Updating Minnesota's Interconnection Standards

Proposed Phase II Plan

Scope

Update or replace the Minnesota's existing interconnection technical requirements (Attachment 2 Technical Requirements in the Commission's September 28, 2004 Order in Docket No. E-999/CI-01-1023) consistent with local and national standards, including the newly revised IEEE 1547, and best practices using the outline described below.

Working Document

Red-lined version of "Regulated Utilities" Technical Interconnection and Interoperability Requirements (TIIR)

Additional Materials

i) Xcel Energy NSPM Electric Energy Storage Interconnection Guidelines (V1.0, 6 Nov 2017)
ii) Participants' Materials and the Meeting Summary for DGWG Meeting #5 (November 3, 2017) related to storage and non-exporting (Energy Freedom Coalition for America, Joint Movants, Xcel Energy)
iii) California Utilities' energy storage interconnection guidelines
iv) California Rule 21
v) Hawaiian Electrics Rule 14
vi) Massachusetts Technical Review Group
    (1) Massachusetts' 2017 Common Technical Standards Manual
vii) New York Interconnection Technical Working Group

Technical Subgroup Schedule

All Technical Subgroup Meetings are 9:30am – 12:30pm CST. Full DGWG Meetings are 9am – 2:30pm.

Date	Topic	Outcome	Prep Work
3/23/18	Meeting 1 Scope/Overview** (Walk-through with explanations: Red-lined TIIR; List of topics in scope of TSMs; Definitions	1) Red-lined TIIR 2) Details on utility TSMs 3) List of Definitions to address	Subgroup members provide proposals and citations to examples, where applicable, to staff by 3/16/18: 1) Red-lined/track changes draft of TIIR; 2) List of topics with summary/examples of content considered in scope of a utility TSM 3) Definitions that need to be discussed

4/13/18	Meeting 2 Performance Categories**; Response to abnormal conditions; MISO Bulk Power System Overview	1) Discuss Performance Categories	
5/18/18	Meeting 3 Reactive Power and Voltage/Power Control Performance**; Protection Requirements		
6/1/18	Full DGWG Meeting Technical Subgroup update; Phase I Update/Next Steps		
6/8/18	Meeting 4 Energy Storage; Non-Export and Inadvertent Export**		
7/20/18	Meeting 5 Interoperability** (Monitor and Control Criteria); Metering**; cyber security		
8/10/18	Meeting 6 Test and Verification**; Witness Test Protocol		
9/14/18	Meeting 7 References; Definitions*; 1-line diagram requirements; Agreements*		
9/21/18	Full DGWG Meeting 2		

Sections in existing MN Technical Requirements	***Sections in IEEE 1547 Revision***	***Technical Interconnection and Interoperability Requirements (Regulated Utilities' Proposal)***
1) Definitions	Clause 3. Definitions and Acronyms	Ch. 3: Definitions and Acronyms Annex B: Clarifications on RPA, PCC, POC, Supplemental devices
2) References	Clause 2. Normative References Annex A Annex D.5, Related Standards	Ch 2: References Annex A: links to utility TSMs
3) Types of Interconnections	Annex B. Guidelines for DER Performance Categories/ Attribute Groupings Storage Non-exporting Parallel Operation	Ch 4: Performance Categories Ch. 10: Energy Storage Ch. 11: Non-exporting and Inadvertent Export
4) Interconnection Issues and Technical Requirements	Clause 4. General Interconnection Technical Specification and Performance Requirements Clause 5. Reactive Power and Voltage Control Clause 7. Power Quality	Ch. 5: Reactive Power Capability and Voltage/Power Control Performance
5) Metering, Monitoring and Control	Clause 10. Interoperability, Monitoring, Control Annex D, DER Communication, Information Guidelines, Network and Cyber Security	Ch. 8: Metering Ch. 9: Interoperability
6) Protective Devices and Systems	Clause 6. Response to Area EPS Abnormal Conditions Clause 8. Islanding Clause 9. DER on Distribution Secondary Grid/Area/Grid Networks and Spot Networks Annex C, DER Intentional and Microgrid Island Configurations Annex E, Ride-Though of Voltage Disturbances, Faults, Protection, Reclosing	Ch 6: Response to Abnormal Conditions Ch. 7: Protection Requirements

7) Agreements	*Operating agreement* *Maintenance agreement*	Ch. 13: Agreements
8) Testing Requirements	Clause 11. Test and Verification Requirements Annex F, Testing and Verification Requirements at PCC or PoC	Ch. 12: Test and Verification Requirements

The following standards and guidelines/guidance will also be considered:

UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use in Distributed Energy Resources (2010)[1] (Including UL 1741 Supplemental A (SA) Advanced Inverters)

NFPA 70 (2017), National Electrical Code

National Electrical Safety Code (ANSI C2-2017)

ANSI C84.1-(2016) Electric Power Systems and Equipment – Voltage Ratings (60 Hertz)

NEMA MG 1-2016, Motors and Generators

IEEE 1547.1 – 2005 Standard Conformance Test Procedures for Equipment Interconnection Distributed Resources with Electric Power Systems (including IEEE 1547.1a Amendment 1)[2]

IEEE 1547.2-2008 Application Guide for IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems

IEEE 1547.3-2007 Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems

IEEE 1547.4-2011 Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems

IEEE 1547.6-2011 Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks

IEEE 1547.7-2013 Guide for Conducting Distribution Impact Studies for Distributed Resources Interconnections

IEEE P1547.8 Draft Recommended Practice for Establishing Methods and Procedures that Provide Supplemental Support for Implementation Strategies for Expanded Use of IEEE Standard 1547

[3,4] Following the finalization of the IEEE 1547 revision, IEEE 1547.1 will be revised to update testing procedures; as will UL 1741. The Commission and members of the DGWG are monitoring this issue and will consider the revised standards when they become available (IEEE 1547.1 is anticipated in Spring 2019, and UL certification will happen after that.)

IEEE C37.90-2005 IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus

IEEE Std C37.90.1(2012) (Revision of IEEE Std C37.90.1-2002), IEEE Standard for Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems Associated with Electric Power Apparatus

IEEE Std C37.90.2 (2004) (Revision of IEEE Std C37.90.2-1995), IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers

IEEE C37.95-2014 Guide for Protective Relaying of Utility-Consumer Interconnections

IEEE C37.108-2002, IEEE Guide for the Protection of Network Transformers

IEEE C57.12.44-2014, IEEE Standard Requirements for Secondary Network Protectors

IEEE C57.32-2015 Standard for Requirements, Terminology, and Test Procedures for Neutral Grounding Devices

IEEE Std C62.41.2-2002, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000V and Less) AC Power Circuits

IEEE Std C62.41.2-2002 Cor 1-2012 (Corrigendum to IEEE Std C62.41.2-2002) - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits Corrigendum 1: Deletion of Table A.2 and Associated Text

IEEE C62.42-2005 Guide for the Application of Component Surge-Protective Devices for Use in Low-Voltage (1000 V and less) AC Circuits

IEEE C62.45-2002, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits

IEEE C62.92.2-2017 Guide for the Application of Neutral Grounding in Electrical Utility Systems, Part II – Synchronous Generator Systems

IEEE Standards Dictionary Online, [Online].

IEEE 141-1993 Recommended Practice for Electric Power Distribution for Industrial Plants (141-1993 Errata)

IEEE 142-2007 Recommended Practice for Grounding of Industrial and Commercial Power Systems

IEEE 242-2001 Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book) (242-2001 Errata)

IEEE 446-1995 Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications

IEEE 519-2014, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

IEEE 1453-2015 Recommended Practices for the Analysis of Fluctuating Installations on the Power Systems

Technical Requirements Subgroup

The Technical Requirements Subgroup will be comprised of utility and non-utility individuals with technical electric and power system engineering expertise. The Technical Requirements Subgroup will work over email and web conference to draft the technical requirements document to replace Attachment 2 Technical Requirements in the Commission's September 28, 2004 Order in Docket No. E-999/CI-01-1023.

Jeff Schoenecker/Craig Turner, Dakota Electric	Robert Jagusch, MMUA	Patrick Dalton/John Harlander/Alan Urban, Xcel Energy
Lise Trudeau, Dept of Commerce	Kevin McLean/Jenna Warmuth, MN Power	Natalie McIntire/TBD, Wind on the Wires
Mike McCarty/Katie Bell, EFCA	Kristi Robinson, MREA	John Dunlop/Chris Jarosch, MNSEIA
Brian Lydic/Sky Stanfield/Laura Hannah – Joint Movants	Dean Pawlowski, Otter Tail Power	Commissioner Matt Schuerger; Michelle Rosier; Cezar Panait
Tam Kemabonta/Professor Mahmoud Kabalan, St. Thomas Affiliation		Technical Assistance*: Michael Coddington and Michael Ingram, National Renewable Energy Laboratory Tom Key, Jens Boemer, Nadav Enbar; Electric Power Research Institute Possibly DOE Solar Energy Innovator Fellow

*****Technical assistance is not a participant or party to the docket and does not advocate for specific outcomes in the proceeding. The role of technical assistance is to support Commission staff in the process for these proceedings, and to provide an objective source of information or data, as requested, by Commission staff to understand areas of disagreement amongst participants.

<u>Anticipated Timeline</u>

The Commission's January 24, 2017 Order in the instant docket noted anticipation that the technical requirements would be considered within 24 months of the Order. The expectation is all Distributed Generation Workgroup Participants from Phase I and Technical Subgroup members participate in the educational In-Person and webinars on the standards under consideration (1Q-2Q 2018) and DGWG In-Person Meetings listed below.

In Person Meetings	Webinars/Working WebEx
	January X TBD Review of standards to be considered
March 12, 2018 8am – 4:30pm IEEE 1547 Workshop	*TBD* EPRI Webcast on IEEE 1547; including Annex B and Distribution considerations

David Narang, NREL, Section Manager, Applied Power Systems – Distributed Energy Systems Integration Group – IEEE 1547 Chair Bob Cummings, NERC, Senior Director of Engineering and Reliability Initiatives Ravi Subramaniam, IEEE, Technical Director, ICAP Jens Boemer, EPRI	
June 1, 2018– Full DGWG In Person Meeting Topics: Review Technical Subgroup progess; Compensation and consumer protection issues	March 16, 2018 (first webex meeting of subgroup) – September 2018– Technical Subgroup Web Conferences – monthly or bimonthly as needed. Assignment follow up over email between the meetings. Fridays 9:30am – 12:30pm CST: March 16; April 20; May 18; June 8; July 13; Aug 10; Sept 14
September 28, 2018 – Full DGWG In Person Meeting re: Preview Technical Subgroup's Draft Technical Requirements Language	October 5, 2018 – Webex Follow up Discussion on Draft Language

Dec 2017 – Oct 2018 (tent)	Phase II Notice for comment; workgroup meetings; conference calls
December 15 - Jan 29	Notice for Comment on Phase II Scope, Plan, DEA proposed Technical Requirements as starting draft
1Q 2018	IEEE 1547 Workshop with IEEE
2Q 2018 (Tentative)	Final approval of new IEEE 1547 standard
Feb – Apr 2018	Comment Period on Phase I Recs/Standards Language
May 2018 (Tentative)	PUC Agenda Meeting re: Phase I
Sept/Oct 2018 (Tentative)	Public Utilities file for Commission approval; Cooperative and Municipal Utilities adopt updated tariffs re: Phase I
Nov 2018 (Tentative)	Notice for Comment on draft staff Phase 2 summary and recommendations
Nov/Dec 2018 (Tentative)	Comment period on public utility Phase I tariff revisions
Feb 2019 (Tentative)	PUC Agenda meeting for consideration and decision on new Interconnection Technical Requirements (Phase II)
April/May 2019 (Tentative)	Final approval of new IEEE 1547.1 testing requirements

PREP WORK

Subgroup members review agenda and provide the following to staff by 3/16/18 (If providing slides, final slides due 3/21/18):

1) If you do not support the Regulated Utilities' Draft Proposal, a proposed discussion topic outline or red-lined/track changes draft of Regulated Utilities' TIIR proposal;
    a. Include a description of the purpose/role of the statewide technical requirements
2) Rationale and list of topics with summary/examples of content considered in scope of a utility TSM
3) List of definitions that need to be discussed
4) Review the proposed Phase II Agenda/Topics for 7 meetings (attached)

Technical Subgroup Meeting 1 DRAFT AGENDA
Friday, March 23rd
9:30am – 12:30pm

WebEx: https://global.gotomeeting.com/join/432598661
Dial in option (webex preferred): 1-571-317-3112; 432-598-661#

1) Introductions – 15 mins
    a. Welcome and Subgroup Expectations

2) Discussion: What is the purpose/role of the statewide technical requirements? – 15 mins

3) What's in and out of scope for statewide technical requirements document? – 2 hours
    a) Regulated Utilities' TIIR Draft Proposal – Regulated Utilities Representative(s) – 25 mins
    b) Proposed discussion topics or changes related to the Regulated Utilities Draft Proposal – Others – 25 mins
    c) List of topics with rationale and summary/examples of content proposed for utility specific TSMs. What level of transparency and approval is appropriate and why? – Utilities – 20 mins; Non-Utilities – 20 mins.
    d) Discussion/Questions – 30 mins

4) Inventory of Definitions we need to address in future meetings – 5 mins

5) Check in on the Phase II Outline – Agendas/Topics for 7 meetings – any changes? – 15 mins

6) Next Steps/Homework – 10 mins

First GoToMeeting? Do a quick system check: https://link.gotomeeting.com/system-check

Phase II Technical Subgroup Roster:

Jeff Schoenecker/Craig Turner, Dakota Electric	Robert Jagusch, MMUA	Patrick Dalton/John Harlander/Alan Urban, Xcel Energy
Lise Trudeau, Dept of Commerce	Kevin McLean, MN Power	Natalie McIntire/TBD, Wind on the Wires
Mike McCarty/Katie Bell, EFCA	Kristi Robinson, MREA	John Dunlop/Chris Jarosch, MNSEIA
Brian Lydic/Sky Stanfield/Laura Hannah – Joint Movants	Dean Pawlowski, Otter Tail Power	Commissioner Matt Schuerger; Michelle Rosier; Cezar Panait
Tam Kemabonta/Professor Mahmoud Kabalan, St. Thomas Affiliation		Technical Assistance*: Michael Coddington and Michael Ingram, National Renewable Energy Laboratory Tom Key, Jens Boemer, Nadav Enbar; Electric Power Research Institute Possible DOE Solar Energy Innovator Fellow

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Draft Meeting Topics Proposal:

Date	**Topic**
3/23/18	Meeting 1 Scope/Overview** (Walk-through with explanations: Red-lined TIIR; List of topics in scope of TSMs; Definitions
4/13/18	Meeting 2 Performance Categories**; Response to abnormal conditions; MISO Bulk Power System
5/18/18	Meeting 3 Reactive Power and Voltage/Power Control Performance**; Protection Requirements
6/1/18	Full DGWG Meeting Technical Subgroup update; Phase I Update/Next Steps
6/8/18	Meeting 4 Energy Storage**; Non-Export and Inadvertent Export**
7/20/18	Meeting 5 Interoperability** (Monitor and Control Criteria); Metering**; cyber security
8/10/18	Meeting 6 Test and Verification**; Witness Test Protocol
9/14/18	Meeting 7 References; Definitions*; 1-line diagram requirements; Agreements*
9/21/18	Full DGWG Meeting 2

Phase II Technical Subgroup Meeting #1

November 3, 2017

(Docket No. 16-521)

MINNESOTA PUBLIC UTILITIES COMMISSION

https://mn.gov/puc

Agenda

Time	Topic
9:30 - 9:45	Welcome, Introductions, Overview of Agenda, Expectations
9:45 – 10:05	Check in on Phase II Outline & Feedback on IEEE 1547 Workshop
10:05 – 10:20	Discussion: Purpose/role of statewide technical requirements
10:20 – 12:15	Scope of the Statewide TIIR & Role of Technical Standards Manual
12:15 – 12:20	Inventory of Definitions to Discuss
12:20 – 12:30	Meeting Evaluation & Next Steps

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

DG Workgroup Charge & Process

1) Prepare for and attend the meetings and conference calls consistently throughout each phase;

2) Engage actively and respectfully in constructive dialogue during the issue discussions;

3) Review in a timely manner workgroup materials distributed by Commission staff provided via workgroup listserv or e-dockets;

4) Develop, when invited, as an organization or a member of an ad hoc subgroup, presentations and/or subtopic materials for consideration by the workgroup at upcoming meetings; and,

5) Work toward agreement where possible and, where not possible, clearly articulate differences.

(February 14, 2017 Notice, Docket No. 16-521)

DG Workgroup Charge & Process

- Treat each other, the organizations represented on the workgroup, the staff, and the workgroup itself with respect and consideration;
- Express fundamental interests rather than fixed positions. Be honest and tactful. Avoid surprises. Encourage candid, frank discussions.
- Ask if you don't understand.
- Openly express any disagreement or concern you have with all workgroup members.
- Offer mutually beneficial solutions. Actively strive to see other's point of view.
- Share information discussed in the meetings with the organization you represent, and relay to the workgroup the viewpoints of your organization.
- Speak one at a time in meetings, as recognized by the facilitator.
- Acknowledge that everyone will participate and no one will dominate.
- Agree that it is okay to disagree and disagree without being disagreeable.
- Do your homework. Read and review materials provided. Be familiar with the discussion topics.
- Stick to the topics on the meeting agenda. Be concise and not repetitive.
- Make every attempt to attend all meetings, to be on time and to stay to the end, and to review all documents prior to the meeting. In the event the primary workgroup member is unable to attend, that member is responsible for notifying commission staff prior to the meeting regarding alternate arrangements.

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
May 18	Reactive Power and Voltage/Power Control Performance; Protection Requirements
June 8	Energy Storage; Non-export; Inadvertent export; Limited export
July 20	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Aug 10	Test and Verification; Witness Test Protocol
Sept 14	References; Definitions; 1-line diagram requirements; Agreements

What is the purpose/role of statewide technical requirements?

Minn. Stat. 216B.1611; Subd. 1 Purpose.

(1) establish the terms and conditions that govern the interconnection and parallel operation of on-site distributed generation;

(2) provide cost savings and reliability benefits to customers;

(3) establish technical requirements that will promote the safe and reliable parallel operation of on-site distributed generation resources;

(4) enhance both the reliability of electric service and economic efficiency in the production and consumption of electricity; and

(5) promote the use of distributed resources in order to provide electric system benefits during periods of capacity constraints.

What is the purpose/role of statewide technical requirements?

Minn. Stat. 216B.1611; Subd. 2 **Distributed Generation; generic proceeding**.

At a minimum these tariff standards must:

(1) to the extent possible, be consistent with industry and other federal and state operational and safety standards;

(2) provide for the low-cost, safe, and standardized interconnection of facilities;

(3) take into account differing system requirements and hardware, as well as the overall demand load requirements of individual utilities;

(4) allow for reasonable terms and conditions, consistent with the cost and operating characteristics of the various technologies, so that a utility can reasonably be assured of the reliable, safe, and efficient operation of the interconnected equipment; and

(5) establish (i) a standard interconnection agreement that sets forth the contractual conditions under which a company and a customer agree that one or more facilities may be interconnected with the company's utility system, and (ii) a standard application for interconnection and parallel operation with the utility system.

What is the purpose/role of statewide technical requirements?

Minn. Stat. 216B.1611; Subd. 3 **Distributed Generation tariff**.

Within 90 days of the issuance of an order under subdivision 2:

(1) each public utility providing electric service at retail shall file a distributed generation tariff consistent with that order, for commission approval or approval with modification; and

(2) each municipal utility and cooperative electric association shall adopt a distributed generation tariff that addresses the issues included in the commission's order.

