MINNESOTA PUBLIC UTILITIES COMMISSION

16-521 Phase II Technical Subgroup In-Person Meeting

September 21, 2018 Meeting Summary

Attendance

Technical Subgroup (TSG) Members: John Dunlop (MNSEIA); Dean Pawlowski (Otter Tail Power); Brian Lydic (IREC); Laura Hannah (Fresh Energy); Craig Turner (Dakota Electric); Kevin McClean/Jenna Warmuth (MN Power); Kristi Robinson (MREA); Lise Trudeau (DOC); Patrick Dalton (Xcel); Mahmoud Kabalan (Unaffiliated)

Guests: Michael Coddington (NREL, in-person); By Web Meeting[1]: Brian Zavesky; Wes Pfaff; Hilal Katmale

PUC: Commissioner Matt Schuerger, Michelle Rosier, Cezar Panait, Pam Johnson (Solar Energy Innovator Fellow)

Power Quality in the TIIR

Adding Power Quality to the TSG discussion topics was flagged at the June DGWG meeting, but PUC staff needed more details on what specifically needed to be discussed. As a subset of Power quality, flicker issues associated with IEEE 1453 came up in Xcel Energy's Community Solar Gardens program, and the resolution appears to have addressed the concerns. A participant asked if issues related to the application of IEEE 1453, such as metering, measuring, and time series data, were still a concern. It was noted that getting the statistical flicker measurements (Pst and Plt (Perceptibility in short and long term) were named specifically) at the PCC prior to the installation of DER does continue to be a logistical challenge that also carries cost implications. With regards to the power quality of the interconnected power system, UL 1741 certification is typically sufficient; especially for residential systems; more likely to see challenges at the PCC for a group of DERs where design evaluation and consideration of impedance is needed. There was some debate whether to include rapid voltage change and flicker alone, or to also include harmonics considerations in the initial version of the Draft TIIR in work. TSG agrees to pursue confirming references, summarizing that DER should not contribute to over voltage, duplicating IEEE 1547-2018 Clause 7.2 in the TIIR, and pointing to (not citing), the balance of Clause 7 and Annex G from 1547-2018. TSG did not see a need to further discuss the issue.

[1] Due to technical difficulties, the web meeting did not have audio so participants could not observe the discussion.

Phase II Timing (Slides 6-8)

While the January 24, 2017 Order "anticipated" Phase II by February 2019, there is flexibility and TSG has flagged several outstanding issues: 1) MISO's bulk power system response for performance categories; 2) timing of IEEE 1547.1-2018 and associated UL 1741 update for inverter certification. TSG does not need to wait until 2020 or 2021 for UL 1741 equipment certified to IEEE 1547.1-2018 to be on the market to finalize the TIIR, but would benefit from more guidance in the 1547.1-2018 draft on testing and verification. TSG agreed with amending the timing of Phase II from Commission Action in Feb 2019 to sometime in 4th quarter of 2019. Additional time would be used by a writing subgroup (Xcel, IREC, MREA, DEA, and Fresh Energy) to attempt to resolve the outstanding edits based both on the red-lined Draft TIIR and the summary of TSG discussion to-date (captured in these notes and the 9/21 slide deck.) The writing group will share updated Draft TIIR sections with the TSG as completed or if an impasse results. Some topics may require additional TSG discussion before writing group tackles (ex. energy storage.) The utility Technical Standards Manuals (TSMs) may need to be developed in parallel to the Draft TIIR (see pg. 8 of this summary for more.)

TSG Member's Priorities for the Draft TIIR

Develop a document where we have areas of agreement so that utilities can go forward with a focus on the 90-99% of applications utilities are seeing today. Identify the edge cases and do that separately or in the future. Estimated that ¾ of the Draft TIIR could be agreed on by TSG fairly soon. Important areas that likely need much more effort: energy storage, non-export and limited export, solar + storage applications. Utility preference with regards to voltage-reactive power mode (i.e. volt-var mode) as the default reactive power control is to learn by doing with applications that go through full study, not fast track. A top priority is working out how capacity is defined and applied because that impacts everything else – the MN DIP 5.14 can be interpreted as an export limitation and that impacts progress on export in the Draft TIIR until resolved.

