Interconnection of Minnesota Distributed Generation

May 31, 2012

Meeting Notes

The meeting participants and agenda are listed at the end of these notes.

Bill Grant (DOC DER) welcomed participants and provided opening remarks. In 2003 and 2004, a very thorough stakeholder process, which many of our panelists today participated in, resulted in a set of comprehensive interconnection requirements, ordered by the Commission in September 2004. It's our understanding that the resulting interconnection documents have, for the most part, worked relatively well. We don't have set ideas of major changes in mind. Still, the world has changed in the last eight years and it is inevitable that some updating will be appropriate; for example, IEEE and UL standards have evolved, small wind standards have been developed, and FERC has developed a small generator interconnection process. Furthermore, the world will continue to change going forward; most significantly, continued maturation of technologies like solar PVs, and the corresponding dropping costs, will likely result in significant increases in the volume of DG interconnection requests in future years. Today's meeting is an initial technical conversation. We need to avoid direct discussion of open dockets. The objective today is to review and discuss the current MN DG interconnection process and requirements and identify areas for update and improvement with a focus on technical issues. What is working well? What could be improved? What process and requirements will be needed in the future? In the final session today we will discuss potential next steps. Again, we don't have set ideas on what these should be. We will be listening carefully to the discussion today and we are interested in thoughts on next steps. We anticipate that we may need to have some follow up discussions to further develop areas that are identified for update and improvement. Thank you.

Matt Schuerger (DOC DER) provided an overview the meeting agenda.

National Perspective on DG Interconnection

Michael Coddington (NREL) presented a national perspective on the interconnection of distributed generation including state policies (interconnection, RPS, net metering), US and MN electricity mix, characteristics of PV systems, DOE SunShot Initiative, PV trends, experience with high penetration of PV, and interconnection screens for PV system. Coddington's key suggestions included: Update interconnection rules to maintain safety, reliability, cost; Utilize best-practices to attract distributed generation. Participants discussed views on how to define a line segment.

Minnesota Distributed Generation Procedures

Lise Trudeau (DOC DER) presented an overview of the current Minnesota interconnection standards (http://www.puc.state.mn.us/portal/groups/public/documents/puc_pdf_orders/008982.pdf) including initial timeline (216B.1611 passed May 2001 directing PUC to establish interconnection standards for DG < 10 MW that is powered by renewable energy or natural gas), process (PUC Docket, Technical Standards Workgroup, Rates Workgroup), additional timeline (MN PUC Order 9/28/04 established standards, FERC Small Generator Interconnection Process May 2005), and document structure (process, requirements, application, and agreement).

The panel discussed the following questions:

- How is the process working? What is good and what could be better?
- How are the technical standards working? What is good and what could be better?
- What will be needed for process and requirements in the future?

Panelists: Steve Andrie (Minnesota Power), Shawn Bagley (Xcel Energy), Dirk Bierbaum (Rochester Public Utilities), Mike Coddington (NREL), John Dunlop (AWEA), Chuck Heins (Redwood Falls), Joel Limoges (Xcel Energy), Mike Michaud (Juhl Wind), Dean Pawlowski (Otter Tail), Kristi Robinson (Steele-Waseca), Larry Schedin (LLS Resources), Matt Schuerger (DOC DER), Michael Sheehan (IREC), Rafi Sohail (CenterPoint Energy), Lise Trudeau (DOC DER), Craig Turner (Dakota Electric), Cari Williamette (Westwood Professional Services)

Most DG projects to date in Minnesota have been smaller projects (<40kW) and most to date have not required an interconnection study; one utility noted that they are studying every proposal.

Utility panelists stated that the current Minnesota DG interconnection process is working well and that the requirements have held up well over time; Having a common set of technical standards that all of the Minnesota utilities use has worked smoothly, particularly for smaller projects. Challenges include: newer installers who do not have experience with the process; some of the larger projects can get complicated.