Discussion: Scope for Statewide Technical Requirements

These topics have been proposed as **in scope**.
Bold have been flagged for discussion.

1. Scope/Overview
2. References
3. Definitions
4. **Performance Category Assignments**
5. **Reactive Power Capability and Voltage/Power Control (volt-var & volt-watt) Performance**
6. **Response to Abnormal Conditions (Ride-through)**
7. **Protection Requirements**
8. **Metering**
9. **Interoperability (Monitoring, Control, Info Exchange, Cyber security)**
10. **Energy Storage**
11. Non-Export; Inadvertent Export
12. **Test and Verification Requirements**
13. **Agreements**
14. **Consumer Protection** (IREC)
15. **Reporting** (IREC)

(Source: "Regulated Utilities" TIIR Draft Proposal)

Discussion: Scope for Statewide Technical Requirements

1. Process requirements
2. Cost allocation
3. Interconnection to transmission system
4. **Protection system details of Area EPS or DER**
5. **Requirements or specification of system impact or facilities studies**
6. **Application of real and reactive power control functions**
7. **Details of communication networks; including architecture, technology and protocols, or other specifications related to interoperability**
8. **Details of metering requirements or specifications**
9. **Planning or operational considerations associated with Affected Systems, Regional Transmission Operator or Transmission Owners**
10. **Intentional Area EPS islanding**

These topics have been proposed as **out of scope** by some participants. Bold are flagged for additional discussion.

(Source: TIIR Draft Proposal, p. 9)

Discussion: Utility Technical Specification Manual Proposal

Scope Identified by Some Participants:

1. Interconnection Coordinator Contact Information
2. Notification/Communication expectations after DER interconnection completed
3. Non-parallel or short-term parallel interconnections
4. DER Protection
5. Protection System requirement details
6. 1-line Diagram Examples
7. Equipment labeling and location requirements
8. DER Specific Settings (Default Settings, Voltage Reference, Reactive and real power control function)
9. Details on implementing DER real and reactive control functions, if applicable.
10. Reactive power constraints related to the bulk power system
11. Interoperability technologies (Communication protocol, Communication & Monitoring Methods)
12. Details on process for determining use of the DER interoperability interface
13. Metering requirements
14. Performance category assignment, or assignment process, for unique technologies
15. Evolving energy storage requirements
16. Cybersecurity requirements
17. Details for implementing IEEE 1547 testing and verification requirements
18. DER Specific Testing (Initial and Ongoing)

(Source: Prep materials)

Inventory of Definitions to Discuss

Area EPS Operator Technical Specification Manual	Non-Export; Non-Exporting
Authority Having Jurisdiction (AHJ)	Non-Parallel Operation
Customers	Parallel Operation
Energy Storage System (ESS)	Regional Transmission Operator (RTO)
Inadvertent Export	Secondary Network
Inverter	Technical Interconnection and Interoperability Requirements (TIIR)
Limited Export	Transmission Power System (Bulk Power System?)
Microgrids	Unintentional Island

Next Steps

March 29	Phase I Draft Staff Recommendations Comments Due
April 6	Prep work for TSG Mtg #2 Due
April 13	TSG Mtg #2: Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
April 13	Phase I Reply Comments Due
May 11	Prep work for TSG Mtg #3 Due
May 18	TSG Mtg #3: Reactive Power and Voltage/Power Control Performance; Protection Requirements
May 2018	Agenda Meeting re: Phase I

MINNESOTA
PUBLIC UTILITIES COMMISSION

Thank You!

MINNESOTA
PUBLIC UTILITIES COMMISSION

PREP WORK

Subgroup members review agenda and provide the following to staff by 4/6/18 (If providing slides, final slides due 4/12/18):

1) Review and red-line staff edits/comments on Regulated Utilities' proposed purpose, scope and limits (p. 8-10) based on 3/23 TSG webex. (See: IEEE 1547* purpose, scope, limits p. 13-15) NOTE: We will address the Overview section later.
2) Review and red-line Regulated Utilities' Performance Categories proposal (p. 18-21) and response to normal and abnormal conditions (p. 22-23). Also, be familiar with relevant IEEE 1547 sections; including performance category assignment (Sec. 1.4 (p. 13-18) and Annex B (p. 105-113)); response to normal conditions (Sec. 5 (p. 37-45)); response to abnormal conditions (Sec. 6 (p. 45-67)
    a. If you support statewide technical requirements addressing normal condition performance categories, propose language with rationale.
3) Utilities – please provide examples of normal and abnormal conditions you are seeing on your systems today (i.e. location; frequency of events; anticipated role and impacts of DER and DER response based on current and forecasted DER penetrations.)

*IEEE 1547 pg numbers are based on Draft 7.3 (December 2017)

Technical Subgroup Meeting 2 DRAFT AGENDA
Friday, April 13th
9:30am – 12:30pm
WebEx: https://global.gotomeeting.com/join/432598661
Dial in option (webex preferred): 1-571-317-3112; 432-598-661#

1) Introductions
2) Follow up on Statewide Technical Requirements Purpose, Scope and Limits
3) MISO presentation on Bulk Power System Voltage and Frequency issues; DER penetration; DER Impact Assessment efforts
4) Utility presentation on Area EPS Normal and Abnormal Conditions
5) Performance Categories and Response to Normal and Abnormal Conditions
    a. Definition of performance category – Normal (A/B); Abnormal (I, II, III)
    b. How a performance category is assigned and role of AGIR, utility, ISO/RTO
    c. What assignment of a performance category means re: capability; implementation/utilization; DER impacts/consumer protections
    d. Proposed Performance Category Assignments and DER Attribute Groupings
6) Next Steps/Homework – 10 mins

PHONE 651-296-0406 • TOLL FREE 1-800-657-3782 • FAX 651-297-7073
121 7TH PLACE EAST • SUITE 350 • SAINT PAUL, MINNESOTA 55101-2147
MN.GOV/PUC

Phase II Technical Subgroup Roster:

Jeff Schoenecker/Craig Turner, Dakota Electric	Robert Jagusch, MMUA	John Dunlop/Chris Jarosch, MNSEIA
Lise Trudeau, Dept of Commerce	Kevin McLean/Jenna Warmuth, MN Power	Commissioner Matt Schuerger; Michelle Rosier; Cezar Panait; Pam Johnson, DOE Solar Energy Innovator Fellow (May 1)
Kevin Joyce/Katie Bell, EFCA	Kristi Robinson, MREA	Technical Assistance*: Michael Coddington and Michael Ingram, National Renewable Energy Laboratory Tom Key, Jens Boemer, Nadav Enbar; Electric Power Research Institute
Brian Lydic/Sky Stanfield/Laura Hannah – Joint Movants	Dean Pawlowski, Otter Tail Power	
Tam Kemabonta/Professor Mahmoud Kabalan, St. Thomas Affiliation	Patrick Dalton/John Harlander/Alan Urban, Xcel Energy	

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Draft Meeting Topics Proposal:

Date	**Topic**
~~3/23/18~~	~~Meeting 1~~ ~~Scope/Overview** (Walk-through with explanations: Red-lined TIIR; List of topics in scope of TSMs; Definitions~~
4/13/18	Meeting 2 Performance Categories**; Response to normal and abnormal conditions; MISO Bulk Power System
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7/20/18	Meeting 5 Interoperability** (Monitor and Control Criteria); Metering**; cyber security
8/10/18	Meeting 6 Test and Verification**; Witness Test Protocol
9/14/18	Meeting 7 References; Definitions*; 1-line diagram requirements; Agreements*
9/21/18	Full DGWG Meeting 2

Phase II Technical Subgroup Meeting #2

April 13, 2018

(Docket No. 16-521)

MINNESOTA
PUBLIC UTILITIES COMMISSION

https://mn.gov/puc

Agenda

Time	Topic
9:30 - 9:40	Welcome and Feedback
9:40 – 9:50	Follow up on Statewide Technical Requirements' purpose, scope and limits
9:50-10:10	MISO Presentation & Questions
10:10 – 10:45	Utility Presentations & Questions (Xcel, Dakota and MREA)
10:45 – 12:15	Performance Categories and Response to Normal and Abnormal Conditions
12:15 – 12:30	Question: Implementation timeline of IEEE 1547 given interim on testing/certification

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

MINNESOTA PUBLIC UTILITIES COMMISSION

MISO Discussion

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Utility Presentations

16-521 DGWG TSG Mtg 2

Normal and Abnormal Performance Categories, Capabilities, and Assignment

4/13/18

Outline

- Utility presentation on Area EPS Normal and Abnormal Conditions
- Performance Categories – Overview of Normal (A/B) and Abnormal (I, II, III)
- Normal Performance Category and Assignment
  - Normal Performance Category Characteristics
  - What assignment of a performance category means re: capability; implementation/utilization; DER impacts/consumer protections
  - How a performance category is assigned and role of AGIR, utility, ISO/RTO
  - Proposed Performance Category Assignments and DER Attribute Groupings
- Abnormal Performance Category and Assignment
  - Abnormal Performance Category Characteristics
  - What assignment of a performance category means re: capability; implementation/utilization; DER impacts/consumer protections
  - How a performance category is assigned and role of AGIR, utility, ISO/RTO
  - Proposed Performance Category Assignments and DER Attribute Groupings

Normal and Abnormal

What is “Normal”?

Xcel Energy’s Interpretation

- No single definition exists for “Normal” or “Abnormal” electric power system conditions

- The IEEE 1547 definition of the ***Continuous Operation Region*** for voltage and frequency is key in differentiating normal from abnormal in the standard
  – ANSI C84.1 voltage standards also plays an important role

- Outside of 1547, a patchwork of standards constitute normal and abnormal conditions on distribution, transmission, and bulk system generators.

Normal Conditions

Standard References

IEEE 1547-2018 defines a ***continuous operation*** region which applies to the ***normal operating performance category***.

- Voltage: between **0.88 and 1.1** times nominal voltage
- Frequency: between **58.8 Hz and 61.2 Hz**

A few other standards to consider:

- Voltage: ANSI C84.1-2016
  - Range A: 0.975 – 1.05 p.u. (Service voltage > 600 V)
  - Range B: 0.95 – 1.058 p.u. (Service voltage > 600 V)
- Frequency: NERC BAL-003
  - 59.964 Hz to 60.036 Hz

Note: Numerous other standards exist that could be considered relevant in a general sense, but are not directly applicable to the TIIR adoption

Abnormal Conditions

Standard Reference

IEEE 1547-2018 defines the ***abnormal operating performance category*** as the grouping for a set of requirements that specify technical capabilities and settings for a DER under abnormal operating conditions, i.e., outside the ***continuous operation*** region.

Voltage outside of **0.88 and 1.1 per unit**
Frequency outside **58.8 Hz - 61.2 Hz**

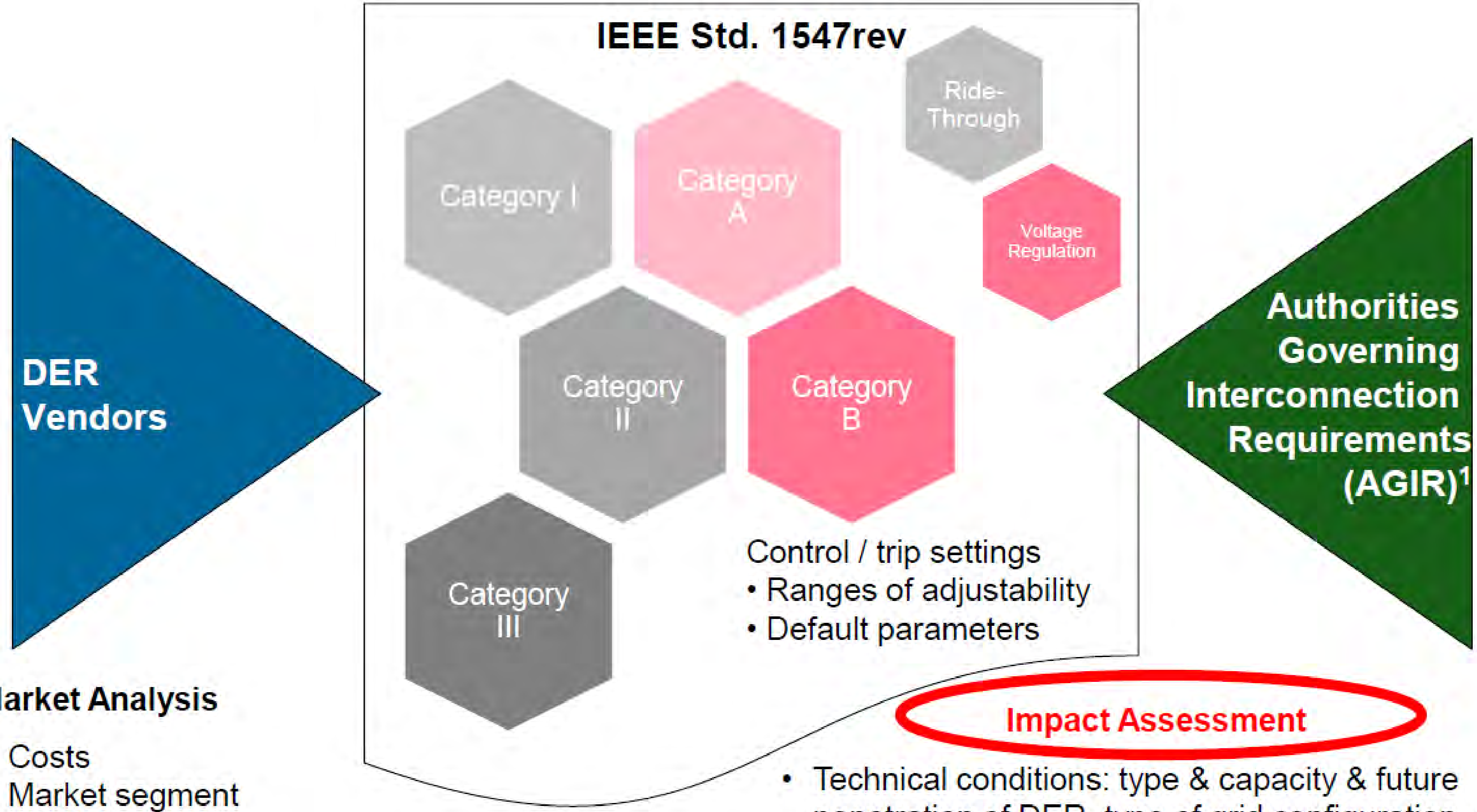
Abnormal Conditions Causes

Xcel Energy's Field Experience

- Faults resulting in short circuit current and low voltage
  - Frequent events on a system wide distribution basis
    - Squirrels, trees, lightning, equipment failure, etc.
  - Severity of voltage drop and fault current and depends on location
  - Reclosing of automatic devices may cause additional events
- Open phase conditions from broken connector or conductor
- Thermal overloads due to current exceeding equipment rating
  - Could be caused by abnormal circuit conditions
- Transmission line or Generator tripping
  - Relatively infrequent compared to distribution events
- High Voltage from Reverse Power flow
  - Typically from abnormal circuit conditions. Relatively rare.
  - Low voltage from heavy loading is also possible.

Performance Category Definition

Performance Category Approach



Market Analysis

- Costs
- Market segment
- Etc.

Impact Assessment

- Technical conditions: type & capacity & future penetration of DER, type of grid configuration, etc.
- Non-technical issues: DER use case, impacts on environment, emissions, and sustainability, etc.

[1] State Regulator, Area EPS or bulk system operator, etc.

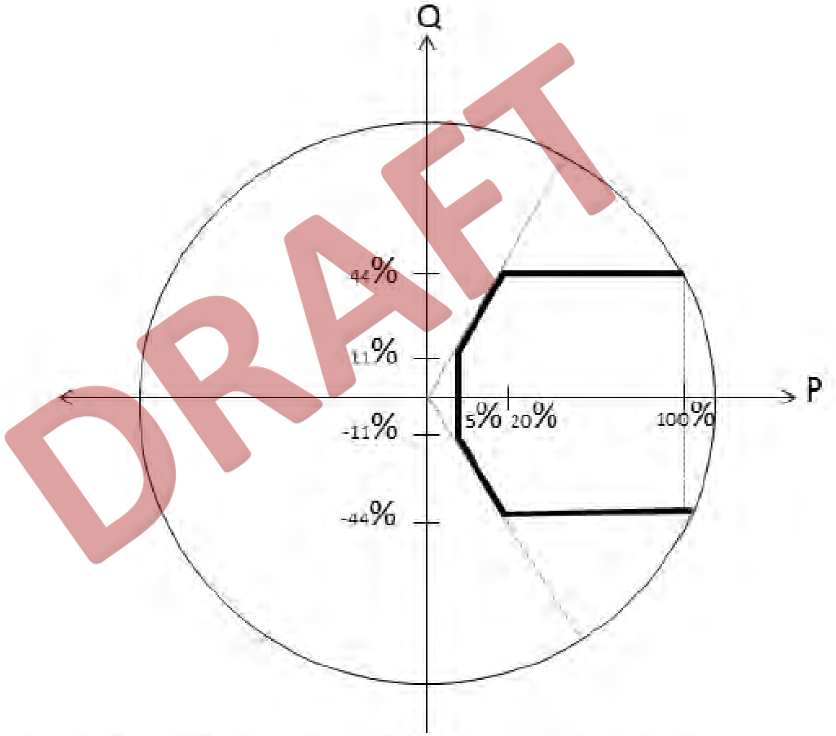
Source: EPRI

Normal Performance Category and Assignment

Xcel Energy

Normal – Reactive Power Capability

IEEE 1547



The DER shall be capable of injecting reactive power (over-excited) and absorbing reactive power (under-excited) equal to the minimum reactive power (kVar) corresponding to the value given in the Table below **at all active power output equal to 20% to 100% of nameplate active power rating (kW)**.