Interim Issue: Certification

For some TIIR topics, consider caveat of "contingent on the availability of UL 1741 certified equipment being available" focused on certification based on IEEE 1547/1547.1-2018/19 (1547.1 is expected to be published in 2019) as the source requirement document. TSG appeared to agree to require certification to IEEE 1547 (2003) in the interim while pointing to upcoming certification to 1547 (2018); however, there was an outstanding question on interim mutual agreement opportunities to utilize advanced inverter functions (i.e. 1547-2018-like capabilities in certified equipment under UL 1741 SA) that have not been tested to 1547.1-2018; including ride-through. Need to be clear if the interim allows for mutual agreement to specify UL 1741 certification with implementation of default settings found in IEEE 1547-2003 and IEEE 1547a-2014 (utility position) or UL1741 SA as an acceptable standard against which to certify without naming the specific SRD. UL1741 SA does include ride-through and category III capabilities (IREC position.)

TSG considered what it might look like to allow for reactive power control using a mode other than constant power factor, as well as what it might look like to allow for voltage-active power mode (volt-watt), under mutual agreement. An example from Hawaii was given of enabling Volt-Watt to avoid a transformer overload. Concern raised that such language invites disputes from DER that want to reduce interconnection costs and hold the perspective that volt-var is more effective than constant power factor; and utilities not seeing the benefit of Volt-Var compared to constant power factor with regards to avoiding distribution system upgrades. Xcel mentioned that they are currently doing some investigation of voltage regulation modes to address abnormal configurations (Hawaii example was based on system under normal conditions.) Xcel is proposing Volt-Watt to help with voltage (thermal is a different issue) which would allow utility to reduce output instead of completely disconnecting a larger DER (e.g. Community Solar Garden) during abnormal conditions.

STAFF NOTE: Limited research in Hawaii found by curtailing power through volt-watt, during the highest voltage week of the year, less power was curtailed than would have been if the PV systems were disconnected when V > 1.1 pu.[2]

Topics for Further TSG Development (Slides 11 – 14)

Staff updated the 9/21 TSG In-Person Meeting slide deck based on discussion (see Updated version attached to this summary.) The topics identified on the slides were from a review of the informal notes on the discussion in the seven previous TSG meetings, and do not necessarily capture the questions and edits that remain unresolved in the 9-14-18 Draft TIIR document. Both documents are meant to be a guide for future TSG work to reconcile the Draft TIIR.

Slide 11 (Performance Categories, Updating Settings, Protection Requirements)

- TSG was not convinced by an EPRI suggestion to footnote the performance category chart in case there are inverter-based technology unable to meet category B.[3] The draft TIIR has a provision to handle exceptions to performance category assignment via mutual agreement between the DER operator and Area EPS operator. IEEE 1547 Annex B Table B.1 suggests fuel cells may not be able to meet category B; but at least one TSG member has heard from fuel cell manufacturers that intend to meet category B III.

Slide 12 (Metering, Intentional Islanding, Local Communication Interface, Cyber Security)

- TSG discussed the challenges of establishing specific metering requirements (even for Simplified eligible projects) and the primary concern being a consideration for optimization of costs when borne by the DER customer. Concerns were raised about: 1) tariff specific metering requirements (e.g.. production meters for renewable energy credit tracking or future grid service compensation); 2) "least cost" being contentious, and "optimization" was better option to recognize cost considerations and transparency for the customer. In addition, there was a discussion of how utilities are approaching metering differently. For instance, Dakota Electric Association is considering disconnection at the production meter and Xcel Energy's continues to evaluate other means of communicating directly to devices capable of meter-grade accuracy (i.e. EV pilot). How energy storage is metered was an area of concern with the suggestion of a basic configuration that would work for net metering or non-exporting? Another concern was

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[2] Giraldez, Julieta and Hoke, Andy, HECO High-Impact Project: Voltage Regulation Operating Strategies (VROS) with Customer-Sited Resources. NREL, Hawai'I AITWG Call, 8/9/18, slides available online:

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the need to recognize utilities are in different places related to advanced metering infrastructure.