Stakeholder panelists agreed that, in many cases (e.g. standard small projects), the technical standards have worked well. Some challenges and concerns have come up on larger DG projects with regards to the length and uncertainty of time for an interconnection study, the amount and uncertainty of the cost of the study, and the allocation of the costs (between the developer and the utility) of any required system upgrades. It was noted that Xcel, in a recent rate case, agreed to provide firm study costs before the start of the study; Other utilities stated that they have been providing 'not to exceed' cost estimates up front which they then try to improve on during the study. Some panelists noted that study costs can vary quite a bit and that it's important to choose the right kind of studies for a particular project; IEEE 1547.7 will provide recommended practice on which studies are appropriate. It was

also noted that "pre-certified" is referenced in the Minnesota interconnection standards but is not defined. Some opportunity to streamline smaller system applications exists.

Challenges and concerns have also come up over some non-standard small projects. In some cases clearer and timely communication is needed regarding the interpretation and application of the requirements. Additionally, there have been some instances of different interpretations of the requirements between the utility and the local electrical inspector (e.g. for equipment that is not 'behind the fence' and is not UL-listed); Utility panelists indicated that this is rare.

It was noted that most DG projects to date in Minnesota have been smaller projects (< 40 kW), we do not yet have much experience with larger projects; it may be too early to assess how well the MN interconnection process is working for larger projects (>40 kW, up to several MW).

It was also noted that new small wind standards have been developed in recent years and that standards for smart grid interoperability are under development – the Minnesota DG interconnection process and requirements may need to be updated to incorporate these developments.

The panel discussed the definitions of distribution (i.e. facilities that are functioning as distribution) and transmission and how that affects jurisdictional issues between state distribution interconnection rules and federal (FERC) transmission interconnection rules. Another comment was that the Minnesota interconnection standards should be updated to reflect the changes (due to the development of MISO over the past decade) to the interaction between the state distribution system interconnection standards and the MISO transmission system requirements.

The panel also discussed process and the possible need for special considerations or requirements for storage / battery systems.

National Codes and Standards

<u>IEEE 1547, UL 1741, FERC Small Generator Interconnection Process</u>

Coddington presented an overview of national distributed generation codes and standards including Bulk System Guidelines (NERC, FERC, IEEE, ANSI, IEC, NESC), Distribution System Guidelines (IEEE 1547, PUC/PRC IEEE, ANSI, IEC NEC), small wind and PV inverter designs (designed to meet IEEE 1547, listed to UL 1741), IEEE standards and guides and recommended practices (published, under development), and the National Electric Safety Code (NESC).

The panel discussed the importance of the IEEE 1547 standards and the applicability to the Minnesota process and requirements. Approaches to anti-islanding were discussed. Dakota Electric (Craig Turner) noted that they have five systems that are designed to intentionally

island when necessary and use part of the Dakota Electric system when they do go into planned island mode.

Small Wind – Minnesota Interconnection Experience

Kristi Robinson (Steele-Waseca Cooperative Electric, SWCE) presented experience with interconnecting small wind generators including an overview of the SWCE system (~9800 services, ~2,000 miles of distribution line, peak system demand of 47 MW, DG capacity is 1.94% of peak load) and status of DG interconnections (currently 29 units, 914 kW interconnected – 21 asynchronous turbines, 35-39 kW each, 800 kW total; 6 inverter turbines, 10-20 kW each, 88 kW total; 3 inverter PV systems, 2-15 kW each, 26 kW total). Challenges include some inexperienced vendors, some experimental / untested generators, and significant penetration of DG on the system (two substations now have enough DG that power back feeds onto the 69 kV lines during low load and high wind). Steele-Waseca has investing in and deployed advanced metering (AMI) technology; An added benefit of the AMI is that it helps with engineering analysis of circuits with DG interconnected. The MN Technical Standards have worked well and provide the requirements and process to be able to maintain system safety and reliability. Key takeaways include the importance of educating owner/members and the need to treat all interconnection requests the same (i.e. everyone must follow the interconnection process and requirements).