Category	Injection Capability as % of Nameplate Apparent Power (kVA) Rating Qmin_{inj}	Absorption Capability as % of Nameplate Apparent Power (kVA) Rating Qmin_{abs}
A (at DER rated voltage)	44	25
B (over the full extent of ANSI C84.1 range A)	44	44

Normal – Required Capabilities

IEEE 1547 Reference

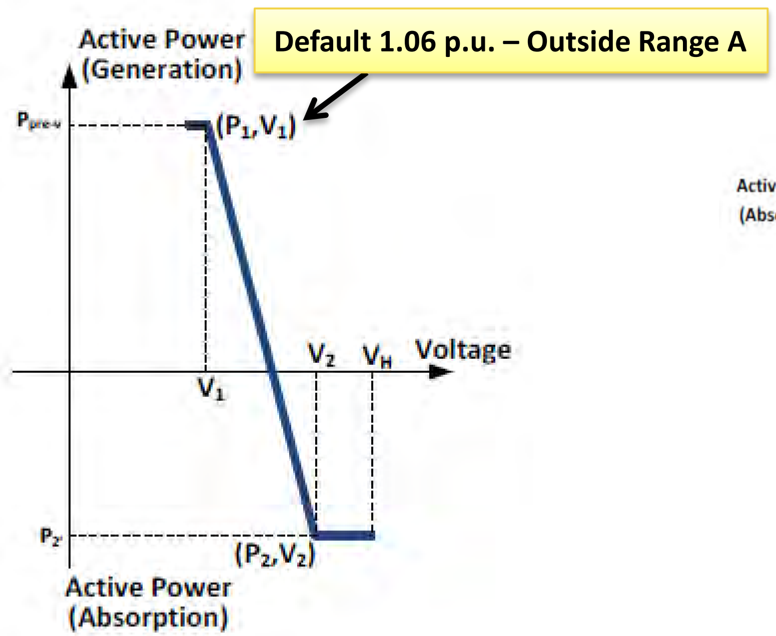
Table 6—Voltage and reactive/active power control function requirements for DER normal operating performance categories

DER Category	Category A	Category B
Voltage regulation by reactive power control		
Constant power factor mode	mandatory	mandatory
Voltage – reactive power mode[61]	mandatory	mandatory
Active power – reactive power mode[62]	not required	mandatory
Constant reactive power mode	mandatory	mandatory
Voltage and active power control		
Voltage – active power (volt-watt) mode	not required	mandatory

Some ***default settings*** and ***range of allowable settings*** for some modes are different based on the ***performance category***

Responses to Normal Conditions

IEEE 1547 P and Q Control Modes



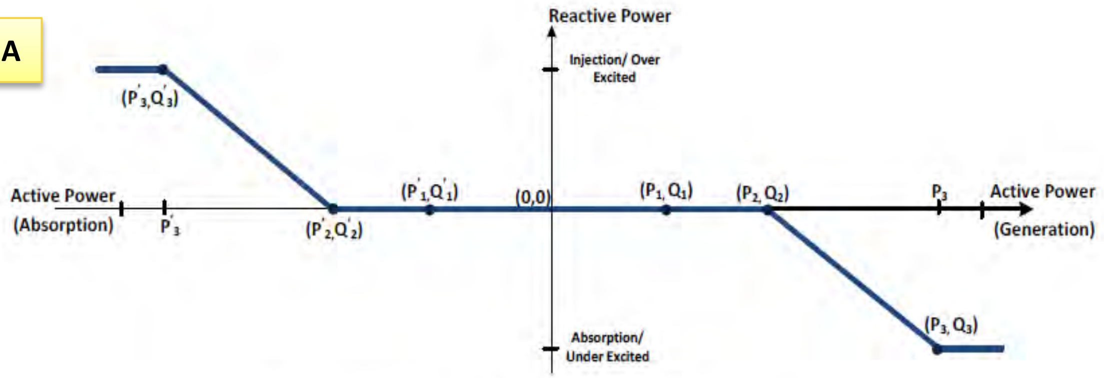


Figure 6—Example Watt-Var characteristic

1547: Default Mode with PF=1

Also Included:

Fixed Power Factor

Fixed Reactive Power

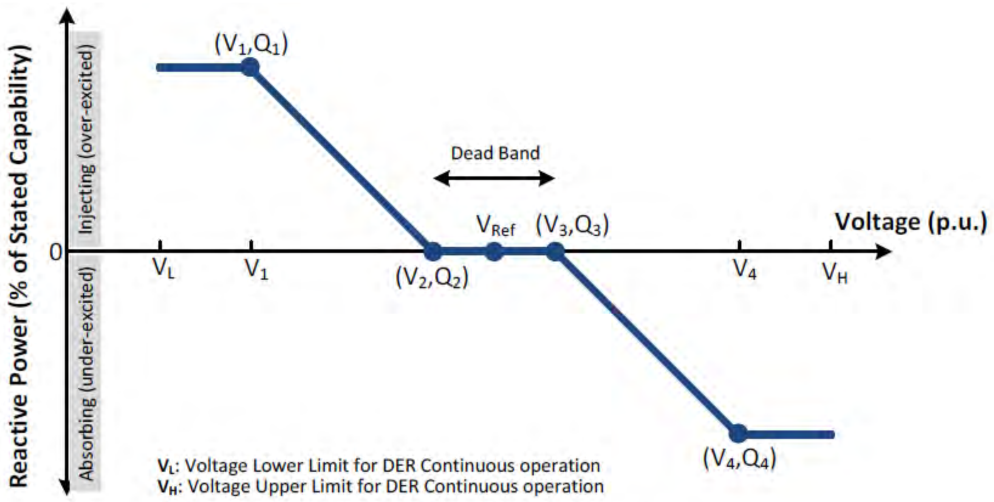


Figure 5—Example volt-var characteristic

How is Normal Performance Assigned?

Reactive power capability and voltage/power control requirements

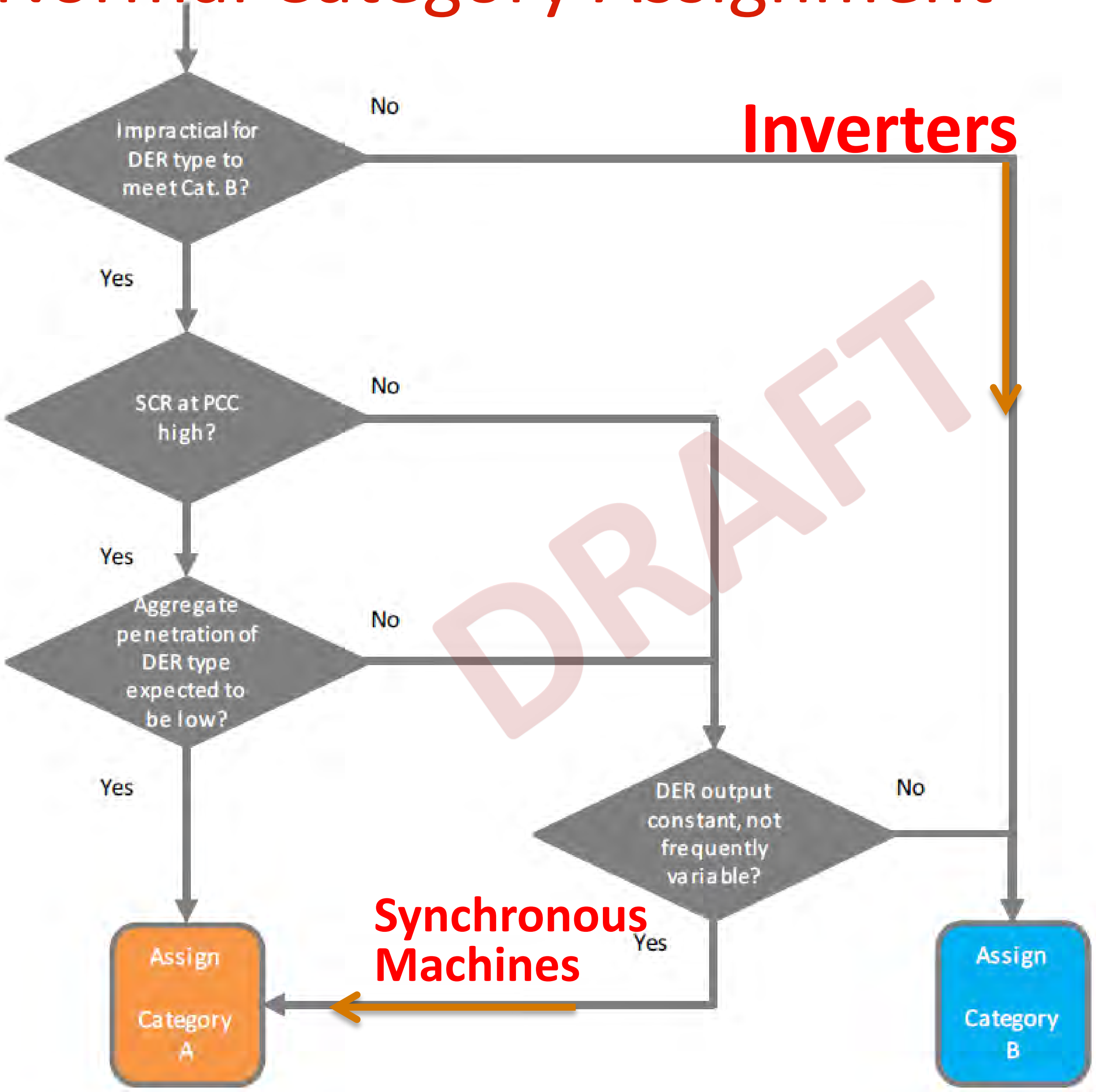
IEEE 1547/D7.3, Section 5.1:

"The Area EPS operator shall specify the DER performance category that is required."

Regulated Utilities' TIIR Proposal:

"Based on IEEE 1547, The Area EPS Operator assigns normal performance categories - Category A and B."

Normal Category Assignment – IEEE 1547 Annex B



Performance Category Assignment – TIIR Proposal

Technology	Normal performance category
Inverter-based DER	Category B
Synchronous machine generation	Category A

The above assignment of Categories A and B is expected to cover the vast majority of interconnections. Any instances that do not fall within the above assignment shall be:

1) reviewed on a case-by-case basis, with the Area EPS making determination for requiring Category A or B; or

2) have performance category assignment specified in the Area EPS Operators TSM

The Area EPS Operator should consider Annex B of IEEE 1547 when making these determinations on a case-by-case basis or in TSM requirements.

Implementation of Normal Modes and Settings

IEEE 1547/D7.3, Section 5.3.1:
"The DER operator shall be responsible for implementing setting modifications and mode selections, as specified by the Area EPS operator within a time acceptable to the Area EPS operator."

Regulated Utilities TIIR Proposal:
"The Area EPS Operator shall notify the DER Operator when a change in reactive power control modes is required to address Area EPS operating needs. Any implementation of functions shall adhere to applicable agreements."

"The DER shall be installed with constant power factor mode with 0.98 power factor settings, absorbing reactive power, unless otherwise specified by the Area EPS Operator."

Abnormal Performance Category and Assignment

Basis of Voltage and Frequency Ride-Through

Source: EPRI

Requirement	Category	Foundation	Justification
Voltage Ride-Through	**Category I**	**German grid code** for synchronous generator-based DER	• ***Essential* bulk system needs** • Attainable by all state-of-the-art DER technologies
	Category II	**NERC PRC-024-2** Without stability exception, Extended LVRT duration for 65-88%	• ***All* bulk system needs** • Considering fault-induced delayed voltage recovery (**FIDVR**)
	Category III	**CA Rule 21 and Hawaii** Minor modifications	• **All bulk system needs** • Considering fault-induced delayed voltage recovery (**FIDVR**) • Distribution Events
Frequency Ride-Through	**All Categories (harmonized)**	**CA Rule 21 and Hawaii** Exceeds PRC-024-2	• **All bulk system needs** • **Low inertia grids**

Shall trip **default settings** and ***range of allowable settings*** are same for frequency but different for voltage

Responses to Abnormal Conditions – IEEE 1547 Terms

Cease to energize: Cessation of active power delivery under steady state and transient conditions and limitation of reactive power exchange.

NOTE 1—This may lead to momentary cessation or trip.

NOTE 2—This does not necessarily imply, nor exclude disconnection, isolation, or a trip.

NOTE 3—Limited reactive power exchange may continue as specified, e.g., through filter banks.

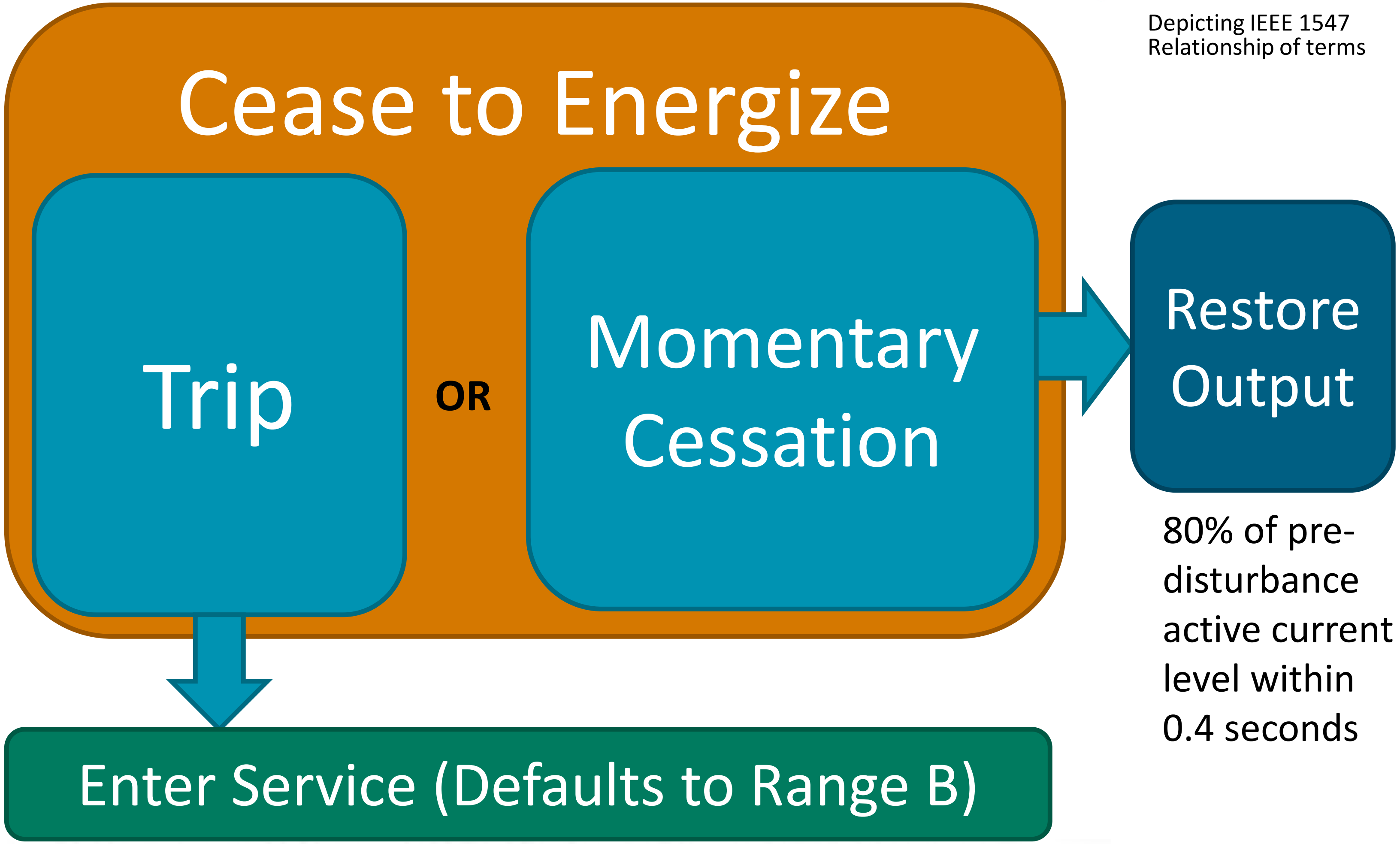
Trip: Inhibition of immediate return to service, which may involve disconnection.

Momentary cessation: Temporarily ***cease to energize*** an EPS, while connected to the Area EPS, in response to a disturbance of the ***applicable voltages*** or the system frequency, with the capability of immediate Restore Output of operation when the ***applicable voltages*** and the system frequency return to within defined ranges.

Restore output: Return operation of the DER to the state prior to the abnormal excursion of voltage or frequency that resulted in a ride-through operation of the DER.

Return to service: Enter service following recovery from a trip.

Depicting IEEE 1547
Relationship of terms

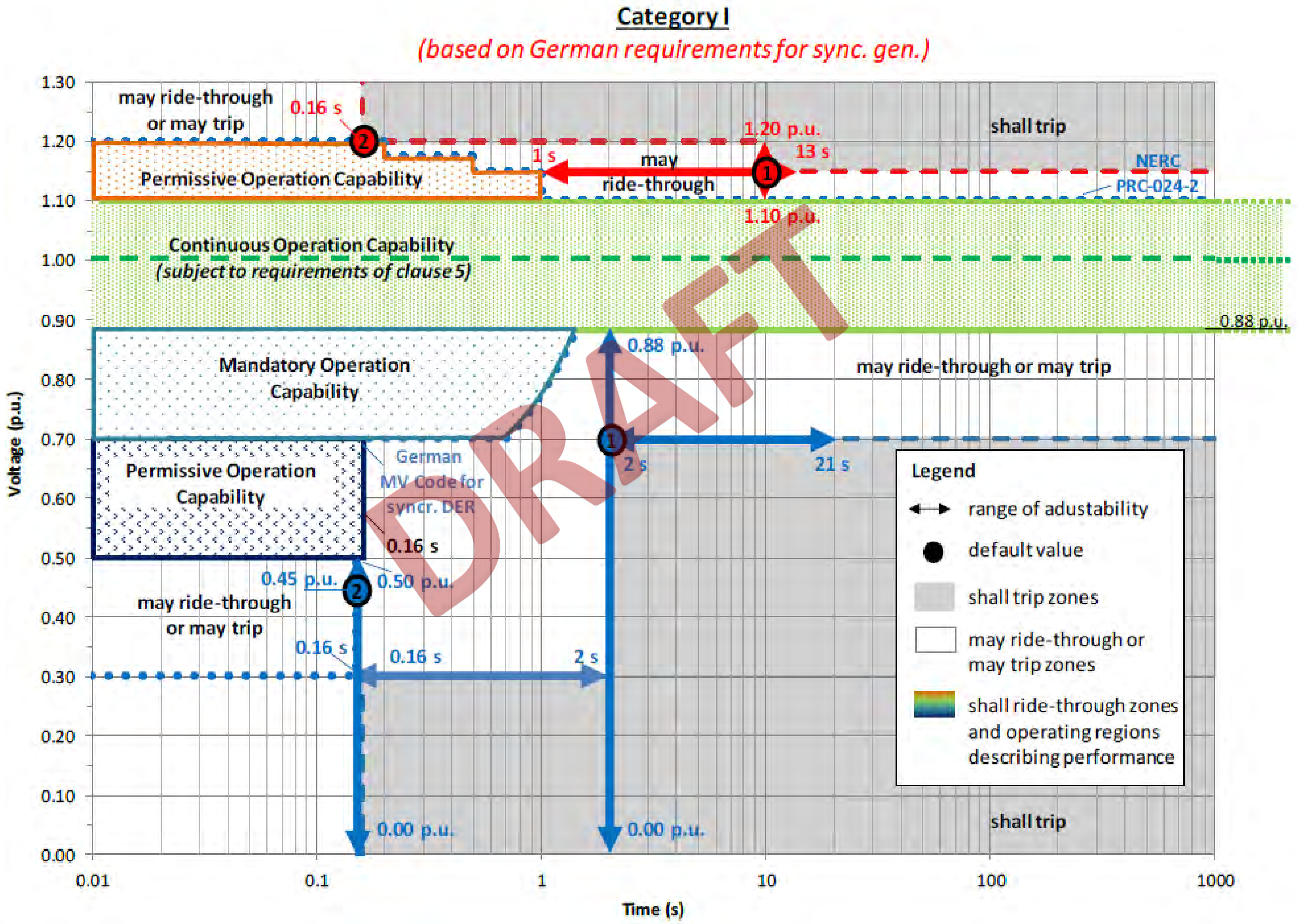


80% of pre-disturbance active current level within 0.4 seconds

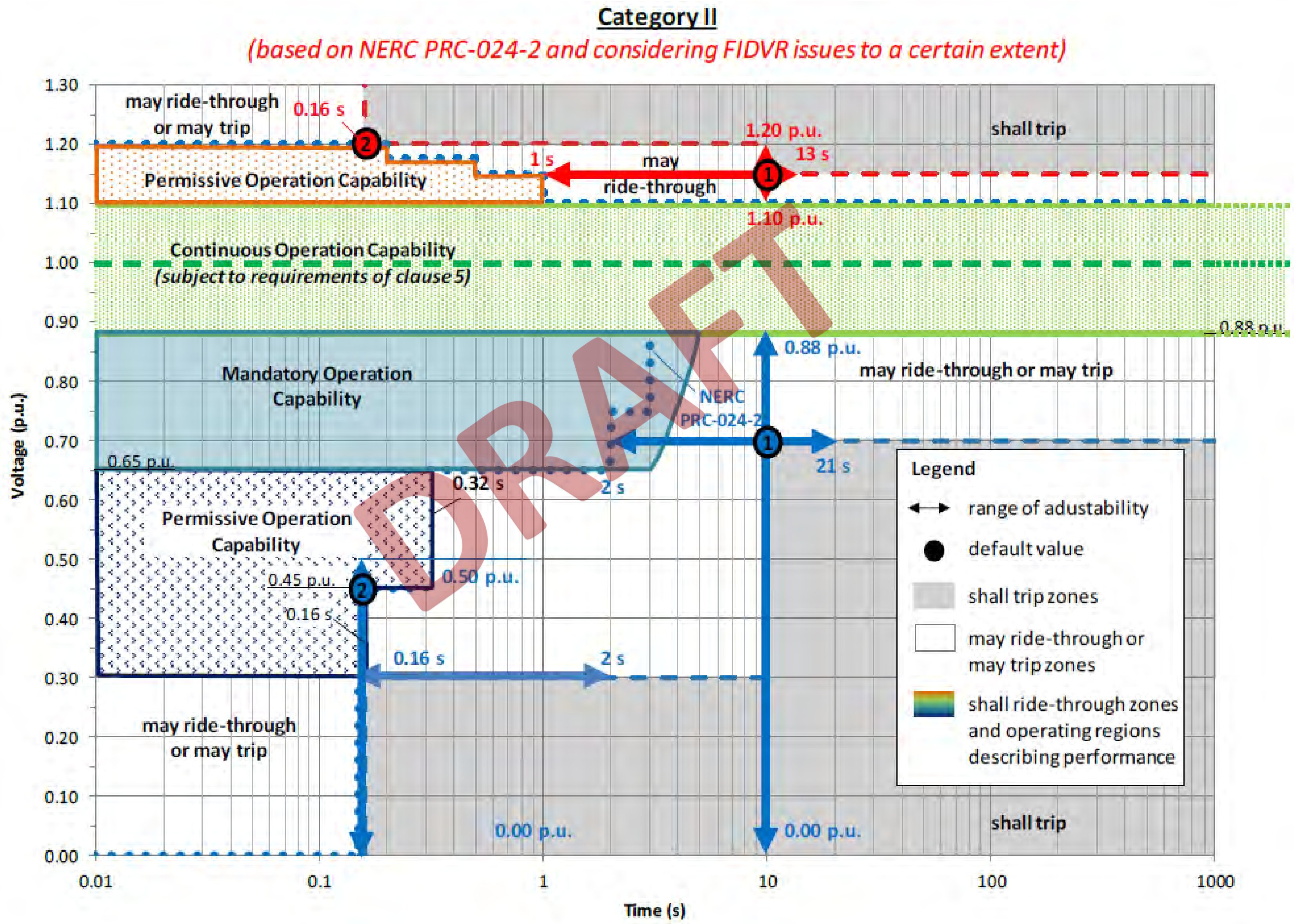
Table 4—Enter service criteria for DER of Category I, Category II, and Category III