Lastly, the concept of a meter collar Fresh Energy proposed in follow up comments to TSG Meeting #6 was raised as an option to replace the supply-side connection, typically for residential systems. Xcel saw it in use inCalifonia, evaluated it and decided not to use it (Patrick is following up to provide more details). Dakota Electric allows for double-lugging, but would need to know more due to concerns that if there were a need to disconnect the DER that could result in disconnecting the entire home. Department of Energy funded some of the development of the meter collar to reduce DER costs, and the collar has overcurrent protection in it according to Michael Coddington.

- TSG clarified the focus of intentional islanding was for the Local EPS. DER islands are allowed and the TIIR should point to the provision in IEEE 1547 on what the DER is required to do. Several TSG members (IREC, Xcel and Prof. Kabalan) have some language to propose.
- TSG appears comfortable with no additional edits or work on the local communication interface.

Slide 13 (Energy Storage System Operational Control Modes)

- TSG discussed that IEEE 1547 considers parallel operation related to discharge state only; although there are additional requirements in terms of the transition to the charging state. The definition of DER (in 1547 and TIIR) says load is not included; so, charging is not covered in DER. TSG agreed this would be good to clarify in the TIIR.
- TSG discussed current policy of a utility requiring a password, available to the installer but not the customer, to lock ESS operational control modes described in an operating agreement. Some wondered why the operating agreement was not sufficient; while others asked what recourse was available if the DER is operated in another mode without the utility's consent. STAFF NOTE: Adverse Operating Effects (MN DIA 3.4.4) and a Material Modification of the DER without utility written authorization (MN DIA 3.4.5) can result in disconnection (MN DIP Att. 2 Simplified Application, 5.0.) One caveat was an approved local EPS island should be able to change ESS operational control modes when islanded from the Area EPS.
- Operating agreements and password protection have been a part of the UL 1741 CRD discussion., A specific example of concern named for the power system was frequency regulation mode – going from full charge mode to full discharge mode quickly or pulsing the charge. It may be helpful to delineate the modes that are of most concern, and see if they apply to ISO or utility uses versus residential applications. Staff noted the chart on back up slide 37 "Understanding ESS Control Modes and Use Cases/Applications" may be a useful tool.

Slide 14 (Non-Exporting, Testing)

- Draft 7 on IEEE 1547.1 on testing and verification recently came out in preparation for meetings scheduled for October 5-6. Participants will provide update at the next TSG meeting (Oct 19.)

Capacity – A Path Forward (Slides 15-24)

MN DIP 5.14 recognizes a DER's capacity may be either aggregate nameplate rating or as currently defined at 5.14.3: "maximum capacity that the DER(s) is capable of injecting into the Area EPS Operator's electric system is limited (e.g. through use of a control system, power relay(s), or other similar device settings or adjustments." The Commission referred further clarification of MN DIP 5.14.3 to the technical subgroup after it became clear that DGWG participants had different concepts of what this might include.[4] The TSG spent much of the July 20th and August 3rd TSG meetings (TSG Mtgs 4-5) on this topic, but had not resolved a path forward. Commission staff proposed at this meeting a path forward based on the input received to-date (see slides 16-21). Staff and members of the TSG agree a path forward on capacity is necessary to resolve some of the other outstanding draft TIIR edits. TSG members may not be in agreement with this path forward, and are encouraged to raise specific concerns with this approach as we continue and, if they wish, argue for an alternative approach before the full Commission.