The panel discussed issues related to the installation of small wind turbines in rural areas.

Small Wind – Standards and Certification

Trudeau presented standards and certification for small wind including standards NEC 694 (guidance for installation of wind turbines < 100 kW; added in the 2011 edition of the National Electric Code), UL 6142 (in development, expected to be issued in 2012; areas addressed will include utility interaction, routine and emergency disconnect, and control panels), and AWEA 9.1-2009 (covers turbines with a swept area < 200 m^2, about 50 kW; includes rated power, annual energy output, rated sound levels, refers to IEC 61400; organizations issuing certification to this standard includes the Small Wind Certification Council and Intertek). Other activities include the Interstate Turbine Advisory Council (ITAC) unified list of turbines for incentive programs and the North American Board of Certified Energy Practitioners (NABCEP). NREL is working with stakeholders to develop a certification program for wind resource site assessors.

The panel discussed options for incorporating these new small wind standards and certifications into the Minnesota interconnection process and requirements.

Small Generation Interconnection Process (< 40 kW)

Craig Turner (Dakota Electric Association) presented proposed Minnesota Standards for <40kW inverter systems (UL1741) including interconnection requirements goals (minimal technical requirements for the interconnection, ensure safety, minimize the possible damage to the electrical power system and other member's property, ensure proper operation), Minnesota DG Standards (covers all sizes of generation, large and technical, new installers can be overwhelmed by the size of the state document. Utility problem: many equipment suppliers – tough to tell what is good and safe, utility liability. UL 1741 (national test standard), provides a solid test for new equipment. Dakota Electric's inverter guide: DEA took the State interconnection requirements and created a set of documents for <40kW using a UL1741 certified inverter http://www.dakotaelectric.com/business/resources/renewable_energy_systems (Process is 5 pages vs 15, Technical is 15 pages vs 29). Current status and remaining issues: education needed for new installers on how the interconnection process works; education needed for customers on how net metering works. Turner also presented a draft comparison table of state, IEEE, and FERC interconnection standards and requested feedback.

The panel discussed issues related to the official status of the DEA small generator interconnection procedures. The panel also discussed some corrections to the DEA draft comparison table.

Michael Sheehan (IREC) presented DG screens and DG process flow including examples from Massachusetts and from Oregon. These states have incorporated screens and tiers that are based on the FERC Small Generator Interconnection Process (SGIP). In the FERC SGIP, the tiers carry throughout the interconnection process. The FERC SGIP and other key models (e.g. MADRI, Mid-Atlantic Demand Resource Initiative procedures) provide an expedited process for smaller projects.

The panel had an extensive discussion about the use of screens and tiers (similar to the FERC Small Generator Interconnection Process), how screens and tiers have been incorporated into other states (e.g. Massachusetts, Oregon), and how the use of screens and tiers relate, or could relate, to the Minnesota interconnection process.

The Minnesota DG interconnection process was adopted several years prior to the development of the FERC Small Generator Interconnection Process. The Minnesota process includes some language on tiers / screens from early drafts of the FERC SGIP but the final SGIP contained improved language.

NREL (Coddington) discussed recently published research work to improve screens for high penetrations of PV (NREL/DOE/Sandia/EPRI technical report: *Updating Interconnection Screens for PV System Integration*, http://www.nrel.gov/docs/fy12osti/54063.pdf).

Several utility panelists stated that the screen to identify situations where the amount of DG capacity on a line section exceeds 15% of the line section peak load (which then triggers the need for supplemental studies) has not been an issue because they don't yet have feeders with DG approaching that level. A notable exception, Steele-Waseca already has DG penetration

levels which exceed 15% on several feeders and is already doing interconnection studies for all new requests to interconnect to these line sections.

Both utility and stakeholder panelists noted that the shortage of complete load data (both peak and minimum loads) for line sections is a difficulty.