Enter service criteria		Default settings	Ranges of allowable settings
Permit service		Enabled	Enabled / Disabled
Applicable voltage within range	Minimum value	≥ 0.917 p.u.[a]	0.88 p.u. to 0.95 p.u.
	Maximum value	≤ 1.05 p.u.	1.05 p.u. to 1.06 p.u.
Frequency within range	Minimum value	≥ 59.5 Hz	59.0 Hz to 59.9 Hz
	Maximum value	≤ 60.1 Hz	60.1 Hz to 61.0 Hz
Note a—This corresponds to the Range B of ANSI C84.1, Table 1, column for service voltage of 120-600 V.			

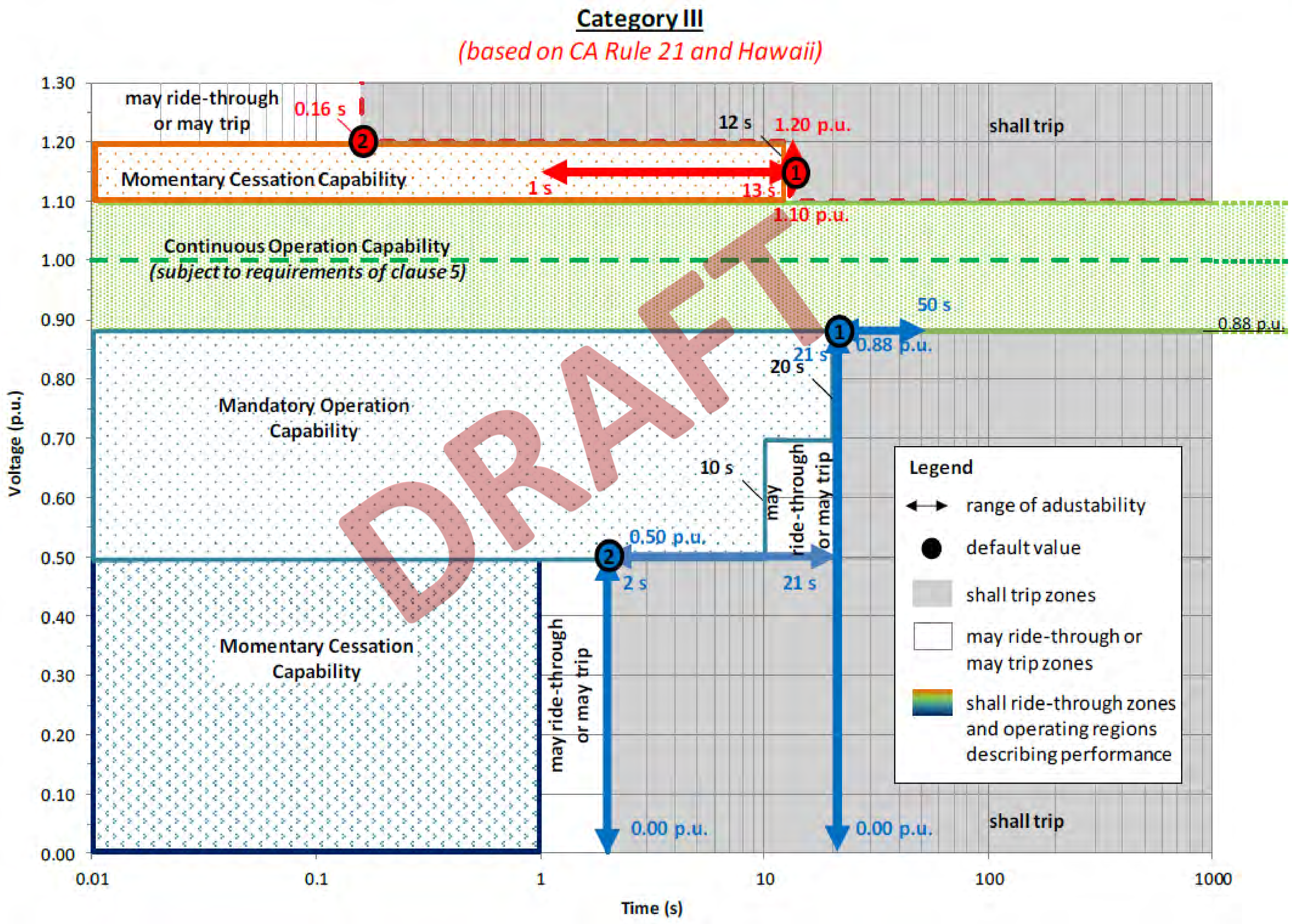
Voltage Ride-Through – Category I



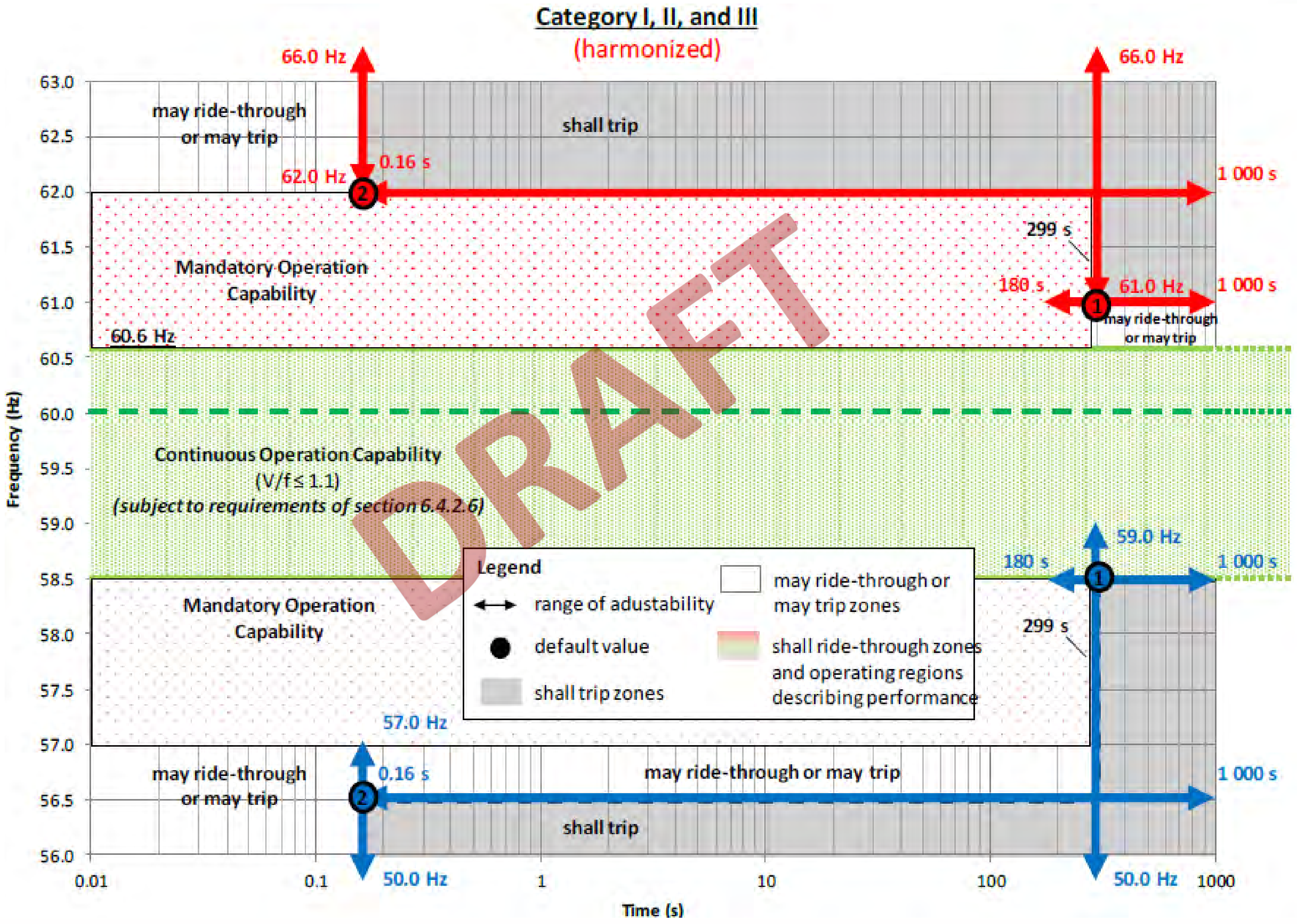
Voltage Ride-Through – Category II



Voltage Ride-Through – Category III



Frequency Ride-Through – All Categories

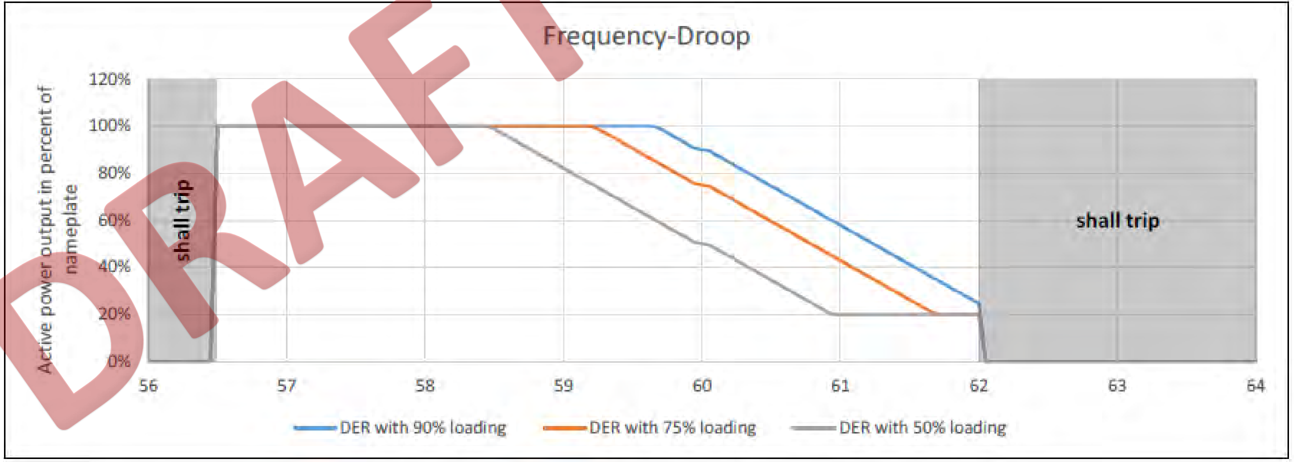


Rate of Change of Frequency Ride-Through (ROCOF)

Category I	Category II	Category III
0.5 Hz/s	2.0 Hz/s	3.0 Hz/s

Frequency-droop (frequency/power) capability

Category	Operation for Low-Frequency Conditions	Operation for High-Frequency Ride-Conditions
I	Optional (may)	Mandatory (shall)
II	Mandatory (shall)	Mandatory (shall)
III	Mandatory (shall)	Mandatory (shall)



How is Abnormal Performance Assigned?
IEEE 1547 Reference

IEEE P1547/D7.3, Section 6.1:

The Area EPS Operator, as guided by the AGIR who determined applicability of the performance categories as outlined in 4.3, shall specify which of *abnormal operating performance category* I, *category* II, or *category* III performance is required. Guidance regarding the assignment of *performance categories* is provided in Annex B of this standard

Abnormal Performance Assignment

IEEE 1547 Informative Annex B

Table B-1— Example Abnormal Performance Category Assignment Grid[147]

DER Type		DER Application Purpose						
		Retail Self Generation	Combined Heat and Power	Waste Fuel Recovery	Renewable Energy	Merchant Generation[a]	Critical Backup[b]	Peak Shaving
		A	B	C	D	E	F	G
1	Engine or turbine driven synchronous generator	Category I	Category I	Category I	Category I	Category I	Category I	Category I
2	Wind turbines (all types)	Category II	N/A	N/A	Category II	Category II	N/A	N/A
3	Inverters sourced by solar PV	Category II[c]	N/A	N/A	Category II[c]	Category II[c]	N/A	N/A
4	Inverters sourced by fuel cells	Category I	Category I	Category I	Category I	Category II	Category I	N/A
5	Synchronous hydrogenerators	Category I	N/A	N/A	Category I	Category I	Category I	N/A
6	Other inverter applications	Category II	Category II	Category II	Category II	Category II	Category II	N/A
7	Inverters sourced by energy storage	Category II	N/A	N/A	N/A	Category II	Category II	Category II
8	Other synchronous generators	Category I	Category I	Category I	Category I	Category I	Category I	N/A
9	Other Induction generators	Category II	Category II	Category II	Category II	Category II	Category II	Category II

NOTE a—Merchant generation in this table is intended to characterize DER facilities installed for the express purpose of exporting power, and is not intended to imply only FERC-jurisdictional generation or other regulatory definitions.
NOTE b—Only applies to critical backup generation interconnected to the Area EPS for the purposes of periodic testing. If backup generation is also used for merchant generation or other purposes, the performance requirements of those purposes apply.
NOTE c—Category III should be required where DER penetration on a distribution feeder exceeds [% VALUE TO BE SPECIFIED BY AGIR], or on the distribution system supplied from a given distribution substation bus exceeds [% VALUE TO BE SPECIFIED BY AGIR].

Abnormal Performance Assignment

TIIR Proposal

The Area EPS Operators in the state of Minnesota shall constructively work with the Regional Transmission Operator to determine whether Category II or Category III is the proper ~~be the~~ default category assignment for inverter based DER. The decision shall balance the needs of the Area EPS and Local EPS with BPS considerations. All synchronous machine DER shall be assigned Category I.

Any instances that do not fall within the above assignment shall:

1) be reviewed on a case-by-case basis, with the Area EPS making determination for requiring Category I,II or III; or

2) have performance category assignment specified in the Area EPS Operators TSM

The Area EPS Operator should consider Annex B of IEEE 1547 when making these determinations on a case-by-case basis or in TSM requirements.

Abnormal Performance Settings
IEEE 1547-2018

- **Frequency Trip Settings (6.5.1)**

  "The underfrequency and overfrequency trip settings shall be specified by the Area EPS operator in coordination with the requirements of the ***regional reliability coordinator***. If the Area EPS operator does not specify any settings, the default settings shall be used."

- **Voltage Trip Settings (6.4.1)**

"Area EPS operators may specify values within the specified range subject to the limitations on voltage trip settings specified by the ***regional reliability coordinator***."

Abnormal Performance Settings

TIIR Proposal

General

“The Area EPS Operators of Minnesota shall be included in any efforts by the Midcontinent Independent System Operator (MISO) seeking to impose default parameter values on DER that differ from IEEE 1547. The process of determining new statewide or regional abnormal response parameter defaults that deviate from national standard default values should only be the outcome of a broad consensus process. The Minnesota statewide default parameters for DER response to abnormal conditions shall not materially impact safety, reliability, or the Area EPS Operator’s ability to operate the Area EPS.”

Voltage and Frequency

“The IEEE 1547 default parameters shall be implemented by the DER Operator for the applicable performance category, unless otherwise specified by the Area EPS Operator’s TSM.”

> New note: Consider if TSM is the proper document for both voltage and frequency (i.e. TIIR or MISO document for frequency; TSM for voltage?)

