2016 10-Year Assessment
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Generation Interconnections

The size and location of new or expanded power plants can have significant impacts on the transmission system. These impacts can range from very positive (adding voltage support in a weak area of the system) to very negative (aggravating loading problems and/or causing generator instability). Information on the status, as of June 1, 2016, of generation requests in ATC's portion of the MISO generation interconnection queue is provided in this section. There continues to be significant activity in ATC's portion of this queue, ranging from newly proposed generation projects to cancellation of previously proposed generation projects.

There are two key aspects in determining the total impacts a proposed new generator may have on the transmission system:

- impacts of interconnecting the new generator to the transmission system and
- impacts of using the transmission system to deliver power from the new generator.

As described in MISO's Attachment X process, a generator interconnection study is usually performed in three stages: Interconnection Feasibility Study (Application Review Phase), Interconnection System Impact Study (System Planning and Analysis and/or Definitive Planning Phase), and an Interconnection Facilities Study (Definitive Planning Phase).

The *Interconnection Feasibility Study* includes a determination of thermal overload or voltage impacts created by the new generator. This study process is performed by MISO approximately five to seven times per calendar year and provides a qualitative screen of the affected facilities, indicating if there is ample capacity on the system to support the new interconnection, and is a factor in determining the deposit required to enter the Definitive Planning Phase (DPP). The Interconnection Customer may then elect to enter into the DPP or the System Planning and Analysis Phase (SPA) to have a System Impact study performed.

The *Interconnection System Impact Study* includes a determination of whether the proposed generator and other nearby generators will remain connected to the system under various disturbance situations, such as line trips and equipment failures and includes a fault duty analysis to determine whether existing system equipment can accommodate the increased short circuit fault duty caused by the new generator. Finally, the System Impact Study will identify solutions for any thermal, stability or fault duty deficiencies.

Delivery impacts are assessed during the DPP portion of the interconnection study process using the MISO deliverability methodology, which determines whether the output of a new generator is deliverable to the MISO energy market and to what percent if not wholly deliverable. Whatever portion of the new generator that is deliverable may then be used as

a Network Resource by Network Customers through MISO's Module E Resource Adequacy procedures.

The *Interconnection Facilities Study* is conducted in the DPP process phase to specify and estimate the time and cost of the equipment, engineering, procurement and construction of the system upgrades identified in the earlier interconnection studies.

The results of the interconnection studies are needed to develop a comprehensive picture of the transmission facilities that will be required for a proposed generator. These necessary changes to the transmission system are why we include in our Assessment models those proposed generators for which interconnection studies have been completed and an Interconnection Agreement has been signed.

The first portion of this section provides the status of the generation queue within our service territory. The second portion of this section describes the transmission system additions associated with various proposed generation projects for which final interconnection studies have been completed. The third portion of this section describes some of the implications associated with interconnecting generation at various locations within our service territory.

ATC Portion of MISO Generation Queue
Since ATC's inception, 20 new generators have gone into service and five uprates to existing generators have been completed, totaling approximately 6,000 MW. The various Tables and Figures noted in the following paragraphs are available on ATC's website, www.atc10yearplan.com.

A list of the past generator requests now in service is given in Table PR-26. Table PR-27 lists the proposed generators in the generation queue for our service territory as of June 1, 2016. This table lists each proposed generation project and summarizes them by zone and MW amount. These proposed projects also are shown by approximate location in Figure PR-9. As shown, the total capacity of proposed generators in this portion of the queue is 2,296 MW. Of this proposed capacity, natural gas fired units reflect 62 percent, wind units reflect 31 percent, and solar 4.4 percent; less than 3 percent is comprised of hydro and biomass generation (see Figure PR-10). Of this generation, 44.2 percent is in Zone 2, 51.4 percent is proposed in Zone 3, 4.4 percent in Zone 4, and zero percent in Zone1 and 5. Table PR-29 lists the required network upgrades associated with the generators shown in Table PR-27 with a signed Interconnection Agreement.

