





Grid Interconnection of Renewable Generation

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Generator Interconnection Rule Responsibility

- In the United States, the responsibility for establishing generator interconnection rules is split between the federal and state governments.
- Rules for generator interconnection to distribution level facilities (generally below 100kV) is generally the responsibility of the state public utility commissions.
- Rules for generator interconnection to transmission level facilities (generally 100kV and above) is the responsibility of the Federal Energy Regulatory Commission (FERC)
 - FERC has also asserted responsibility for interconnections at distribution level facilities if the intent is to sell energy in wholesale markets.







FERC Interconnection Rules

- In 2003, FERC adopted standard procedures and a standard agreement for the interconnection of large generation facilities to the grid (Order 2003).
 - \succ Large = capacity of more than 20 megawatts.
- In 2005, FERC adopted procedures and technical requirements for the Interconnection of Wind Energy for facilities having a capacity of more than 20 megawatts (Order 661).
- FERC also has established procedures and a standard agreement for the interconnection of small generators rated at 20 MW or less, regardless of technology type (Order 2006).







FERC Order 661 (Large Wind Interconnection)

- Low voltage ride-through: wind generating plant must be able to remain online during voltage disturbances up to established time periods and associated voltage levels.
- Power factor design criteria: wind generating plant must maintain a power factor within the range of 0.95 leading to 0.95 lagging, measured at the point of interconnection.
 - But, only if the grid operator's System Impact Study shows that such a requirement is necessary to ensure safety or reliability.
- SCADA: wind generating plant must have capability to transmit data and receive instructions from the grid operator to protect system reliability.
- Permits limited special interconnection procedures applicable to wind plants that are not generally available to conventional generation developers.







Role of RTOs

The regional transmission organizations that serve Illinois (PJM Interconnection and the Midcontinent System Operator (MISO)) implement the rules established by FERC for generator interconnection.

- Referred to as the interconnection queue process.







What is a Queue?

- The interconnection queue (queue) refers to the process of getting a new generator connected to the operating system's grid.
- There are several requirements to stay in the queue and advance toward an interconnection agreement.
 - An interconnection agreement between the generator developer and the regional transmission organization is needed before the generator can put energy on the system.







Basic Queue Process in MISO

- 1. Applicant submits a completed application (including deposit payment and technical data).
- 2. The application is reviewed for completeness.
- 3. Feasibility study (evaluates the applicant's impact on the System)
- 4. System Planning and Analysis (SPA)

Uses a system impact study to identify the transmission upgrades needed to permit the generator to interconnect

- 5. Applicant meets all M2 Milestones and submits Deposit D3
- 6. SPA review (including potential restudy)
- 7. Applicant meets all M3 Milestones
- 8. Facility Study (estimates the cost and time to construct needed transmission upgrades
- **9. Interconnection Agreement** (once finalized, the GIA must be filed with FERC)







MISO Queue Trends

- Significant recent growth in wind generator interconnection requests.
 - In 2012, MISO received 31 interconnection requests.
 - > 19 were wind related.
 - In 2011, MISO received 64 interconnection requests.
 - ➤ 44 were wind related.
 - In 2010, MISO received 55 interconnection requests.
 - ➤ 39 were wind related
- As of July 1, 2013, there were 23,198 MW in the interconnection queue representing 138 projects.
 - 14,858 MW (119 projects) were wind-related, representing 64 percent of the megawatts and 86 percent of the projects.
- MISO's current installed capacity is: Coal (48%), Gas/Oil (32%), Nuclear (6%) and Renewables (14%)







Feasibility Study

- The purpose of the Feasibility Study is to test the system readiness for an interconnection.
 - Uses power flow analysis







System Impact Study

- The System Impact Study generally includes:
 - thermal analysis,
 - short circuit analysis,
 - transient and voltage stability analysis.
- The study may also include:
 - system protection,
 - loss analyses
- The study will also provide a planning level estimate of cost and length of time that would be necessary to implement any transmission upgrades identified in the analysis.







Facility Study

The Facility Study will determine the cost and time estimate to construct the transmission upgrades and transmission owner's interconnection facilities necessary to physically and electrically interconnect the proposed generating facility to the transmission system.

- The interconnection facility study will be done in parallel with the System Impact Study
- The transmission upgrade facility study will be done after the System Impact Study is complete.







Generation Interconnection Agreement

- An agreement between the Generator Developer and (1) the grid operator; or (2) with the transmission owner and the grid operator.
- Required for the generation developer to proceed with subsequent steps to interconnect the proposed generating facility to the transmission system.
- General provisions for the generator interconnection agreement are specified in FERC rules.







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Transmission Upgrades Frequently Needed to Enable Generator Interconnection (MISO Example)









Summary of MISO Queue Milestone Process

- There are 3 different sets of milestones that must be completed: M1, M2 and M3
- Under each, there are two different kinds of milestones: technical and non-technical
- There are 3 deposits (D1, D2, D3) that are not milestones, but usually must be paid in conjunction with a milestone







M1 Technical Milestones

• Generic Stability Model

 Simplified stability model that approximately mimics the dynamics behavior of the Generating Facility

- Point of Interconnection (POI)
 - Location of the POI
 - The information provided should be descriptive enough to locate the POI in a power flow model







M1 Technical Milestones (continued)

• Impedance from collective substation to POI

 Impedance of the radial line from generator substation (GSU) to POI

Impedance is the measure of the opposition that a circuit presents

• Technical data to run studies

 Other technical data (as applicable) required to run studies such as sequence impedances, Generating Facility reactance, saturation curves, etc.







M1 Technical Milestones (continued)

- One-line diagram
 - Diagram of the Generating Facility clearly showing the Interconnection Facilities and POI
- Generation output (MW)
 - Gross and Net MW output of the Generating
 Facility under Summer and Winter conditions
- Step-up transformer data

Specifications of the Generating Facility Step-up transformer







M1 Non-Technical Milestones

- Application
 - Interconnection Request that is fully completed and correct
- Proof of Site Control
 - Documentation demonstrating ownership, leasehold interest, or a right to develop a Generating Facility on specified site

Proof that there is sufficient land area equal to at least 50% of that required to support proposed Generating Facility

- \$100,000 refundable deposit in lieu of site control







M2 Technical Milestones

- Detailed stability Model
 - Actual stability model representing dynamics of the Generating Facility
- Definitive Point of Interconnection
- Definitive one-line diagram
- Definitive generation output (MW)







M2 Non-Technical Milestones

Proof of Site Control

- Re-validation of site control demonstrated at M1 milestone submission

Any two of the following six milestones:

1. Equipment on order

- Demonstration that generation turbines have been ordered
- 2. Necessary permits*
 - Submitted application for required federal, state or local permits
- 3. Regulatory approval*

– Approval of the facility by a state utility regulatory commission

- 4. Board of Directors approval*
 - Approval to proceed with project from Interconnection

Customer's Board of Directors or its highest level of authority

*letter of credit or deposit may be used in lieu of milestone







M3 Non-Technical Milestones There are no technical M3 milestones

- Deposit or Letter of Credit
 - For the greater of the estimated transmission upgrades cost or cost of Interconnection Facilities
- Contract Sale or Inclusion in Resource Adequacy Plan
 - Execution of a contract for sale of electric energy or capacity from the Generating Facility, or statement attesting that the Generating Facility is included in an applicable state resource adequacy plan
- Equipment on order
 - Demonstration that generation turbines have been ordered







M3 Milestones Complete

- In the event an applicant fails to meet M3 milestones, the project will be withdrawn from the queue.
- If all milestones are met, queue process is complete. Interconnection agreement offered.