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Technical Standards Meeting #2

MPUC DGWG– April 13, 2018

Normal Operations (Design)

- No standard national definition of "normal"
- Normal (N-0)
  - All distribution facilities fully functional
  - System Configuration "normal"
    - No contingency switching
  - No outages
  - Able to serve 100% of peak demand (kW)
  - Full Load Control available
- Distribution Voltage consistent with ANSI C84.1 Range A
- Power Factor near unity
- Conductor and equipment thermal loading is limited to <100%
- Protection Systems in place and fully functional
  - Devices properly coordinated

Abnormal Operations (Design)

- No standard national definition of "abnormal"
- System Design
  - Plan for single contingency (N-1)
  - Single element failure (ex. equipment failure, public accident, etc.)
  - Outages
  - System Configuration is abnormal
    - Switching taking place
- Distribution Voltage consistent with ANSI C84.1 Range B
- Power Factor not be less than unity
- Load control may not be available
- Conductor and equipment thermal loaded to 100% of rating
- Protection Systems in place and functional
  - Protective Devices possibly are not coordinated

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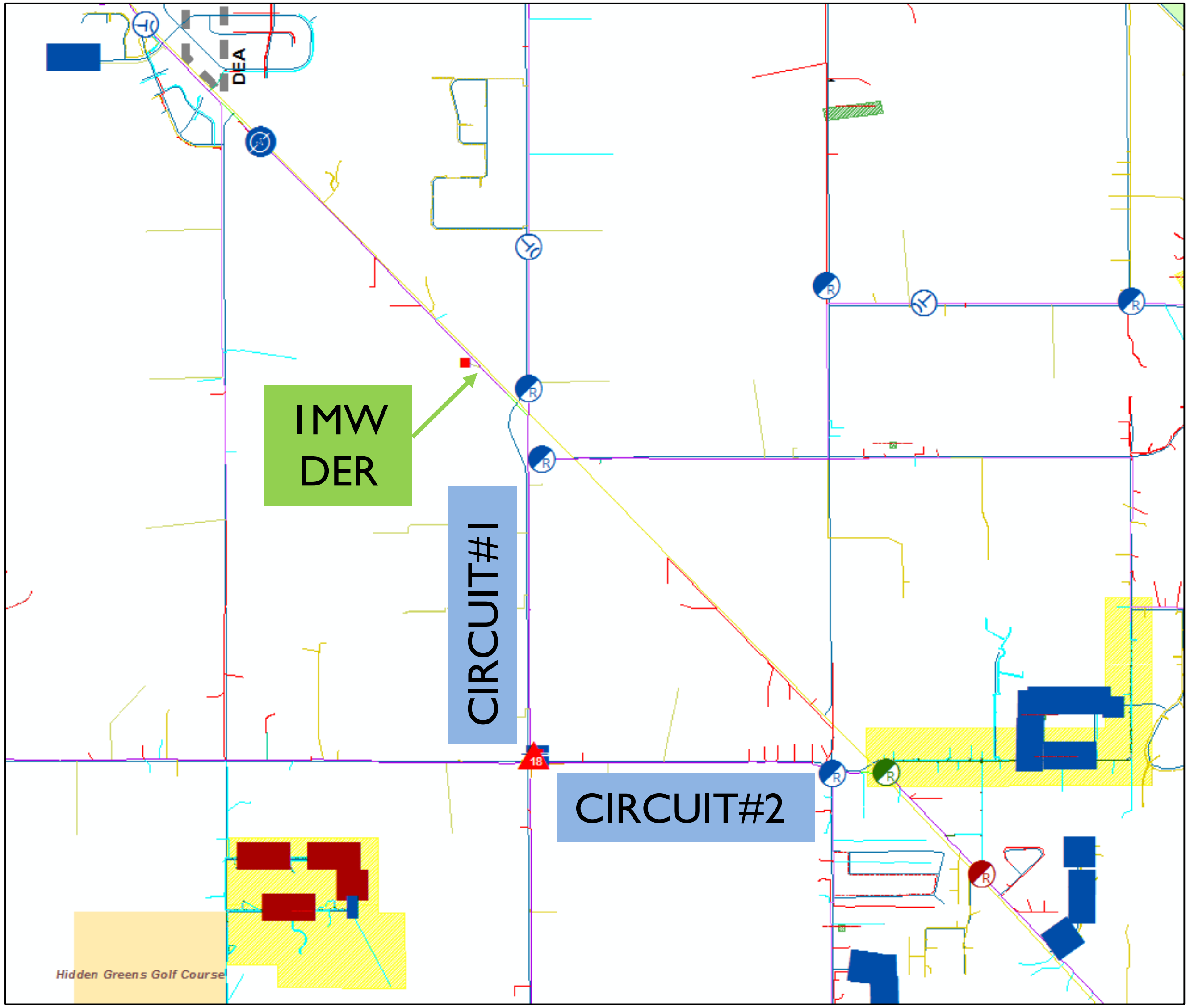
Normal Conditions (Actual)

- Distribution System is Normally "Abnormal"

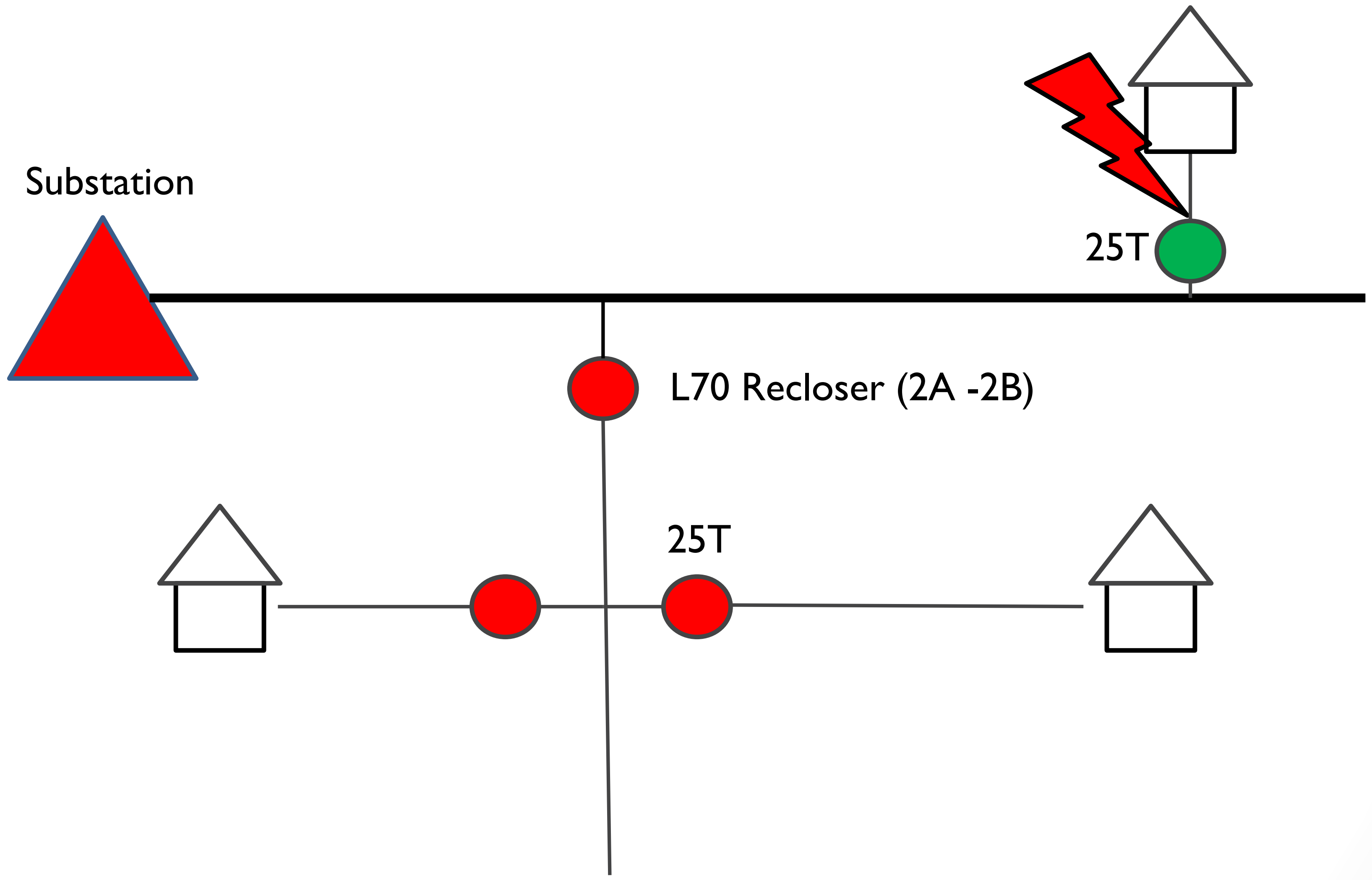
  - Planned switching (minimal if any outages to members)
    - Scheduled maintenance, line upgrades/rebuilds, scheduled outages
    - Frequency (DEA averages)
      - ~600 switching procedures per year
      - ~2x daily
    - Duration
      - 5 minutes to 6+ months

  - Unplanned switching (outages to members)
    - Emergencies, Storms, equipment failures, car accidents, etc.
    - Frequency
      - ~1000 outages per year
      - Average ~3 outages per day
    - Duration (5 minutes to 2+ hours)

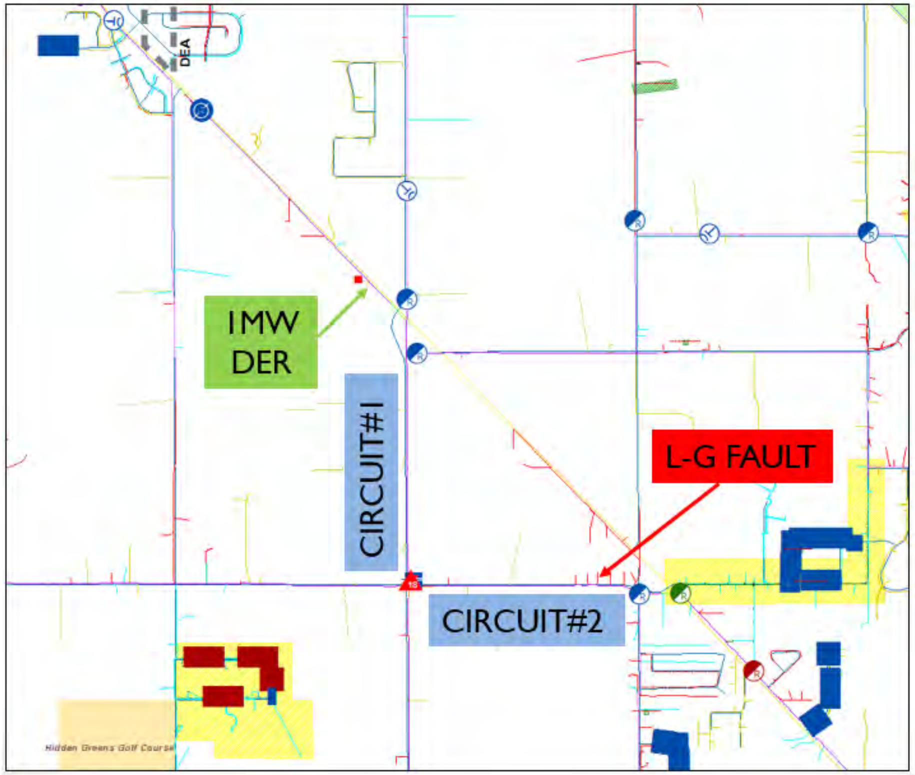
Recent Fault Condition Example



Typical Rural OC Protection



Event Summary



- Event 7:20 am on 3/5/18 (Monday)
  - DER tripped offline
- DER operator contacted DEA 5PM (3/5/18)
  - 1MW solar tripped offline
  - No events on circuit 1
  - Developer upset system is offline
- DER operator contacted engineering 9PM
  - System tripped on voltage event
  - DEA crew dispatch to download event files from relays
  - Developer sent their event files
  - Next day spent analyzing event files
- Outcome – summary provided to developer later in the week
  - DEA had a L-G fault on feeder 1 which created a voltage sag for ~6 cycles
  - Fuse isolated fault, DEA crews made repairs, re-fused
  - DER tripped on voltage unbalance caused by the fault after 5 cycles
  - DEA recommended relay setting change to developer
  - Developer implemented new relay settings and it was re-tested

Operational Considerations

- DEA’s DER Penetrations today (low)
  - Large DERs
    - 1MW PV System (operating)
    - 2MW PV System (under construction)
    - Up to 10 MW (pending RFP)
  - Small DER Penetration
    - ~130 PV and wind systems

- Operational impacts
  - Troubleshooting is more complex
  - More opportunity for miscoordination (can’t test all real life situations)
  - Distribution System is normally abnormal
    - Additional steps taken for unplanned and planned switching when DER is included

- Technical Requirements
  - The more standardization the better for all
  - DEA’s current penetration is low, but it doesn’t take much to impact normal operations.
  - DER penetration levels will continue to increase

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Questions??

MREA Examples

Example 1 – Crop Drying	Example 2 – Contingency to Industrial Loads
During the fall in the rural areas will see higher loads due crop drying during non-dry years. While most utilities require soft start on motors, during the high stress level time of crop drying, agricultural setups have been known to bypass soft start to get augurs to start with packed bins. The bypass of soft start will cause a high current inrush on the distribution system which lowers the distribution voltage. The voltage may drop below ideal set points of IEEE 1547 which then also trips off DER system that may also exist on the same distribution feeder. The tripping off of the DER compounds the voltage drop which then puts more strain on the line regulation and capacitance to address the voltage issue. The amount of crop drying or the instances when voltage issues due to crop drying are expected to occur are hard to predict. However the situation can be a regular event that occurs yearly throughout rural distribution systems.	Rural distributions systems are often lightly loaded compared to urban systems. It is common place for a rural substation to be the contingency for an industrial load substation. Utilities will plan to perform maintenance on the industrial substation during periods when one or some of the industrial accounts are shut down for quarterly maintenance. The industrial substation’s load is then fed by the neighboring rural substation while the utility perform maintenance on the industrial substation. If there is DER existing on the industrial and rural substation and all loading is fed of the rural substation while some of the industrial load is shut down, there is a good chance of power quality issues specifically with voltage regulation.

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Performance Category & DER Attribute Considerations

Overview of Performance-Based Category Approach (Annex B, p. 106)

- The AGIR, which could be state regulators, *bulk power system* operators, or the Area EPS Operator **would perform a DER impact assessment based on anticipated DER deployment for the future.**
  - This assessment would consider technical conditions such as:
    - Future DER penetration levels;
    - DER power output variability;
    - Distribution system characteristics, e.g., fault-induced delayed voltage recovery (FIDVR) issues, feeder configuration and protection;
    - Bulk system characteristics, e.g., power reserves or future system inertia.
    - It could also consider non-technical issues such as DER use cases and the broader impacts of DER on the environment, emissions, sustainability.
    - This analysis could be a starting point for a stakeholder process, initiated and managed by the AGIR, with the ultimate goal of assigning DER performance categories to specific DER (technology) types and application purposes (use cases).

DER Attributes to Consider (Annex B, p. 109)

- Power conversion device technology, such as synchronous generator, voltage-source inverter, induction generator, doubly fed generator, etc.
- Primary power source, such as solar, biogas, fossil fuel, hydro, wind, energy storage device, etc.
- Prime mover or type of primary energy source conversion, such as reciprocating engine, turbine, fuel cell, etc.
- DER application purpose, such as combined heat and power (cogeneration), merchant power generation, backup generation for critical facilities, retail customer self-supply, waste fuel recovery, etc.
- Factors related to the point of common coupling into the Area EPS, such as high-penetration feeders, areas of high regional DER penetration, dedicated distribution feeders, relative system strength, PCC location on a specific feeder, etc.
- Inherent output variability of the DER type.
- Other attributes.

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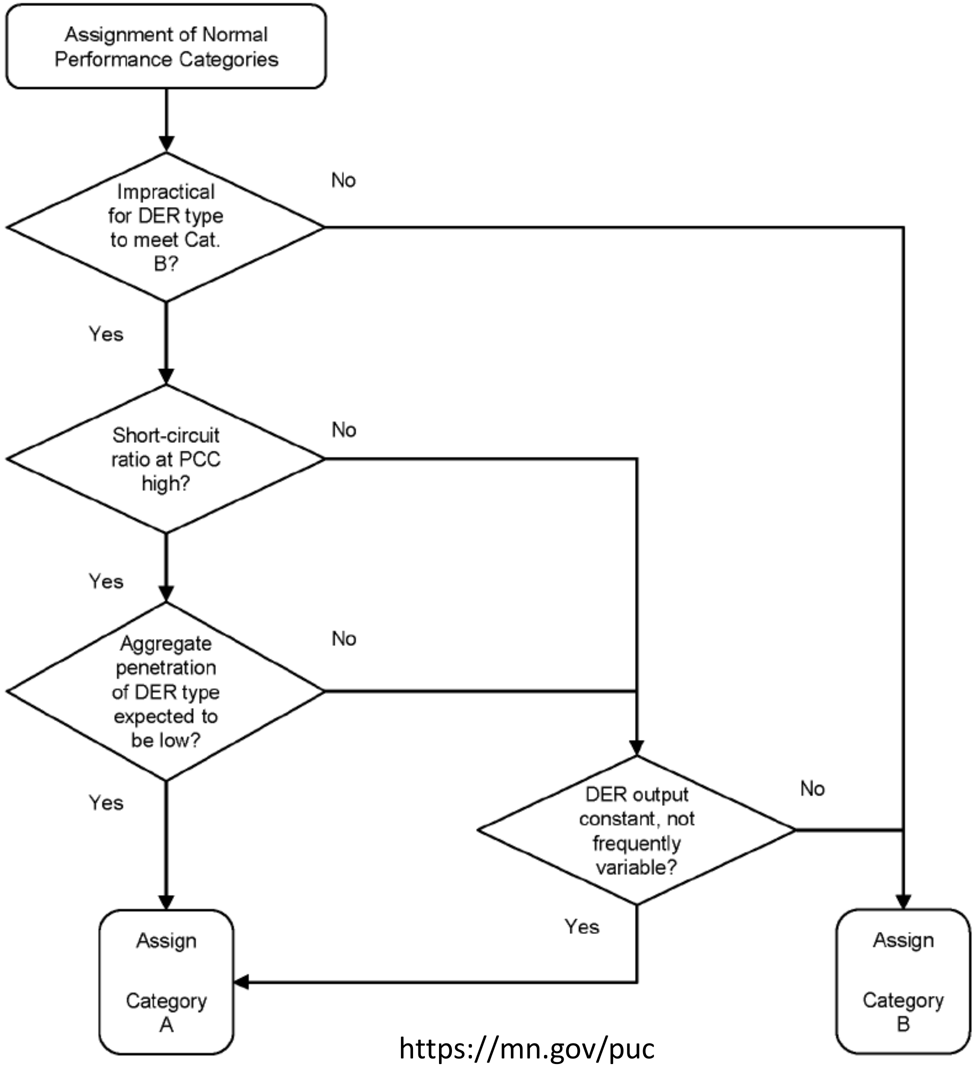
Normal Performance Category Assignment

Considerations for Normal Performance Category (A/B) Assignments (Annex B, p. 110)

- Is it impractical for the given DER type to be designed to meet Category B?
- Is the power output of the DER constant and not subject to frequent large variations?
- Is the rating of the DER, relative to the distribution system short-circuit strength at the point of common coupling, small such that the DER does not have significant impact on distribution voltage?
- Is the projected penetration of all DER types allowed to interconnect with Category A capability and performance relatively small compared to the total load level on the particular feeder?

Example Normal Performance Category Assignment (Annex B, p. 111)

For Discussion Reference only. Do not duplicate. Source: IEEE P1547



Regulated Utilities Proposal (p. 20-21)

Based on IEEE 1547, The Area EPS Operator assigns normal performance categories - Category A and B. The AGIR, which in Minnesota is the state Public Utilities Commission, assigns abnormal Categories I, II, and III. The process of assigning performance categories considers Area EPS needs as well as BPS needs, on a regional and wider basis.

1. Normal – Category A and B

Considering existing* and future high penetration DER conditions, and the example decision tree in Annex B of IEEE 1547, the assignment of the category for reactive power capabilities and voltage regulation performance of DER in Minnesota shall be as follows:

Technology	Normal performance category
Inverter-based DER	Category B
Synchronous machine generation	Category A

Table 2 – Normal performance category assignment

The above assignment of Categories A and B is expected to cover the vast majority of interconnections. Any instances that do not fall within the above assignment shall be:

1) reviewed on a case-by-case basis, with the Area EPS making determination** for requiring Category A or B; or

2) have performance category assignment specified in the Area EPS Operators TSM

*At the time this document is being written, portions of the Area EPS in Minnesota are exhibiting power flow characteristics of a high penetration DER environment. Based on these localized pockets of high penetration at the Area EPS level, a future with high penetration both at the Area EPS and bulk power system is considered when assigning performance categories in Minnesota.

**The Area EPS Operator should consider Annex B of IEEE 1547 when making these determinations on a case-by-case basis or in TSM requirements.

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Abnormal Performance Category Assignment

Considerations for Abnormal Performance Category (I,II,III) Assignments (Annex B, p. 112)

- Is it impractical for the given DER type to be designed to meet Category II or III performance?
- Is there a societal benefit provided by the DER type that offsets the potential adverse impact on system security due to reduced capability?
- Is the projected penetration of all DER types allowed to interconnect with Category I performance relatively small compared to the total load level in the region?