How to measure Aggregate Nameplate Rating in kWac

The TSG was in agreement that a DER's aggregate nameplate rating in kWac is the inverter's/s' maximum power AC rating. It is common for larger DERs to have a 1.2 dc to 1 ac rating. In rare instances, inverters can produce more than the nameplate rating. UL will allow 10% oversizing on the ac side of an inverter – if the maximum ac rating is a current limit instead of a real power limit – power can be produced at up to 110% of what is rated depending on the inverter's specifications. It was noted that this concern does apply in MN in the situation where a system has a current limited inverter, since the voltage contribution of power production can increase significantly on cold, sunny days. Utilities also use inverter ac rating in interconnection technical review when the dc panels behind the inverter are undersized. Most utilities are not monitoring individual systems' output[5], but one utility representative reported they will put on hold the DER customer's net metering compensation if it is exceeding the net metering limit until the issue is addressed.

The Role of Capacity and Export in the Interconnection Process

Staff summarized TSG discussion to-date as suggesting the path forward:

1) The aggregate nameplate rating will be used for process track eligibility and short circuit current analysis;
2) The limit value will be used for steady state aspects of technical review.

TSG discussed perspectives on using the limit rather than Aggregate Nameplate Rating for process track eligibility for at least the Simplified Process. The proponents are most concerned about the impacts on solar + storage applications of using aggregate nameplate for storage that isn't tied to the same inverter as the solar. According to one TSG participant, the average Solar*Rewards (production-based incentive) application is 16 kW solar.

With a PV system of that size, it is likely AC-coupled storage, implying 2 inverters minimum, would not be eligible for Simplified Process if Aggregate Nameplate Rating determines process eligibility (DC-coupled storage would keep the project Simplified eligible.) Solar*Rewards tariff requires a production meter, so whether the storage is DC or AC-coupled should not impact the utility's ability to measure solar production. Another TSG participant argued residential peak load is typically around 5 kVa, so the

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[4] August 13, 2018 Order (E999/CI-16-521), p. 7-9.

[5] Xcel response after meeting: Xcel is monitoring output on all Community Solar Gardens greater than or equal to 250 kW using cellular telemetry.

20 kW size threshold for Simplified Process should cover solar + storage residential applications (the larger Solar*Rewards projects are likely small commercial or farm applications.) For those that do exceed the Simplified Process threshold, the Fast Track Process has a slightly longer timeline and applies to all inverter-based, certified DER up to 500 kW and some up to 5 MW depending on location and line size. Fast Track includes the same initial review screens as the Simplified process and allows for supplemental review as necessary. The performance of the Simplified and Fast Track Processes are something that can be evaluated over time to make sure it is working for all parties.

There was additional discussion about why the DER capacity limit was not limited- or no- export which has been a primary area of disagreement for the group in both Phase I and II. The MN DIP initial review screens (MN DIP 3.2) are not the same screens as are used in states that consider non-export. Utilities are concerned with how load is considered when an export limit is provided, and initially intended non-exporting systems to apply for other program tariff compliance (e.g. net metering integrity). UL 1741 CRD is currently being drafted and may offer a future path for certified DER systems with an export limit; however, at this point it has not been released. Also noted that a CRD is an attestation that begins the UL process to become a UL standard, which then creates the standard which can be leveraged for certification. The CRD began in UL 1741, but applies to more than inverters; for instance, the safety of breaker panels. Utility staff doing process track determination may not be technical staff, so certification option to add to a checklist would be the best option in the future.

Capacity and MN DIP 5.14.3

Staff highlighted EPRI's proposal that the limit to a DER's capacity could be captured in its configuration settings (IEEE 1547 Clause 10.4). Both Xcel Energy and IREC noted this was too restrictive of a definition, and the TSG agreed the limit referenced in 5.14 could be either: nameplate alternative configuration setting, alternative certification (e.g. UL 1741 CRD) or mutual agreement as provided in the Interconnection Agreement.

Path forward on Capacity and MN DIP 5.14.3

The path forward discussed at this meeting could be summarized as:

The limit referenced in 5.14.1 and 5.14.3 shall be the nameplate alternative configuration setting, alternate certification or mutual agreement as provided in the Interconnection Agreement.

- The aggregate nameplate rating will be used for process track eligibility and short circuit current analysis.
- The limit will be used for steady state aspects of technical review.