External Disconnect Switch

Coddington presented perspectives on and evaluation of the rationale for the utility accessible External Disconnect Switch (UAEDS) including external disconnect discussion points, focal points for utilities (safety, reliability, cost), PV system standards (IEEE 1547, UL 1741, National Electric Code), utility issues, utility line work practices (NESC, Manual of Safe Practice), UAEDS context, examples of utilities and states that have eliminated the UAEDS requirement, and conclusions and remarks.

The panel had an extensive and robust discussion of UAEDSs.

NREL and stakeholder panelists stated that many utilities and states have eliminated the requirement for a UAEDS for small projects (Tier 1) that are inverter based (i.e. expedited projects) and that Minnesota should consider this. Stakeholder panelists also stated that it can be difficult to meet the requirement of some Minnesota utilities that the UAEDS must be outside and must be within 10 feet of the customer meter (some customers have existing meters installed indoors).

Utility panelists strongly objected to elimination of the Minnesota requirement for a UAEDS on any projects noting the priority of keeping lineman safe under all conditions and circumstances with an accessible, lockable, visual open disconnect. Some nonutility stakeholders strongly suggested elimination of this requirement.

A key point that came up in discussion is that in many Minnesota DG installations (including small inverter based projects) the DC disconnect switch is not installed outside in a readily accessible location. If the DC disconnect switch was outside and readily accessible, then a lock could be applied there if necessary.

The panel discussed utility operating and line work practices as they relate to use of the UAEDS. NREL and stakeholder noted that if DG projects are required to pay for and install UAEDSs that utilities should be requiring the use of them in their practices and procedures.

Network Interconnections

Joel Limoges (Xcel Energy) presented network connected distributed generation including characteristics and design of secondary network systems, network protectors, protection requirements (IEEE 1547, UL 1741, Utility Grade relaying / IEEE C37.90), relaying (minimum load relay, comparative relay system, dynamically controlled inverter system), Standards (IEEE 1547-2003), Recommended Practice (IEEE 1547.6-2011), Network PV, and Xcel Energy Pilot Requirements:

- Additional protective relaying system is not required if:
- Minimum load > 20 times the generation nameplate as measured instantaneously (Requires previous 12 months of data. Subject to revocation)
- Protective relaying requirements:
  - -Minimum Load Relay (Minimum Import Relay, MIR)
    Trip the Generation instantaneously if generation rated output exceeds 25% of the actual service load
  - -Comparative relaying system
    Prevent the Generation output from exceeding 50% of the service demand
- Protective relaying systems proposed by customer and evaluated for approval by Xcel Energy
- All equipment providing relaying functions shall meet or exceed ANSI/IEEE Standards for protective relays, i.e. C37.90, C37.90.1 and C37.90.2
- Protective Devices and System per Tariff Section 10.

Stakeholder panelist response to Xcel's pilot requirements included the following points:

- Load data requirements: Xcel wants the absolute lowest instantaneous consumption for the building used for this. But most recording meters, including their own, only record 5 – 15 minute averages. So this information is usually not readily available. Also, the lowest consumption for most buildings occurs between 2 – 5 AM, not when the PV is producing, so this is a difficult option to accomplish.
- Protective relaying requirements: This is easiest to describe using some real numbers. If a building has a peak consumption of 200 kW, 25% of this would be 50 kW. A minimum load relay needs to be installed that would immediately disconnect the PV from the system if the building load were to ever fall below 150 kW (200 – 50 kw). But this disconnect would occur even if the PV was not producing at the time. As this is a manual reset device, it would have to have someone reset it every morning, as nighttime consumption would probably fall below the 150 kW. And if you have a really nice day, lots of production, but minimal HVAC loads, there is a good chance that the PV would bring the power draw from the utility to under the 150 kW mark, again disconnecting the PV.
- Comparative relaying system: Using the same building above, this option is more costly, as both the demand on the utility and the PV are monitored simultaneously. If the building demand is at 100 kW, the PV system would be permitted to produce up to 50% of the demand, or 50 kW. But the more the PV produces, the more it lowers the demand from the utility. So if my PV system is producing 49 kW, and the building demand is still 100 kW, while my comparative relay is still allowing for PV

production, we are actually only at 33%, as the building load would actually be the 100 kW from the utility + the 49 kW used internally from the PV.

