's value may be necessary to keep the data as accurate as possible. The Generator shall communicate the outage of any data communication equipment connecting the facility to PJM Dispatch.

8.2.2 Aggregate Real Time Output

The Wind Farms are required to provide the real time aggregate Wind Farm MW output along with other data points. This output should be telemetered at low-side net and high side-net of the Wind Farm.

8.2.3 Real Time Meteorological Tower (or mutually agreed upon alternative source)

The Wind Power Forecasting accuracy is highly dependent on the availability of the real time meteorological tower data for tuning the forecaster model. Each wind farm must install at least one meteorological tower (or wind speed and direction from selected turbines’ anemometer and wind vane) in the farm and provide real time meteorological data to PJM through ICCP or DNP 3.0, Level 2 link. Depending upon the topology and the accuracy of the Wind Power Forecast, PJM may request addition of more meteorological towers at a Wind Farm site.

The height of the meteorological tower should be same or close to the hub height of the wind turbine. The generation owner should calibrate and check the accuracy of the met tower every year as per standard.

The meteorological data shall include the following parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Speed</td>
<td>meters/second</td>
<td>Required</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>Degree from True North</td>
<td>Required</td>
</tr>
<tr>
<td>Temperature</td>
<td>Fahrenheit</td>
<td>Preferred</td>
</tr>
<tr>
<td>Pressure</td>
<td>Hectopascals</td>
<td>Preferred</td>
</tr>
</tbody>
</table>
Attachment L – Wind Farm Communications Model

Manual dispatch directives to multiple wind owners delay controlling actions resulting in less efficient market operations and a potential adverse impact to system reliability. Manual dispatch to a subset of owners at a common Wind Farm may result in customers questioning curtailments and additional administrative procedures to ensure fair/equitable reductions to an aggregate plant on a rotating basis. A single SCED basepoint for a Wind Farm to a single MOC Generation System Operator is an effective solution to ensure efficient and reliable operations.

The purpose of this section is to define a dependable real-time communications model to manage wind, ensuring:

1. A single MOC Generation System Operator (single operational contact) for the processing of all real-time dispatch electronic signals and operational issues.
2. Accurate outage data, which is essential for an accurate Wind Power Forecast
3. Prompt wind power reduction via the mandatory use of the “Curtailment Indicator,” which typically would occur as a last resort just prior to emergency procedures.

Note 1: This communication model may be expanded to include other renewable resources as PJM develops forecast tools or their penetration levels increase.

Note 2: The MOC Generation System Operators (single operational contact) will need to meet the PJM certification and training requirements outlined in PJM Manual 40: Training and Certification Requirements.

Option 1: PJM Operations would prefer a model where there is a single MOC Generation System Operator (single operational contact) responsible for the entire Wind Farm operations. The single contact would be responsible for all day-ahead and real-time bidding into PJM Systems (eMkt), process an SCED basepoint, real-time communications with PJM Dispatch, as well as providing accurate turbine outage information within eDart. Settlements can be allocated by PJM based on ownership shares.
Option 2: The alternate solution would still require a single MOC Generation System Operator (single operational contact), however, each owner/off taker would still be able to interact with eMkt, providing day-ahead bids and hourly updates. The single operational contact would be responsible for processing SCED basepoints, all real-time communications with PJM Dispatch, as well as providing accurate turbine outage information within eDart. PJM SCED would send individual basepoints to each owner/off taker as well as sending an aggregate base point to the operational contact. Settlements will model individual owner/offtakers.

3. **Manual 12** – Balancing Operations, Attachment B: Transmission Constraint Control Guidelines

**Note 1:** In order to ensure resources do not force emergency procedures they must be dispatchable (Dispatchable Generation) in the range between the greater of the resource’s physical minimum operating level or Capacity Interconnection Rights (CIR) and Maximum Facility Output (MFO) (i.e. fixed gen flag must not be selected).

**Note 2:** Resources may not submit an economic minimum that exceeds the greater of the resource’s physical minimum operating level or the level of their CIR in the real-time energy market. This restriction does not apply to the day ahead market.

**Note 3:** An intermittent resource’s Economic Minimum shall not exceed the level of its CIR.

**Note 4:** An intermittent resource’s Emergency Minimum should be set to 0.

**Note 5:** During Constrained Operations, Resources will redispatched cost effectively based on their bid parameters.

**Note 6:** Cost-effective redispatch ($/MW effect) objective is to minimize the function [(Current Dispatch Rate – Unit Bid) ÷ Unit Generation Shift Factor]].

**Note 7:** The unit default cost/price bid will be assumed 0 unless provided via eMkt.

**Note 8:** Intermittent resource curtailment should be achieved within 15 minutes or consistent with the resources ramp rate bid. PJM should be notified if curtailment is expected to exceed 15 minutes.

**PJM Member Actions:**
• Generation Dispatchers ensure their units are following PJM economic base points to Economic Minimum output.

• Wind Generator Operators will adjust Wind Turbine Control Systems or manually adjust turbine output to achieve the desired RT-SCED basepoint.