STAFF NOTE: At October 19 TSG Meeting #8, the TSG discussed how load would be considered if the language above was the only clarification offered to 5.14.3 (whether offered in the MN DIP or the TIIR.) Utilities raised ongoing concern that existing MN DIP 5.14.3 appears to consider export (with load included) as capacity which, as described above, does not work with the MN DIP technical review screens as written. Further, an alternate certification of a limit (e.g. a breaker) may not be exclusive of load. The Control Limited Capacity definition offered by Xcel Energy at the October 19th TSG meeting raised questions regarding the use of "point of interconnection" instead of "point of DER connection."

Per MN DIP 5.14.1, "The maximum capacity of a Distributed Energy Resource shall be the Aggregate Nameplate Rating or may be limited as described in 5.14.3." Staff understand the following edit to MN DIP 5.14.3 to capture utility concerns with treating export as capacity; however, it does not necessarily address load within a DER (e.g. a DER with certified equipment that serves as the DER's capacity limit at a point other than the Point of DER connection) except that it requires Area EPS agreement:

MN DIP 5.14.3:

> ~~The Interconnection Application shall use the maximum AC capacity, that the DER(s) is capable of injecting into the Area EPS Operator's electric system over a sustained time which may be limited.~~ If the maximum capacity of the ~~that the~~ DER~~(s) is capable of injecting into the Area EPS Operator's electric system~~ is limited (e.g., through use of a control system, power relay(s), or other similar device settings or adjustments), then the Interconnection Customer must obtain the Area EPS Operator's agreement that the manner in which the Interconnection Customer proposes to implement such a limit will effectively limit active power output so as to not adversely affect the safety and reliability of the Area EPS Operator's system. Such agreement shall not to be unreasonably withheld. If the Area EPS Operator does not so agree, then the Interconnection Application must be withdrawn or revised. ~~to specify the maximum capacity that the DER is capable of injecting into the Area EPS Operator's electric system without such limitations.~~ Nothing in this section shall prevent an Area EPS Operator from considering an output higher than the limited output (e.g. ~~a~~ Aggregate Nameplate Rating), if the limitations do not provide adequate assurance, when evaluating system impacts. See Minnesota Technical Requirements for more detail.

The TSG could decide if an edit to MN DIP 5.14.3 would be useful, and if that edit should provide additional detail outlined in the 9/21 meeting about what the limit is and how it applies in the MN DIP or if a definition is necessary given the Draft TIIR will not be finalized in time for the MN DIP effective date (June 17, 2019).

Enabling Voltage Regulation Functions (Slides 25-27)

The TSG discussed voltage regulation power modes at TSG Meeting #3. The draft TIIR proposes a constant power factor of .98; however, the TSG identified five instances where being able to instead enable voltage-reactive power mode (Volt-Var) to utilize advanced inverter functions may be desired.

- Larger DER systems using the detailed Study Process (not Fast Track)
- Utility discretion or consideration
- When required communication is enabled
- Under mutual agreement
- Future TIIR consideration based on studies, pilots, national learnings or revisit the question on a future date.

One of the ongoing questions the TSG has addressed is what level of detail copied from IEEE 1547 into the TIIR is useful or necessary for transparency versus incomplete and at risk of misinforming the reader (out of date, not utility specific, etc.)

Slide 26: Enabling Voltage-Reactive Power Mode

Some on the TSG wanted more time to consider what specifically should be included. Of specific concern for Volt-Var was that the allowable range of settings for reactive power may not be constrained in IEEE 1547, so this was referred to the writing subgroup. If the IEEE 1547 table is included, it should be labeled as a reference to the standard and the default settings for a given utility may be more specific. May be better to reference the TSM and include some of the table there where the utility could note the default settings it uses.