Link to publicly posted generation queue:
http://www.oasis.oati.com/woa/docs/ATC/ATCdocs/Cluster_8_Queue.mhtml

Implications of generation development

Availability of fuel, water and transmission interconnections are among the key aspects to be considered when sighting generation.

From a transmission perspective, the ability of the transmission system to accommodate new generation is a function of stability, power flow and short circuit analyses. For certain generation technologies, harmonics, fast control interactions, and voltage fluctuations may need to be considered as well. In most instances, new generation will require certain transmission system reinforcements to interconnect and deliver the generation output. In a few specific instances, new generation can be beneficial to the transmission system, perhaps even deferring or eliminating the need for transmission reinforcements that would be necessary absent the new generation. The ability of generation to defer or eliminate the need for transmission reinforcements also can be a function of the generation location, number of generators and/or expected generator capacity factor.

In this section, a general zone-by-zone evaluation of the likelihood of needing or deferring transmission reinforcements for various generator locations is provided. The purpose of these evaluations is to provide a cursory indication to the generation market of the likely magnitude of the impact and the transmission reinforcements that would likely be needed by general location.

Zone 1
Within Zone 1, generation has been proposed in various locations, and most of the proposals have involved generation located in the vicinity of the 345-kV infrastructure. Based on studies that we have conducted for proposed generation interconnections to date, some transmission reinforcements are likely to be required for any significant generation development. The extent and nature of the reinforcements largely would be a function of where the power from the generation is to be delivered.

The reliability of the northern portion of Zone 1, the Rhinelander Loop, has been significantly improved with the completion of the Cranberry to Conover 115-kV line and the Conover to Plains 138 kV conversion. While no new generator requests have been studied for this area, the addition of the Rhinelander Loop improvement projects may be able to support small-sized (depending on location) generation development, provided generator stability can be maintained, and provided it can be located in the northern portion of the Loop. Whether this generation would be cost-effective as a transmission-deferral mechanism would depend on a number of factors. The need for additional stability and thermal reinforcements in and outside of the Loop would be a function of where the new generation is sited and where the power is to be delivered. These improvements will be required to ensure that NERC reliability standards are continuously being met and that the security of the Rhinelander loop is not compromised.

The transmission infrastructure in the central portion of Zone 1 was improved to include three 345-kV lines (Gardner Park – Highway 22, Morgan – Highway 22, and Highway 22 – Werner West). These additional lines significantly strengthen the Weston area, bringing much needed support to the area for both stability and thermal considerations.

The infrastructure in the southern portion of Zone 1 consists of five 138-kV lines and several 69-kV lines. The existing infrastructure in this portion of Zone 1 is not suitable for significant generation development.

The following table lists Zone 1 generator studies completed in the last five years.

Zone 1 completed generation studies:

Request	Size	Type	County, State	Status
None	None	None	None	None

Zone 2

ATC has seen substantial interest in siting wind turbine and natural gas fired generators in the Upper Peninsula of Michigan. One of the major challenges generation proposed for the Upper Peninsula will face is the limited transmission infrastructure to interconnect and deliver the energy produced by these power plants. Since the Upper Peninsula transmission grid was primarily designed to serve local load, transmission upgrades may be required to accommodate these proposed plants. Completion of the Northern Umbrella Plan and the ATC Energy Collaborative-Michigan projects have started to improve this infrastructure. ATC is also working with MISO and particularly our Michigan stakeholders to identify appropriate solutions to potential generation retirements.

There are areas in Zone 2, such as the western end of the Upper Peninsula, which are or will be in need of transmission reinforcements where smaller generation projects could be beneficial in terms of deferring transmission expenditures. The allowable capacity of such generation would depend on the location. However, other potential impacts (stability, fault duties) would need to be evaluated on a location-by-location basis.

The following table lists Zone 2 generator studies completed in the last five years.