  In areas of particularly high DER penetration and where nuisance tripping of DER could cause voltage collapse or system overloads, requirements for DER to meet Category III performance may be necessary.

Regulated Utilities’ Proposal (p. 21)

- The abnormal performance category assignment should also consider a future level of DER penetration that could impact the bulk power system if not properly coordinated. The Area EPS Operators in the state of Minnesota shall constructively work with the Regional Transmission Operator to determine whether Category II or Category III is the proper be the default category assignment for inverter based DER. The decision shall balance the needs of the Area EPS and Local EPS with BPS considerations. All synchronous machine DER shall be assigned Category I. Any instances that do not fall within the above assignment shall:

  1) be reviewed on a case-by-case basis, with the Area EPS making determination* for requiring Category I,II or III; or

  2) have performance category assignment specified in the Area EPS Operators TSM

* The Area EPS Operator should consider Annex B of IEEE 1547 when making these determinations on a case-by-case basis or in TSM requirements.

Recommended Starting Point for Abnormal Performance Category Assignments (Annex B, p. 113)

For Discussion Reference only. Do not duplicate. Source: IEEE P1547

Table B-1— Example Abnormal Performance Category Assignment Grid[147]

	DER Type	DER Application Purpose						
		Retail Self Generation	Combined Heat and Power	Waste Fuel Recovery	Renewable Energy	Merchant Generation[a]	Critical Backup[b]	Peak Shaving
		A	B	C	D	E	F	G
1	Engine or turbine driven synchronous generator	Category I	Category I	Category I	Category I	Category I	Category I	Category I
2	Wind turbines (all types)	Category II	N/A	N/A	Category II	Category II	N/A	N/A
3	Inverters sourced by solar PV	Category II[c]	N/A	N/A	Category II[c]	Category II[c]	N/A	N/A
4	Inverters sourced by fuel cells	Category I	Category I	Category I	Category I	Category II	Category I	N/A
5	Synchronous hydrogenerators	Category I	N/A	N/A	Category I	Category I	Category I	N/A
6	Other inverter applications	Category II	Category II	Category II	Category II	Category II	Category II	N/A
7	Inverters sourced by energy storage	Category II	N/A	N/A	N/A	Category II	Category II	Category II
8	Other synchronous generators	Category I	Category I	Category I	Category I	Category I	Category I	N/A
9	Other Induction generators	Category II	Category II	Category II	Category II	Category II	Category II	Category II

NOTE a—Merchant generation in this table is intended to characterize DER facilities installed for the express purpose of exporting power, and is not intended to imply only FERC-jurisdictional generation or other regulatory definitions.
NOTE b—Only applies to critical backup generation interconnected to the Area EPS for the purposes of periodic testing. If backup generation is also used for merchant generation or other purposes, the performance requirements of those purposes apply.
NOTE c—Category III should be required where DER penetration on a distribution feeder exceeds [% VALUE TO BE SPECIFIED BY AGIR], or on the distribution system supplied from a given distribution substation bus exceeds [% VALUE TO BE SPECIFIED BY AGIR].

Interim Implementation?

Step	Timeline
IEEE 1547 2nd Edition (2018) Published	April 6, 2018
MN Statewide Technical Requirements Approved	*1Q 2019*
UL 1741 Interim SRD for IEEE 1547 2nd Edition (2018)	*TBD. Expected to address about 85% of 1547 2nd Edition.*
IEEE 1547.1 Published	*Mid-to-late 2019*
UL 1741 Certified Products Available on Market	*18 months after IEEE 1547.1 Published (~2020)*

- Some areas (CA, HI, ISO-NE) are developing interim implementation using UL 1741SA (contains some, but not all of the functionality required in IEEE 1547-2018.) If this approach, TSG must discuss the Source Requirements Document:

Location	SRD
California	Rule 21
Hawaii	14H
ISO-NE	1547-2018

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
May 18	Reactive Power and Voltage/Power Control Performance; Protection Requirements
June 8	Energy Storage; Non-export; Inadvertent export; Limited export
July 20	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Aug 10	Test and Verification; Witness Test Protocol
Sept 14	References; Definitions; 1-line diagram requirements; Agreements

Next Steps

March 29	Phase I Draft Staff Recommendations Comments Due
April 6	Prep work for TSG Mtg #2 Due
April 13	TSG Mtg #2: Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
REVISED: April 20	Phase I Reply Comments Due
May 11	Prep work for TSG Mtg #3 Due
May 18	TSG Mtg #3: Reactive Power and Voltage/Power Control Performance; Protection Requirements
May 2018	Agenda Meeting re: Phase I

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Thank You!

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PREP WORK

Subgroup members review agenda and provide the following to staff by 6/4/18:

1) **Propose edits to the Regulated Utilities' TIIR Draft Proposal (Sections 5-7, p. 21-23) and/or flag topics for discussion. Send as red-lines/track changes to the 4-11-18 draft of Regulated Utilities' TIIR proposal (attached).**
    a. Voltage regulation and control methods using reactive power control; Section 5
    b. Voltage and Active Power Control; Section 5C
    c. Voltage and Frequency Ride-Through as a response to Abnormal Conditions (Section 6)
    d. Protection requirements as a Response to Faults (Section 7)
2) **Review and be prepared to reference IEEE 1547-2018 (Clauses 4.8, 5.1-5.4, 6.1.-6.4)**
    a. Voltage regulation by Reactive Power Control; Clauses 5.1 – 5.3
    b. Voltage and Active Power Control; Clause 5.4
    c. Voltage Ride-Through as a response to Abnormal Conditions; Clauses 6.1 - 6.4
    d. Protection requirements (Clauses 4.8 and 6.1-6.4)
3) **Please provide examples of the following if possible.**
    a. Controlling voltage by reactive power control using constant power factor mode
    b. Operations leveraging default settings for normal operating performance in Table 8 of IEEE 1547-2018 (page 39)
        i. Please share any lessons learned.
    c. Making updates to voltage and reactive power control settings
        i. How long did it take?
        ii. What type of DER was involved?
        iii. Where there any cost implications?
    d. Making updates to voltage and active power control setting
        i. How long did it take?
        ii. What type of DER was involved?
        iii. Where there any cost implications?

See end of Draft Agenda for more details regarding TIIR and 1547-2018 references. Please copy michelle.rosier@state.mn.us and pam.johnson@state.mn.us on your prep work responses.

Technical Subgroup Meeting 3 DRAFT AGENDA
Friday, June 8th
9:30am – 12:30pm
WebEx: https://global.gotomeeting.com/join/432598661

Time	Topic
9:30 – 9:45	Welcome, Introductions, Overview of Agenda, Expectations
9:45 – 9:50	Recap and highlights of some of the new suggestions re: Section 4; Performance Categories
9:50 – 9:55	IREC Presentation on Regulation Functions and Consumer Protections
9:55 – 10:35	Voltage Regulation via Reactive Power Control: Normal Conditions
10:35 – 11:20	Voltage and Active (Real) Power Control
11:20 – 11:55	Voltage Ride-Through as a response to Abnormal Conditions
11:55 – 12:20	Protection Requirements as a Response to Faults
12:20 – 12:30	Meeting Evaluation & Next Steps

Phase II Technical Subgroup Roster:

Jeff Schoenecker/Craig Turner, Dakota Electric	Robert Jagusch, MMUA	Patrick Dalton/John Harlander/Alan Urban, Xcel Energy
Lise Trudeau, Dept of Commerce	Kevin McLean/Jenna Warmuth, MN Power	~~Natalie McIntire/TBD, Wind on the Wires~~
Mike McCarty/Katie Bell, EFCA	Kristi Robinson, MREA	John Dunlop/Chris Jarosch, MNSEIA
Brian Lydic/Sky Stanfield/Laura Hannah – Joint Movants	Dean Pawlowski, Otter Tail Power	Commissioner Matt Schuerger; Michelle Rosier; Cezar Panait
Tam Kemabonta/Professor Mahmoud Kabalan, St. Thomas Affiliation		Technical Assistance*: Michael Coddington and Michael Ingram, National Renewable Energy Laboratory Tom Key, Jens Boemer, Nadav Enbar; Electric Power Research Institute Pam Johnson, DOE Solar Energy Innovator Fellow

*Technical assistance is not a participant or party to the docket and does not advocate for specific outcomes in the proceeding. The role of technical assistance is to support Commission staff in the process for these proceedings, and to provide an objective source of information or data, as requested, by Commission staff to understand areas of disagreement amongst participants.

Draft Meeting Topics Proposal:

Date	**Topic**
3/23/18	Meeting 1 Scope/Overview** (Walk-through with explanations: Red-lined TIIR; List of topics in scope of TSMs; Definitions
4/13/18	Meeting 2 Performance Categories**; Response to abnormal conditions; MISO Bulk Power System
6/1/18	Full DGWG Meeting Technical Subgroup update; Phase I Update/Next Steps
6/8/18	Meeting 3 Reactive Power and Voltage/Power Control Performance**; Protection Requirements
7/20/18	Meeting 4 Energy Storage**; Non-Export and Inadvertent Export**; Capacity
8/3/18	*July 20 topics continued*
8/10/18	Meeting 5 Interoperability** (Monitor and Control Criteria); Metering**; cyber security
9/14/18	Meeting 6 Test and Verification**; Witness Test Protocol
10/19/18	Meeting 7 References; Definitions*; 1-line diagram requirements; Agreements*, Frequency Response and Ride-Through
11/9/18	Full DGWG Meeting 2

References to 6/8/18 Topics in Draft from Regulated Utilities of TIIR or IEEE 1547-2018

Reactive Power is discussed or has assumptions about how it is treated in the following places, i.e. not merely mentioned or defined (Focus is TIIR draft Section 5)

- Draft TIIR
  - Page 20-21 in the discussion of Category A and B assignment (IEEE citing)
  - Page 21-24 in Reactive Power Capability and Voltage/Power Control Performance (Section 5)
  -
- IEEE 1547-2018
  - Clause 5.1
  - Clause 5.2, Reactive Power Capability of the DER
  - Clause 5.3.1, Voltage and Reactive Power Control

Protection Requirements are discussed in the following places, i.e. not merely mentioned or defined (Focus is TIIR draft Section 7)

- Draft TIIR
  - Pages 25-26 in Protection Requirements (Section 7)
  - See figure on Page 37 in Annex B; Clarification on RPA, PoCC, PoC, and Supplemental DER Devices for relevant physical drawing with regards to relative locations, as it is relevant to protection requirements.
  - Other places protection requirements come up, but we propose not focusing on during June 8 meeting
    - Page 31 in Energy Storage Load Aspects (Section 10, Subsection C)
    - Pages 32-33 in Non-Exporting and Inadvertent Export Functional Definition and Requirements and Testability (Section 11, Subsections B and C)
- IEEE 1547-2018
  - 4.8 Isolation Device
  - Are there other parts of Clause 4 specifically in reference to Protection Requirements?
    - Page 35 in Protection from EMI in 4.11.1 (possibly not of enough relevance to cite)
    - Annex E
  - Clause 6.1; Introduction
  - Clause 6.2, Area EPS faults and open phase conditions
  - Clause 6.3; Area EPS reclosing coordination
  - Clause 6.4; Voltage
  - Other places protection requirements come up, but we propose not focusing on during June 8 meeting
    - Clause 6.5 Frequency

Abnormal conditions are discussed or has assumptions about how it is treated in the following places

- Draft TIIR
  - Page 25 in Response to Abnormal Conditions (Section 6)
- IEEE 1547-2018; 6.1 through 6.4, with focus on the following two sections
  - Clause 6.1, Introduction
  - Clause 6.4, Voltage (Note: this is a long section)

Phase II Technical Subgroup Meeting #3
June 8, 2018
(Docket No. 16-521)

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https://mn.gov/puc

Agenda

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, Expectations
9:40 – 9:45	Recap and highlights of some of the new suggestions re: Section 4; Performance Categories
9:45 – 9:55	IREC Presentation on Regulation Functions and Consumer Protections
9:55 – 10:35	Voltage Regulation via Reactive Power Control: Normal Conditions
10:35 – 11:20	Voltage and Active (Real) Power Control
11:20 – 11:55	Voltage Ride-Through as a response to Abnormal Conditions
11:55 – 12:20	Protection Requirements as a Response to Faults
12:20 – 12:30	Meeting Evaluation & Next Steps

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
June 8	Reactive Power and Voltage/Power Control Performance; Protection Requirements
July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 3	*July 20 topics continued*
Aug 10	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 14	Test and Verification; Witness Test Protocol
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

Glossary/Phrases used interchangeably in this presentation

- Volt-var mode = Voltage-reactive power mode (IEEE 1547-2018, p. 37)
- Watt-var mode = Active power-reactive power mode (IEEE 1547-2018, p. 37)
- Normal operating performance category = inside the continuous operation region (TIIR Section 3B and IEEE 1457; Definitions)
- Reference point of applicability (RPA): The location where the interconnection and interoperability performance requirements specified in this standard apply. (TIIR Section 3B)
- Reference point of applicability: The reference point of applicability (RPA) is the location where the interconnection and interoperability performance requirements specified in this standard shall be met. (IEEE 1547-2018, Clause 4.1, p. 27)

Recap: Normal Performance Category Assignments (Draft TIIR, Section 4, p. 20-21)

Based on IEEE 1547, The Area EPS Operator assigns normal performance categories - Category A and B. The AGIR, which in Minnesota is the state Public Utilities Commission, assigns abnormal Categories I, II, and III. The process of assigning performance categories considers Area EPS needs as w regional and wider basis.

TSG discussion flagged Annex B, Fig. B1 and PUC authority/ responsibility . Further discussion/edits needed.

1. Normal Performance Categories– Category A and B

Considering existing* and future high penetration DER conditions, and the example decision tree in Annex B of IEEE 1547, the assignment of the category for reactive power capabilities and voltage regulation performance of DER in Minnesota shall be as follows:

Technology	Normal performance category
Inverter-based DER	Category B
Synchronous machine generation	Category A

Table 2 – Normal performance category assignment

4/13 TSG flagged clarification: Does "voltage regulation performance" mean "modes of performance when enabled"?

The above assignment of Categories A and B is expected to cover the vast majority of interconnections. Any instances that do not fall within the above assignment shall be:

1) reviewed on a case-by-case basis, with the Area EPS making determination** for requiring Category A or B; or

2) have performance category assignment specified in the Area EPS Operators TSM

4/13 TSG flagged questions about how case-by-case review works (proposed at time of screening or technical review), and what role stakeholders/Commission would have.

~~*At the time this document is being written, portions of the Area EPS in Minnesota are exhibiting power flow characteristics of a hig environment. Based on these localized pockets of high penetration at the Area EPS level, a future with high penetration both at the system is considered when assigning performance categories in Minnesota.~~

**The Area EPS Operator should consider Annex B of IEEE 1547 when making these determinations on a case-by-case basis or in TSM requirements.

Additional edits have been made to the sections discussed last time that we may discuss later

- A proposal has been made for how to determine alternative performance categories. How should we proceed to determine the criteria? (Page 25 of Draft TIIR 6-5-18, Section 5E)
  - Category A may be utilized instead of Category B under mutual agreement between the DER operator and Area EPS operator where the aggregate generation of the DER type, including the proposed DER, is less than 1% of the substation ~~annual peak~~ load as most recently measured. (IREC)
- A proposal has been made to move Assignment of alternative performance categories for Abnormal Conditions (Section 6E) to Section 4; Performance Categories (Xcel).
  - Is there also a proposal to move the Assignment of alterative performance categories for Normal Conditions to Section 4; Performance Categories? (Section 5E of Draft TIIR page 25)

Response to Abnormal Conditions

Ride-through and frequency droop

Suggest MN TIIR requires default trip settings for abnormal voltage and frequency responses

- Proposed MN TIIR requires including distribution utilities in processes initiated at the MISO level to change abnormal response parameters from default settings in IEEE 1547-2018 Sections 6.4 and 6.5.
  - Not enforceable, but rather intended to communicate importance of sticking to defaults and the effort involved in implementing changes from default.

- Draft MN TIIR is silent on frequency droop, but Xcel Energy would support adding, as proposed by a comment, if default values are used.

- Propose modifying Draft MN TIIR frequency trip settings to be statewide only by removing language allowing changes in a TSM.

Regulation Functions and Consumer Protection

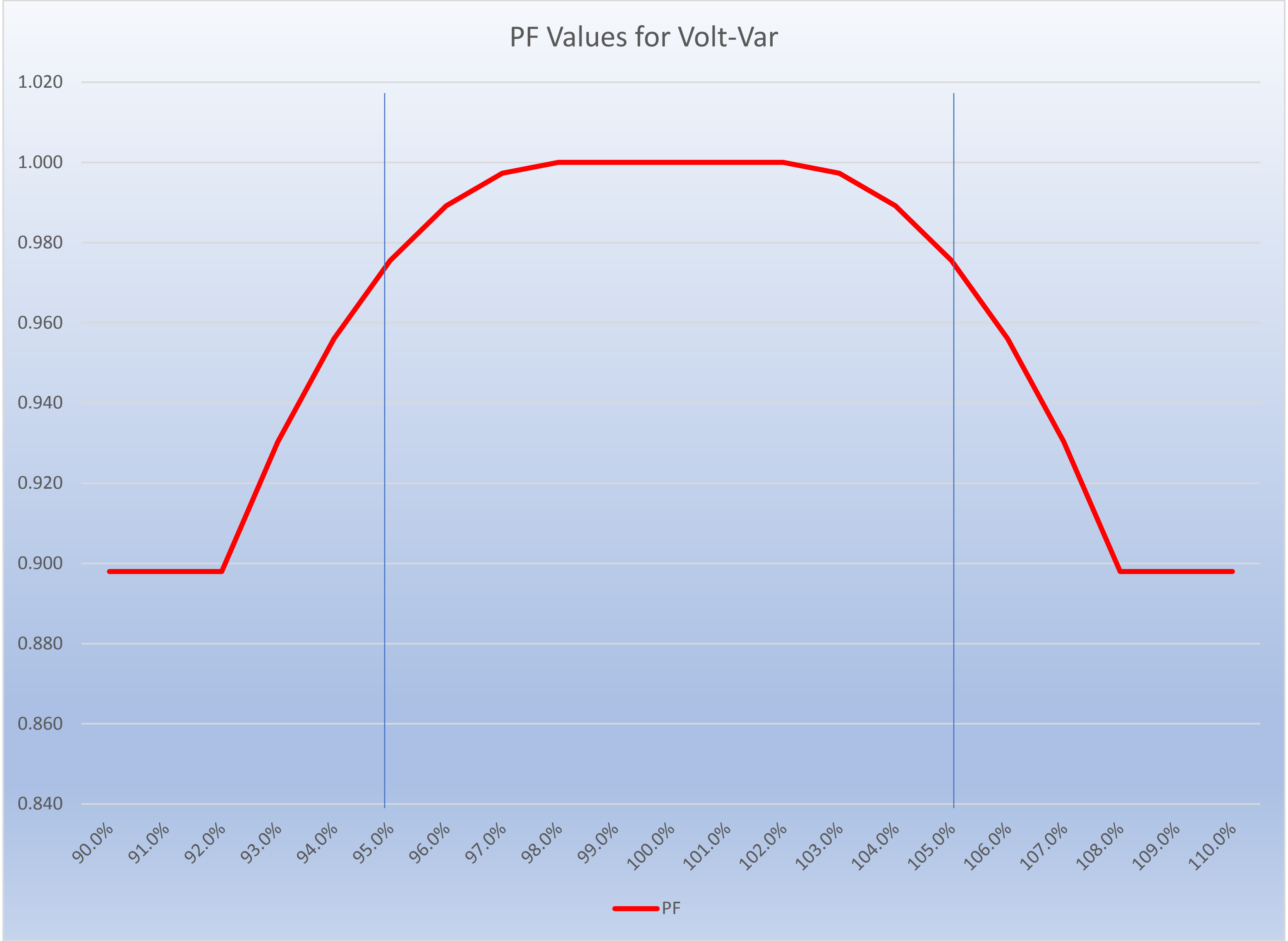
Guiding Principles

- Settings commissioned today will be challenging to update in the future (due to lack of control channels).
- Prepare for high penetration now. If it happens in the future, the prep will be useful.
- In general, high penetration settings shouldn't greatly impact customers or utility in near-term (low penetration).
- However, prepare for those impacts and ensure parties have recourse.
- DER should provide "self mitigation."
- DER can be a grid resource. They should not be required to provide grid services (unless contracted and/or compensated to do so).