Slide 27: Enabling Voltage-Active Power Mode (Volt-Watt)

Volt-Watt was discussed in detail at TSG Meeting 3. Volt-Watt is able to remain active with any of the reactive power control functions (e.g. Constant Power Factor mode and Voltage-Reactive Power mode). Voltage-Active Power mode default is disabled in IEEE 1547 5.4.1; however, the TSG discussed enabling Voltage-Active Power mode for future proofing with the default setting not beginning to curtail real power until the voltage is beyond 1.06 per unit voltage – above the upper end of the range of normal voltages allowed under ANSI C84.1 Range A. However, voltage can be a localized issue and is not limited to emergency or abnormal conditions. Some have proposed including consumer protection language or clarifying the intent of using Volt-Watt – not creating a new complaint process, perhaps referring to MN DIP 5.3 on Disputes. One challenge is determining what is triggering the Volt-Watt because a utility may be within the ANSI range, but the impedance in the customer's system could be activating Volt-Watt. One person suggested pointing out the difference between utility vs developer/designer caused issues. Perhaps the TSM could outline how the utility or DER would test to demonstrate causality? California has been collecting data on the impacts of enabling Volt-Watt on DER real power production which may be informative.

Scope of the Statewide Technical Interconnection and Interoperability Requirements (TIIR) (Slides 29-30)

Slide 29: Scope of Statewide TIIR

Thirteen topics were identified as in scope and have been the basis for the TSG meeting topics (see slide 29.) One additional topic should be added: Intentional Local EPS Islanding. Additionally, four overarching topics were identified by some TSG participants as within scope: consumer protection; reporting; requirements related to other tariff requirements/restrictions; and additional details for Simplified Process eligible systems on metering, testing, etc. The bolded items on the slide have not yet been fully discussed or resolved. Discussion focused on what should be said about technical requirements related to tariff requirements. The Commission and DGWG's goal has been to move as much of the interconnection-specific requirements into the statewide interconnection standards; however, there are instances where program tariffs have additional requirements (ex. production meters for Renewable Energy Credit accounting or production-based incentives.) Net Energy Metering (NEM) integrity was another example raised with discussion of DC charging, non-export storage, or recognizing a system could use controls to limit charging. IREC and others? are working on language they will share with the writing group. Staff flagged the need to check if it was appropriate to address

NEM integrity in the technical requirements or if there are policy considerations that should be addressed in the NEM tariffs.

Slide 30: Out of scope for the TIIR

The first three topics on the slide are addressed in the MN DIP. There was no additional discussion on this slide.

Scope of the Utility Technical Standard Manuals (Slide 31)

Scope of the Utility TSM is not defined in the draft TIIR. Slide 31 captures what has been offered as in the scope of the TSM over the course of the TSG meetings. Including an outline of what is included in a utility TSM may help alleviate some non-utility concerns about additional, unwarranted interconnection requirements. Utilities stated their goal is if all utilities are saying the same thing in their TSM moving it to the TIIR; however, some details are utility specific (see list on slide).

Another ongoing concern is what oversight there is for the TSMs. The Draft TIIR proposal is the TSM is publicly available on the utility's webpage and an annual informational filing with the Commission, but not subject to Commission review or approval. The TSG did not discuss how TSM disputes may be handled or unique from TIIR disputes under MN DIP 5.3.

Next Steps

Oct 3	Reply Comments re: Att. 6: Rates?
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7
Nov 13	Otter Tail Power, Minnesota Power, Dakota Electric Phase I tariff filings
Dec 28	Xcel Energy Phase I tariff filing
~Jan - Mar	Commission Review and Approval Rate-regulated Phase I tariff filings
Jun 17, 2019	Effective Date of the MN DIP and MN DIA

TSG writing group will be Patrick Dalton (Xcel), Laura Hannah (Fresh Energy), Brian Lydic (IREC), Kristi Robinson (MREA), Craig Turner (DEA). The writing group will have until 2nd quarter of 2019 (April 2019) to attempt to reconcile the TSG edits to the Draft TIIR and should proceed in a way that allows full participation of the writing group members. Staff began to untangle track changes edits and can make that document available to the writing group. The writing group should use this meeting summary and corrected slides to advance the editing process, and are encouraged to share progress with the full TSG as TIIR sections are proposed as resolved. If the writing group is unable to resolve a topic, they should attempt to clarify the proposals and why the group remains unresolved. Staff imagines Energy Storage System Operational Control modes may be an example the full TSG needs to discuss further for progress in the edits.