- Relaying equipment standards: Many of the protective relays that fulfill this requirement meet IEEE standards, but have never been evaluated to UL standards, as they have commonly only been used by the utility industry in the past. When used in non-utility installations, UL is now an issue for the local electrical inspector.

Coddington presented interconnecting PV systems onto secondary network distribution systems including case studies of what other utilities are doing, network grid interconnection solutions (maintain minimum load, reverse power relays, minimum import relays, dynamically controlled inverters), and NREL technical report (*Photovoltaic Systems Interconnected onto Secondary Network Distribution Systems – Success systems,* http://www.nrel.gov/docs/fy09osti/45061.pdf)

The panel discussed challenges, opportunities, and requirements for interconnecting DG into network systems.

Next Steps

The meeting wrapped up with an open discussion of potential next steps.

The utility panelists were in agreement the current Minnesota DG interconnection process and requirements are working well. Stakeholder panelists noted that updating is needed to incorporate current standards and certifications and to incorporate more explicit tiers (e.g. clearer expedited process for small inverter based projects that meet current standards and testing and smaller wind turbines that meet newly developed national standards). Utility panelists indicated agreement that some updating may be appropriate but expressed concern about the difficulties of re-opening the entire process for DG interconnection. Several panelists noted that it may be possible to do some limited / target updating without re-opening the entire process (e.g. perhaps a small group could be convened to develop recommendations to the PUC for focused updating). It was also noted that most DG projects to date in Minnesota have been smaller projects (< 40 kW) and we do not yet have much experience with larger DG projects; it may be too early to assess how well the MN interconnection process is working for larger projects.

DOC DER thanked the group for their participation and outlined some next steps. The department doesn't have set ideas on what should happen next with the technical interconnection standards. We have been listening carefully to the discussion today and we will incorporate the ideas raised today into the initial DG assessment that we are doing over the next six months. We anticipate that we may need to have some follow up discussions with you to further develop areas that are identified for update and improvement.

Supplemental Information (follow up from participants in response to questions raised)

Several participants provided follow-up information in response to questions raised during the meeting.

From Craig Turner regarding examples of intentional islanding:

> As discussed at yesterday's meeting on distributed generation, Dakota Electric Association has several "campus" generation systems, where we island a portion of our 12.5kV distribution system on the member's generation. I wrote a paper for a local presentation many years ago about one of the installations. The installation in the paper is a Casino complex, including gas station, Muni wells and water towers, parking lots, hotels, stage, office tower and several transformers supplying the casino. The most recent installation is at the Minnesota State Zoo. We also have two merchant diesel generation systems, located at two of our substations, which can carry the entire substation loads and be manually islanded with the substation load. These were installed in 2001.

From Michael Sheehan regarding disconnect switched:

> 1. "SMUD Waives Switch Requirement for Solar Systems: Move Makes Solar Installations Easier." SMUD, Feb. 21, 2007. http://www.smud.org/news/releases/07archive/02_21solar.pdf
>
> 2. PG&E link: AC Disconnect Switches for Inverter-Based Generation
>
> 3. SDG&E (page 4 of 8) a. A description and location of the visible, lockable AC disconnect switch if present. Effective January 01, 2010 customers installing inverter-based systems will no longer be required to include an AC disconnect switch when the facility has a self-contained electric revenue meter (i.e., 0-320 amp socket-based meters or 400 amp K-based meters). This type of meter is used by the vast majority of all SDG&E customers.

Meeting Participants

Panelists

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Michael Sheehan (IREC)

Rafi Sohail (CenterPoint Energy)

Lise Trudeau (DOC DER)

Craig Turner (Dakota Electric)

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