Voltage Regulation

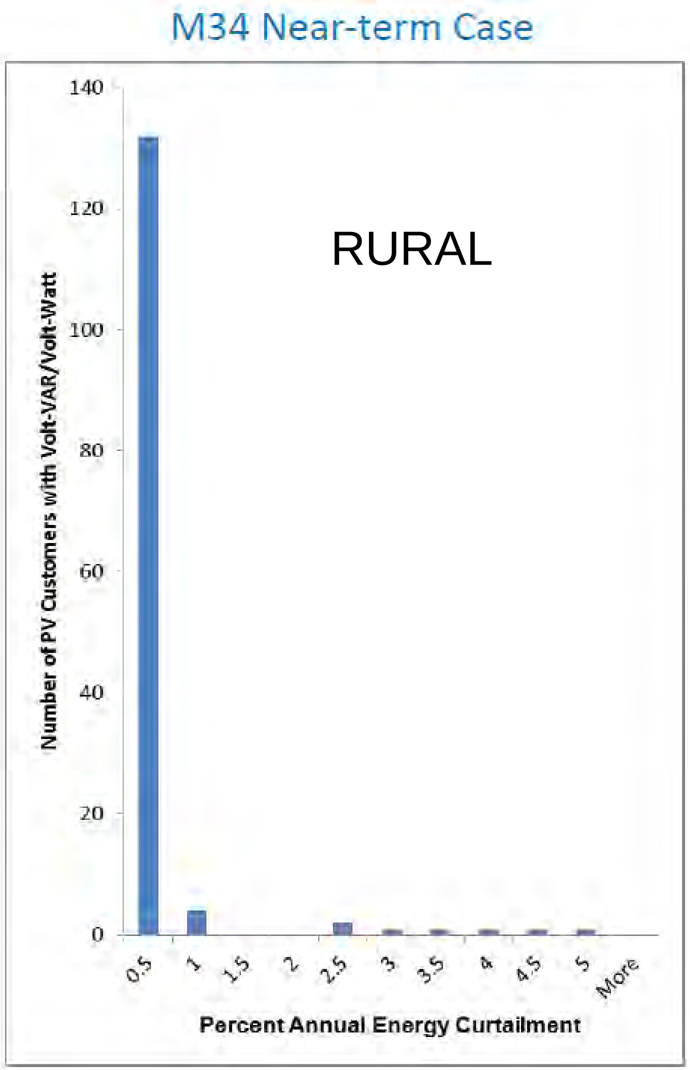
- Voltage regulation can be used as self mitigation as well as a service.
- There is a blurred line between the two.
- IEEE 1547 default settings for volt-var and volt-watt are “gentle” within ANSI B and “extreme” outside ANSI B

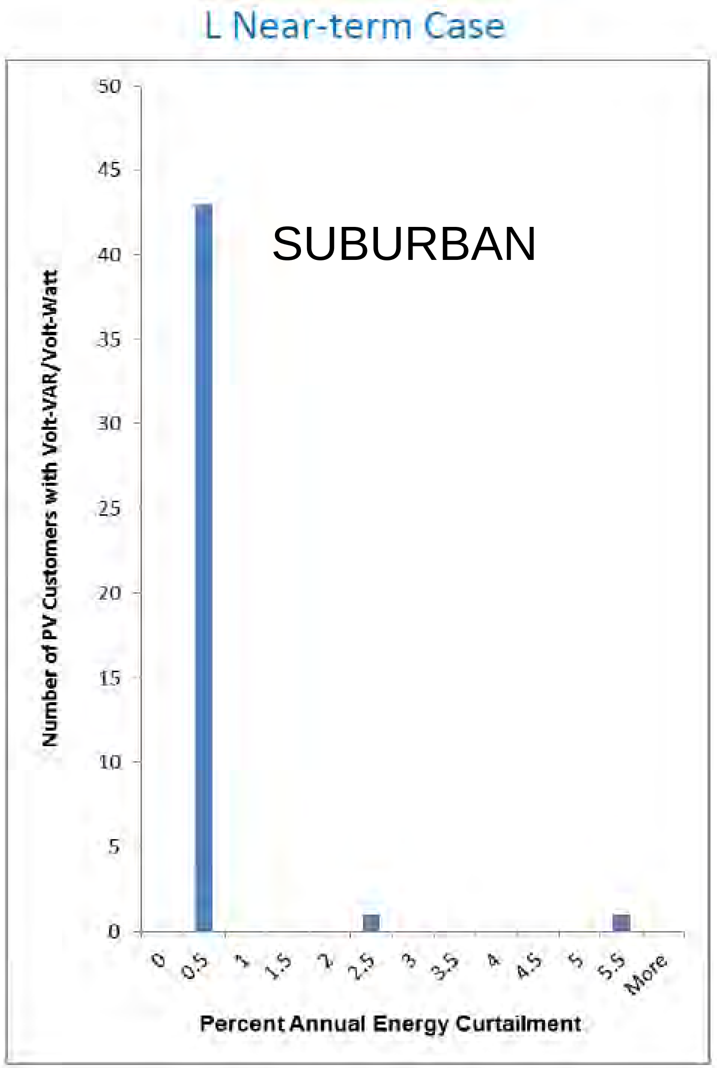
IEEE 1547 DEFAULT VOLT-VAR



Power Factor

Voltage





Credit: Giraldez, NREL

@IRECUSA

Measurement and Data

- Customers cannot know ahead of time how they might be impacted by voltage.
- We do not know how well the utilities regulate voltage on all circuits subject to DER interconnection (do we?).
- Utilities are in the best position to provide voltage data (through AMI or other instrumentation).
- Stakeholders/customers should have confidence that a) voltage is well-regulated, and/or b) they will be compensated for regulation services if it is not.
- We need data to gain that confidence.

Recourse

- Customer complaint process
- Changing settings (e.g. V_{ref}, volt-watt threshold)
- Compensation
- Reporting utility>PUC on complaint and resolution process

- Consider threshold of *var-hours* or *hours in curtailment* to determine mitigation vs service

Correction: Table – Voltage – Active Power Settings (IREC edit, TIIR, 5(D))

- IREC earlier edit of TIIR accidentally used the Watt-Var Table. IREC recommends including this IEEE 1547 Volt-Watt table:

Voltage-active power parameters	Default Settings
V_1	1.06 V_N
P_1	P_{rated}
V_2	1.1 V_N
P_2 (applicable to DER that can only generate active power)	The lesser of 0.2 P_{rated} or P_{min}[a]
P'_2 (applicable to DER that can generate and absorb active power)	0
Open loop response time	10s

Source: Brian Lydic Email, 6/7/18; IEEE 1547, Clause 5.4.2, Table 10, p. 41

General Notes – Normal Response

- **Draft MN TIIR Implementation details for both Real and Reactive in Section 5A**
  - Interoperability interface when applicable
  - Manual updates – 48 hours, mutual agreement or TSM
    - Sensitivity considered when determining time frame

- ***Reactive* power control functions for *normal (long term operating)* voltage conditions and Real power control for contingency (unplanned emergency or temporarily maintenance) voltage conditions**

- **MN TIIR use of real and reactive controls is for mitigating *DER feeder impacts*, within defined parameters.**

Voltage and Reactive Power Control

Reactive Power Capabilities and Control Functions

Table 6—Voltage and reactive/active power control function requirements for DER normal operating performance categories

DER category	Category A	Category B
Voltage regulation by reactive power control		
Constant power factor mode	Mandatory	Mandatory
Voltage—reactive power mode[a]	Mandatory	Mandatory
Active power—reactive power mode[b]	Not required	Mandatory
Constant reactive power mode	Mandatory	Mandatory
Voltage and active power control		
Voltage—active power (volt-watt) mode	Not required	Mandatory

[a]Voltage-reactive power mode may also be commonly referred to as "volt-var" mode.
[b]Active power-reactive power mode may be commonly referred to as "watt-var" mode.

Table 7—Minimum reactive power injection and absorption capability

Category	Injection capability as % of nameplate apparent power (kVA) rating	Absorption capability as % of nameplate apparent power (kVa) rating
A (at DER rated voltage)	44	25
B (over the full extent of ANSI C84.1 range A)	44	44

Source: IEEE 1547-2018, Table 6 and Table 7

Use of Reactive Power Capabilities

Proposed MN TIIR Section 5A

As defined by IEEE 1547, and the applicable performance category, the full range of the DER reactive power capability shall be available for use by the Area EPS Operator for the purpose of mitigating impacts of DER on the Area EPS.

IEEE 1547-2018, 5.3.1

The approval of the Area EPS operator shall be required for the DER to actively participate in voltage regulation.

The DER operator shall be responsible for implementing setting modifications and mode selections, as specified by the Area EPS operator within a time acceptable to the Area EPS operator.

Default Reactive Power Function Mode

Proposed MN TIIR, Section 5

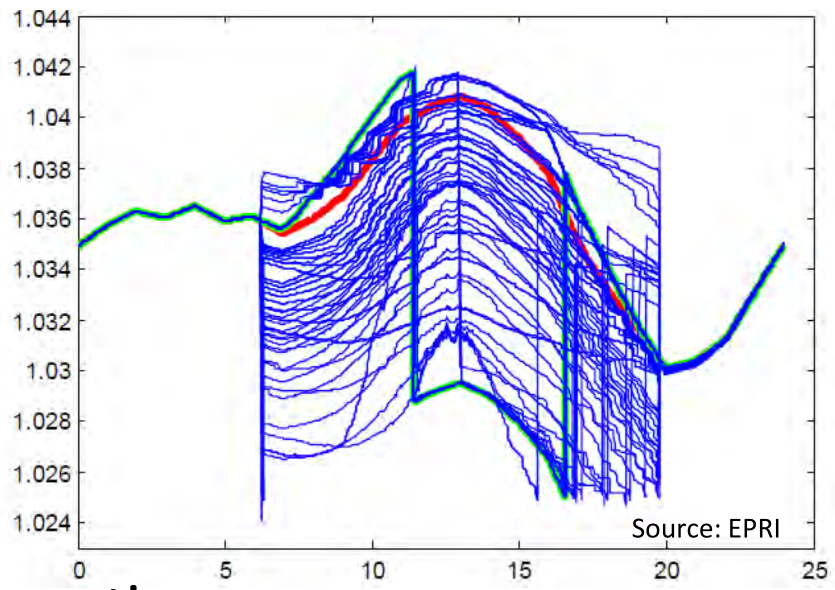
The DER shall be installed with constant power factor mode with 0.98 power factor settings, absorbing reactive power, unless otherwise specified by the Area EPS Operator.

IEEE 1547-2018, 5.3.1

Constant power factor mode with unity power factor setting shall be the default mode of the installed DER unless otherwise specified by the Area EPS operator.

Volt-Var Control Considerations

1. Volt-VAr response and system impacts are dependent on settings



2. The IEEE 1547 default maximum reactive power requirement is equivalent to a power factor of approximately +/- 0.9 for category B for voltages < 0.92 or > 1.08 p.u.

3. Power factor of about +/- 0.95 reached near upper and lower ANSI C84.1 limits for default settings

Reactive Power Control Settings Change Process

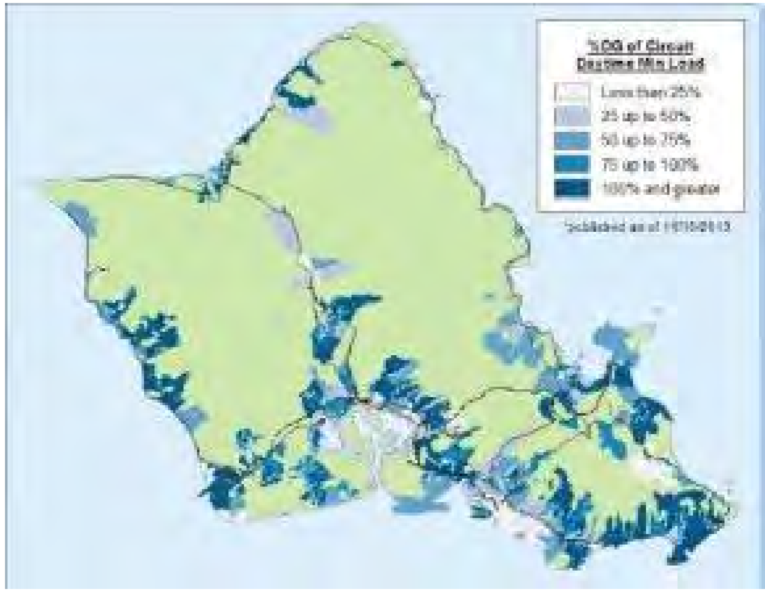
- Operating Agreement defines range of allowable parameters and implementation requirements
  - Typically a power factor range of +/- 0.9
  - Power factors required can change over time based on additional DER or load changes
  - Implementation timeframe: *"Xcel Energy shall provide reasonable advance notice to Interconnection Customer pursuant Section XII(B) of the Generating System Interconnection Agreement in order to coordinate the implementation of such changes*."

- Ease of implementation depends on DER design
  - For large plants, central versus string inverters
  - Local manual changes versus remote/automated changes

Example importance of interoperability functions - Hawaii case study

- In 2014, Hawaii was headed for a repeat of Germany's "50.2 Hz problem"
    - o Inverters could trip en masse due to frequency excursion, worsening excursion and potentially blacking out grid
- In February 2015, Enphase remotely reprogrammed 800,000 inverters (154 MW) in Hawaii to enable frequency ride-through
- Required close coordination between utility and inverter manufacturer

Oahu feeder PV penetration



Enphase inverter locations

Slide used with courtesy of Dr. Andy Hoke, NREL

Figure credit: https://www.greentechmedia.com/articles/read/enphase-to-help-hawaii-ride-its-solar-energy-wave#gs.4gZ7w1Q

Source: David Narang, NREL, 3/12/18, MN PUC/OMS 1547 Workshop

Discuss: Voltage Regulation and Reactive Power Control under Normal Operating Conditions

- TIIR Section 5A cites IEEE 1547 (Clause 5.2) which states that the full range of the DER reactive power capability shall be available for use by the Area EPS Operator
  - If no communication channel exists, the DER Operator shall update settings (to) implement the changes *within 48 hours* of the Area EPS submitting the change request per the Area EPS established protocol defined in agreements or; within some other mutually agreed upon timeframe between the Area EPS Operator and the DER Owner or; within the protocol defined in the Area EPS Operator's TSM (TIIR Section 5A page 22 Simple Markup)
- Discuss implications on schedule
  - When can the Area EPS Operator request a change for what the DER is utilizing?
  - What is the timeframe in which this must be implemented?

Discuss: There are multiple proposals in the TIIR regarding a default setting being enabled for normal operating conditions

- IEEE 1547, Clause 5.3.1 states: Constant power factor mode with *unity power factor* setting [62] shall be the default mode of the installed DER unless otherwise specified by the Area EPS operator.
- Proposals in TIIR have included (TIIR Sections 5A and 5B; Pages 21-23 of 6-5-18 Draft and earlier edits)
  - Constant power factor mode of 0.98
  - Voltage-reactive power mode (Volt-var), with default settings from IEEE 1547-2018 Table 8
- What implications (including possible benefits) do these settings have for different stakeholders?
- Experience other jurisdictions have had include
  - Constant power factor mode with 0.95 PF: Hawaiian Electric territory Rule 14 parties from Jan ‘16 to Mar ’18
  - Volt-var settings similar (but not identical) to Table 8 of IEEE 1547-2018: Hawaiian Electric territory Rule 14 parties since ~Mar ’18
  - Volt-var with voltage and reactive power setpoints that vary from 1547-2018: CA IOU Rule 21 since Sept. 2017

IEEE 1547-2018 Footnote 62: DER may operate at any power factor, e.g., for the purpose of compensating for the reactive power demand of the Local EPS, as long as the power factor requirements specified by the Area EPS are met at the RPA.

Voltage and Active (Real) Power Control

Default State and Settings for of Volt-Watt

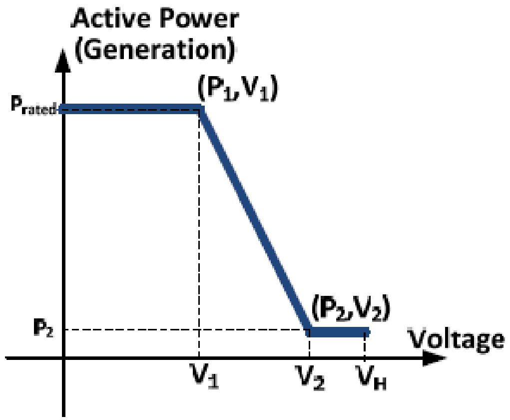
Proposed MN TIIR, Section 5C

When equipment conforming to IEEE 1547-2018 standard is available, unless otherwise specified by the Area EPS Operator, all DER installed in Minnesota on a go-forward basis shall be installed with the voltage-active power function enabled with default settings used.

IEEE 1547-2018, 5.4.2

Enabling/disabling this function is at the discretion of the Area EPS operator. The default is that this function is disabled.

Voltage-active power parameters	Default settings
V_1	$1.06\ V_N$
P_1	P_{rated}
V_2	$1.1\ V_N$
P_2 *(applicable to DER that can only generate active power)*	The lesser of $0.2\ P_{rated}$ or P_{min} [a]



V_H: Voltage upper limit for DER continuous operation

Source: IEEE 1547-2018, Table 10 and Figure H.6

Active Power Control Settings Change Process

- Limited experience due to lack of approved standard functions, until recently, and lack of availability for IEEE 1547-2018 compliant equipment.

- Solar Gardens over production example:
  - A few 3-5 MW plants from one Developer were producing up to 108% of Interconnection Agreement approved capacity

Discuss: Voltage and Active Power Control Settings

- When equipment conforming to IEEE 1547-2018 standard is available, unless otherwise specified by the Area EPS Operator, the DER shall operate with the voltage-active power function enabled with the following default settings [28]. The default in IEEE 1547 is to disable voltage-active power function . The TIIR requirement may necessitate a settings change from the default settings that a DER will contain when shipped from a manufacturer. (TIIR pages 23 and 25, Section 5D)
- IEEE 1547-2018 has this disabled; discuss implications of enabling (Clause 5.4.1)
  - Manufacturers' process
  - UL listing
  - Availability of voltage vs. active power profiles at the time the standard becomes effective
- Discuss expected evolution
  - In understanding of settings that are best in certain use cases
  - In technology that allows for and encourages more frequent changes in settings

MN DER TIIR Footnote 28: The default IEEE 1547 volt-watt default setting will not begin curtailing real power until the voltage is beyond 1.06 per unit voltage, which is the upper end of the range of normal voltages allowed under ANSI C84.1.