Zone 2 completed generation studies:

Request	Size	Type	County, State	Status
J061	70 MW	Wind	Delta County, MI	In Queue
J119	61.2 MW	Wind	Chippewa County, MI	Out of Queue
J147	60 MW	Wind	Chippewa County, MI	Out of Queue
J241	3.7 MW	Hydro	Florence County, WI	In Queue
J394	327 MW	Gas	Marquette County, MI	In Queue

We have completed studies of seven generation interconnection requests for the Zone 2 area in the last five years. Even though five of these requests are out of the MISO queue,

they have helped us build a base of knowledge similar to what we have in other zones related to likely generation interconnection impacts.

Zone 3
In Zone 3, generation has been proposed in various locations, but over half have been in the southern-most counties in Zone 3. Generation could be beneficial in a few areas depending on the capacity of such generation and the exact location.

Even with the on-going reinforcement plans for Dane County, smaller-scale generation in certain locations could be beneficial to improving the voltage profile in the area and potentially deferring transmission reinforcements. Stability analysis would need to be conducted to ensure stable operation of such generation.

Similarly, the southeast portion of Zone 3 is heavily loaded and will require transmission reinforcements in the future to ensure reliable operation. Small-scale generation in certain locations could be beneficial to changing power flow patterns and improving the voltage profile in the area. Generation studies completed in the southwest corner of the state have demonstrated that sighting large amounts of generation in rural areas may require substantial upgrades to the transmission system to ensure reliable operation.

The following table lists Zone 3 generator studies completed in the last five years.

Zone 3 completed generation studies:

Request	Size	Type	County, State	Status
J134	150 MW	Wind	Dane County, WI	Out of Queue
J217	50 MW	Wind	Columbia County, WI	Out of Queue
J384	21 MW	Gas	Dane County, WI	In Queue
J390	702 MW	Gas	Rock County, WI	In Queue
J395	98 MW	Wind	Lafayette County, WI	In Queue

Zone 4
Generation has been proposed in various locations in Zone 4. Generation could be beneficial in a few areas depending on the capacity of such generation and exact location. Given the nature of the issues in Zone 4, however, it is unlikely that new generation will significantly alter the need for the major transmission reinforcements contemplated in that zone.

One area where generation could defer the need for transmission reinforcements is in Door County, provided such generation is small-scale and appropriately located. Currently, the northern portion of the county is served radially, and electric service is subject to interruption for the loss of the single 69-kV line serving the area. The voltage profile in Door

County is projected to precipitate the need for reinforcements in the future. Small-scale generation potentially could defer certain of these reinforcements.

The following table lists Zone 4 generator studies completed in the last five years.

Zone 4 completed generation studies:

Request	Size	Type	County, State	Status
G427	98 MW	Wind	Fond du Lac County, WI	Out of Queue
J293	475 MW	Natural Gas	Outagamie County, WI	Out of Queue

Zone 5

Two major generation additions have been completed for Zone 5. The first addition is at Port Washington Power Plant, which was completed in June of 2008. In order to accommodate the two blocks of generation at Port Washington, the two Port Washington–Rangeline 138-kV lines and the three Port Washington–Saukville 138-kV lines were rebuilt in 2005 and the Saukville–Pleasant Valley–Arthur Road–St. Lawrence 138-kV line was rebuilt in 2007.

The other site of generation is the Oak Creek Power Plant. The first unit achieved Commercial Operation in December of 2009 and the second unit achieved Commercial Operation in January of 2011.

Studies of other proposed generation projects that are no longer in the generation queue indicate that additional generation in certain areas of Zone 5 would pose stability problems. In particular, larger-scale generation interconnecting to the 345-kV network could pose stability issues.

Smaller-scale generation in certain locations in Washington and Waukesha counties potentially could be accommodated without the need for transmission reinforcements if located appropriately.

No Zone 5 generator studies have been completed in the last five years.