Response to Abnormal Conditions/ Protection

Response to Abnormal Conditions/ Protection

Area EPS Faults and Open Phase Conditions; Reclose coordination

Condition	IEEE 1547-2018	Draft MN TIIR
Area EPS Faults	Cease to energize and trip	Cease to energize and trip
Open Phase	Cease to energize and trip* all phases	Cease to energize and trip* all phases

* the 2-second anti-islanding requirement applies for the open phase condition

MN TIIR is Section 7 (Protection), where IEEE 1547 is in Section 6.2 and 6.3 with Response to Abnormal Conditions. This could be harmonized by moving some MN TIIR content from Section 7 into new sub-sections in Section 6 to be consistent with the 1547 document structure.

Response to Abnormal Conditions/ Protection

Area EPS reclosing coordination

Proposed MN TIIR, Section 7

The restore output settings of the DER shall be coordinated with the Area EPS reclosing timing.

IEEE 1547-2018, Section 6.3

Appropriate means shall be implemented to help ensure that Area EPS automatic reclosing onto a circuit remaining energized by the DER does not expose the Area EPS to unacceptable stresses or disturbances…

IEEE 1547-2018 voltage ride-through detail example (Category II is shown)

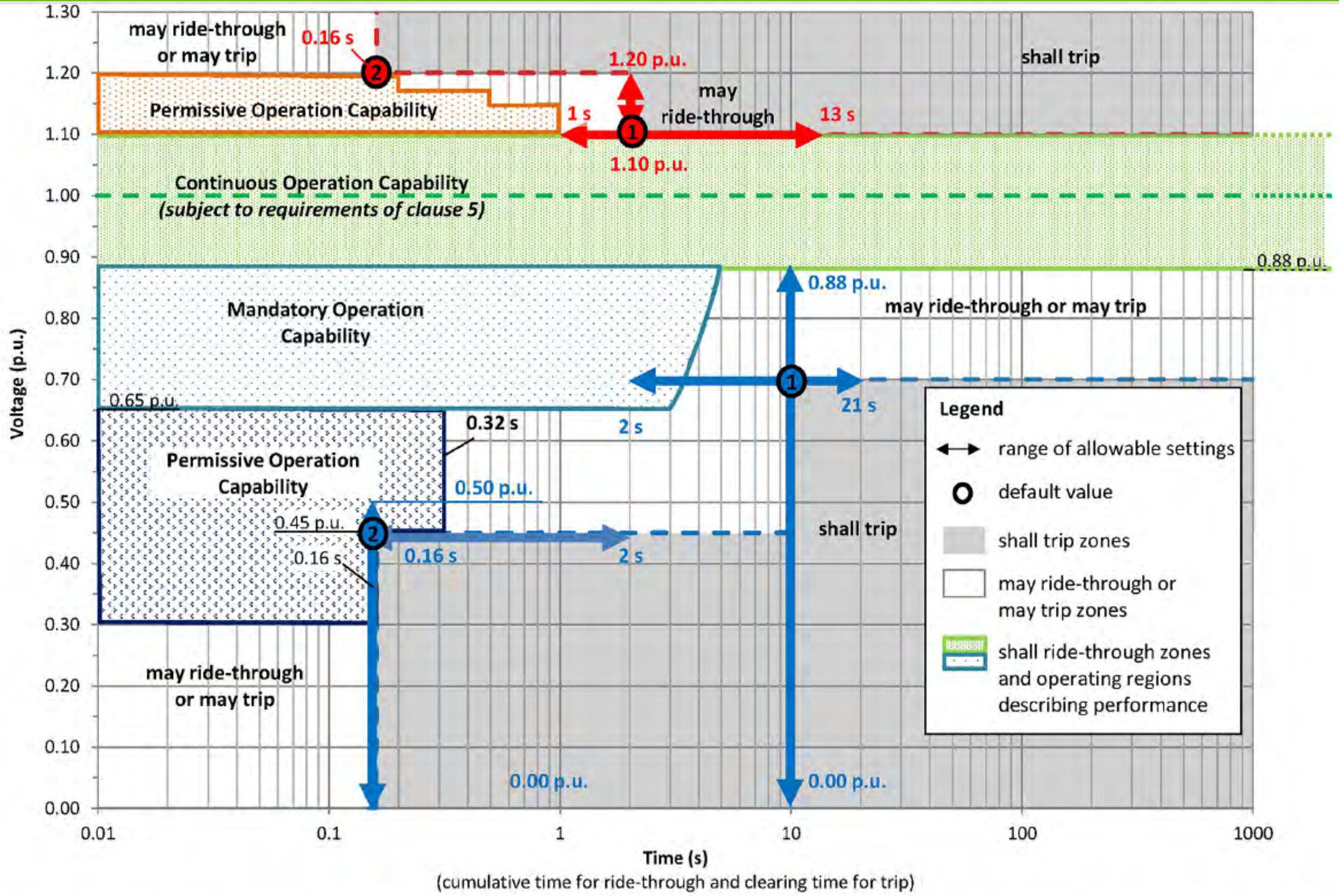


Figure H.8—DER response to abnormal voltages and voltage ride-through requirements for DER of abnormal operating performance Category II

Source: IEEE 1547-2018, p. 134

Protection – MN TIIR Proposal

- TIIR and TSM requirements are to protect Area EPS and customers from adverse DER impacts. Protection of the DER is out of scope.
- Protection may be required to limit Area EPS exposure to reliability impacts or in other unique circumstances such as low voltage secondary network interconnections.
- Proposed TIIR specifies the TSM as location for protection requirements outside of IEEE 1547-2018.
- In general, an increased degree of protection is required for increased DER size.
- Protection equipment shall meet applicable industry standards

Discuss: Protection Requirements (Draft TIIR Section 7, page 26)

- The DER shall cease to energize and trip for faults on the Area EPS. (Draft TIIR)
- The DER shall cease to energize and trip all phases for an open phase condition occurring directly at the reference point of applicability. (Draft TIIR)
  - Is this saying for an open phase condition at the reference point of applicability (RPA)?
  - Is this saying the location at which the DER must cease to energize is at the RPA?

Discuss: Protection Requirements (slide 2 of 3)

- Regarding increased DER size, other protection and instrument transformer application may be specified by the Area EPS Operator. (TIIR Simple Markup, page 26, Section 7)
  - Has anyone thought about what these additional requirements on a given system may be? Can that be included here? Is it more than the disconnect device? (IREC comment)
- Draft TIIR Section 7, Protection Requirements, is proposed to read as follows for consistency with the MN DIP (staff).
  - If specified by Area EPS Operator's TSM, an AC disconnect shall be furnished by the DER Operator. (TIIR simple markup, page 26)
  - If required, the disconnect shall provide a visible open, be lockable, and accessible to Area EPS personnel to safely isolate the DER from the Area EPS.

Discuss: Protection Requirements (slide 3 of 3)

- Are there additional requirements beyond disconnecting and coordinating reclosing? (Comments on Page 26 of TIIR, Section 7; Protection Requirements) (IREC)

Next Steps

June 22	Draft Agendas and Prep Work Assignments from Staff to TSG
July 6	Prep work due for July 20 and Aug 3 meetings
July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 3	*July 20 topics continued*
Aug 10	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 14	Test and Verification; Witness Test Protocol
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

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Thank You!

Back Up Slides

IEEE 1547-2018 Reference for normal operating performance categories

- Focus for current topic is on top section of Table 6 for reactive power control

Table 6—Voltage and reactive/active power control function requirements for DER normal operating performance categories

DER category	Category A	Category B
Voltage regulation by reactive power control		
Constant power factor mode	Mandatory	Mandatory
Voltage—reactive power mode[a]	Mandatory	Mandatory
Active power—reactive power mode[b]	Not required	Mandatory
Constant reactive power mode	Mandatory	Mandatory
Voltage and active power control		
Voltage—active power (volt-watt) mode	Not required	Mandatory

[a]Voltage-reactive power mode may also be commonly referred to as "volt-var" mode.
[b]Active power-reactive power mode may be commonly referred to as "watt-var" mode.

Source: IEEE 1547-2018, p. 37

Discussion: Scope for Statewide Technical Requirements

These topics have been proposed as **in scope**.
Bold have been flagged for discussion.

1. Scope/Overview
2. References
3. Definitions
4. **Performance Category Assignments**
5. **Reactive Power Capability and Voltage/Power Control (volt-var & volt-watt) Performance**
6. **Response to Abnormal Conditions (Ride-through)**
7. **Protection Requirements**
8. **Metering**
9. **Interoperability (Monitoring, Control, Info Exchange, Cyber security)**
10. **Energy Storage**
11. Non-Export; Inadvertent Export
12. **Test and Verification Requirements**
13. **Agreements**
14. **Consumer Protection** (IREC)
15. **Reporting** (IREC)

(Source: "Regulated Utilities" TIIR Draft Proposal)

Discussion: Scope for Statewide Technical Requirements

1. Process requirements
2. Cost allocation
3. Interconnection to transmission system
4. **Protection system details of Area EPS or DER**
5. **Requirements or specification of system impact or facilities studies**
6. **Application of real and reactive power control functions**
7. **Details of communication networks; including architecture, technology and protocols, or other specifications related to interoperability**
8. **Details of metering requirements or specifications**
9. **Planning or operational considerations associated with Affected Systems, Regional Transmission Operator or Transmission Owners**
10. **Intentional Area EPS islanding**

These topics have been proposed as **out of scope** by some participants. Bold are flagged for additional discussion.

(Source: TIIR Draft Proposal, p. 9)

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PREP WORK for July 20th TSG (will also support Aug. 3rd TSG)

Subgroup members review agenda and provide the following to staff by 7/9/18.

1) **Propose edits to the Regulated Utilities' TIIR Draft Proposal and/or flag topics for discussion. Send as red-lines and comments using track changes to the 6-8-18 Draft TIIR.**
   a. Definitions in Section 3B for Energy Storage System, Inadvertent Export, Nameplate Ratings, Non-export
   b. Energy Storage; Section 10
   c. Non-Exporting and Inadvertent Export; Section 11
   d. Capacity (Potential future home in definition section of TIIR: Section 3B) (See MN DIP 5.14.3 in Updated Staff Recommendations attached to 5/16/18 briefing papers, p. 18-23; MN DIP 5.14.3)
2) **Review and be prepared to reference IEEE 1547-2018**
   a. Definitions in Clause 3.1
      i. Nameplate Ratings
      ii. Point of Common Coupling (PCC)
      iii. Point of DER Connection (PoC)
      iv. Reference Point of Applicability (RPA)
   b. Capacity as related to Reference Point of Applicability; Clauses 4.1 and 4.2
   c. Capability to limit active power; Clause 4.6.2
   d. Energy Storage
      i. Performance during Entering Service; Clause 4.10.3
      ii. Specifications regarding voltage-active power mode; Clause 5.4.2
      iii. Frequency ride-through exception; Clause 6.5.2.1
      iv. Frequency-droop operation; in footnote to Table 23 of Clause 6.5.2.7.2
      v. Guidelines for DER performance category assignment in Annex B; B.4.1 and Table B.1
      vi. DER intentional and microgrid island system configurations in Annex C; C.2
   e. Concept of net export ("net active power exported") is covered within
      i. Voltage ride-through exceptions; Clause 6.4.2.1
      ii. Frequency ride-through exceptions; Clauses 6.5.2.1 and 6.5.2.3
   f. Non-Exporting and Inadvertent Export; Clauses 4.9 and 8.2
3) **Please provide input to the below, slides are encouraged**
   a. During the DGWG work group and the TSG process, different proposals have been made as to the definition of capacity.
      i. How could we define capacity in a way that keeps the MN TIIR as consistent as possible with IEEE 1547-2018, the MN DIP and the MN DIA?
      ii. What are the edge cases that would have a negative impact based on the proposals you've had the most concerns about?

1. Could those edge cases be mitigated by clarifications elsewhere?

b. Considering different types of limits …such as control systems, power relay(s), or other similar device settings or adjustments (MN DIP 5.14.3); what types of limits can be easily (inadvertently or purposefully) changed after initial system interconnection?
   i. What level of impact could this have on equipment?
   ii. What level of impact could this have on people?
   iii. Are there changes in technology expected that would make this use case look significantly different?
c. What are the specific analyses within a system impact study that require full DER capacity (e.g. short circuit analysis,)?
d. Provide similarities and differences with regards to the impact on the Area EPS of energy storage compared to a traditional load.
e. Provide similarities and differences with regards to the impact on the Area EPS of energy storage compared to other distributed generation.

4) Electrical Engineering for the rest of us…(an additional request for slides)

a. Please provide a diagram(s) in which the following can be illustrated
   i. A non-exporting system influencing voltage levels within the Area EPS
   ii. A non-exporting system influencing the thermal performance within the Area EPS
   iii. A component of a non-exporting system protecting the Area EPS from fault current
   iv. An inverter from a non-exporting system contributing to fault current

----------------------------End Of Prep Work -------------------------------

Technical Subgroup Meeting 4 DRAFT AGENDA
Friday, July 20th
9:30am – 12:30pm

Join WebEx meeting

Meeting number (access code): 741 336 029
Meeting password: yH5HJy39

Join from a video system or application

Dial 741336029@mn.webex.com

Join by phone

+1 2065960378 US Toll

8443020362 US Toll Free

Global call-in numbers | Toll-free calling restrictions

Can't join the meeting?

Proposed Agenda

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, Expectations
9:40 – 9:45	Recap
9:45 – 10:10	Energy Storage, including comparing and contrasting to other load and generation
10:10 – 10:20	Case Study: Non-exporting DER influencing voltage on Area EPS
10:20 – 10:30	Case Study: Non-exporting inverter contributing to fault current
10:30 – 10:35	Case Study: Non-exporting DER providing Area EPS fault protection
10:35 – 10:45	Non-Exporting Systems
10:45 – 11:00	Discuss aspects of limiting production; high confidence systems vs. challenges 15
11:00 – 11:25	Inadvertent Export
11:25 – 11:30	Break (5 minutes)
11:30 – 11:40	System impact study assumptions that are consistent with aggregate nameplate rating
11:40 – 11:50	Unintended consequences resulting from capacity = aggregate nameplate rating
11:50 – 12:20	Capacity, including a discussion of Limits and Load
12:20 – 12:30	Meeting Evaluation & Next Steps

Phase II Technical Subgroup Roster

Craig Turner, Dakota Electric	Robert Jagusch, MMUA	Patrick Dalton/John Harlander/Alan Urban, Xcel Energy
Lise Trudeau, Dept of Commerce	Kevin McLean/Jenna Warmuth, MN Power	
Kevin Joyce/Katie Bell, EFCA	Kristi Robinson, MREA	John Dunlop/Chris Jarosch, MNSEIA
Brian Lydic/Sky Stanfield/Laura Hannah – Joint Movants	Dean Pawlowski, Otter Tail Power	Commissioner Matt Schuerger; Michelle Rosier; Cezar Panait
Professor Mahmoud Kabalan, St. Thomas Affiliation		Technical Assistance*: Michael Coddington and Michael Ingram, National Renewable Energy Laboratory Tom Key, Jens Boemer, Nadav Enbar; Electric Power Research Institute Pam Johnson, DOE Solar Energy Innovator Fellow

*Technical assistance is not a participant or party to the docket and does not advocate for specific outcomes in the proceeding. The role of technical assistance is to support Commission staff in the process for these proceedings, and to provide an objective source of information or data, as requested, by Commission staff to understand areas of disagreement amongst participants.

Draft Meeting Topics Proposal

Date	Topic
3/23/18	Meeting 1 Scope/Overview** (Walk-through with explanations: Red-lined TIIR; List of topics in scope of TSMs; Definitions
4/13/18	Meeting 2 Performance Categories**; Response to abnormal conditions; MISO Bulk Power System
5/18/18	
6/1/18	Full DGWG Meeting Technical Subgroup update; Phase I Update/Next Steps
6/8/18	Meeting 3 Reactive Power and Voltage/Power Control Performance**; Protection Requirements
7/20/18	Meeting 4 Energy Storage**; Non-Export and Inadvertent Export**; Capacity**
8/3/18	Meeting 4 topics continued
8/10/18	Meeting 5 Interoperability** (Monitor and Control Criteria); Metering**; cyber security
9/14/18	Meeting 7; Test and Verification**; Witness Test Protocol
9/21/18	Full Day, In Person TSG Meeting – Power Quality; Follow up items; Review/Reconcile edits in the draft TIIR
10/19/18	References; Definitions*; 1-line diagram requirements; Agreements*, Frequency Ride-through
11/9/18	Full DGWG Meeting 7

Phase II Technical Subgroup Meetings #4 and #5
July 20, 2018 and August 3, 2018
(Docket No. 16-521)

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July 20th Agenda (TSG #4)

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, 6/8 TSG Recap
9:40 – 9:50	Meeting Goals & Definitions
9:50 – 10:40	Draft TIIR Sec 10: Energy Storage • Storage compared to load and DER generating facilities • IREC proposed edits to Sec. 10 • Discussion
10:40 – 12:10	Draft TIIR Definitions: Capacity and Export • Xcel Case Study • Role of Capacity in Interconnection Process and Technical Review; Other Uses • Limited Capacity and Export definitions • Discussion
12:10 – 12:30	Meeting Evaluation & Next Steps; including input on 8/3 Agenda

SEE SLIDE 43 for August 3rd TSG Meeting Agenda re: Limited Export and Inadvertent Export

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
June 8	Reactive Power and Voltage/Power Control Performance; Protection Requirements
July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 3	*July 20 topics continued*
Aug 10	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 14	Test and Verification; Witness Test Protocol
Sept 21	In-Person TSG: Power Quality; Follow up items; TIIR edits discussion
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

Recap from June 8

- General consensus that Frequency Droop should be included in the TIIR as information, and that only default settings will be used. (Add page in TIIR here).
  - Suggestion that could say in the TIIR that Area EPS Operators won't make frequency droop settings unique in the TSM.
  - Acknowledgement that MISO could come back with something different on frequency than IEEE 1547-2018. Will deal with it at that time if so.
- We will meet in person September 21 to review/address red-lines provided to-date to TIIR
- We will e-file meeting slides and prep materials, but not TIIR redlines

TSG #4 and TSG #5 Meeting Goals (7/20 & 8/3)

- Discuss and address draft TIIR language and proposed edits related to Draft TIIR Sections 10 & 11 and associated definitions.

Build shared understanding of:

- Energy storage & non-exporting DER compared to traditional loads
- Impacts a non-exporting DER may have on an Area EPS system; including inadvertent exports
- What is necessary to provide adequate assurance DER export limits will not be exceeded
- The allowable duration for inadvertent exports and why
- How the TIIR proposals compare to IEEE 1547-2018; and the rationale for any exceptions/differences
- Risks (technical and other) of either under-estimating or over-estimating capacity in a screening process

IEEE 1547 Definitions

- **nameplate ratings**: Nominal voltage (V), current (A), maximum active power (kW), apparent power (kVA), and reactive power (kvar) at which a DER is capable of sustained operation. NOTE—For Local EPS with multiple DER units, the aggregate DER nameplate rating is equal to the sum of all DERs nameplate rating in the Local EPS, not including aggregate capacity limiting mechanisms such as coincidence factors, plant controller limits, etc., that may be applicable for specific cases. (IEEE 1547-2018, Clause 3.1, p. 24)

- **distributed energy resource (DER):** A source of electric power that is not directly connected to a bulk power system. DER includes both generators and energy storage technologies capable of exporting active power to an EPS. An interconnection system or a supplemental DER device that is necessary for compliance with this standard is part of a DER. [23] (IEEE 1547-2018, Clause 3.1, p. 22)

  - [23] Equivalent to "distributed resources (DR)" as defined and used in IEEE Std 1547-2003.

- **Reference point of applicability**: The reference point of applicability (RPA) is the location where the interconnection and interoperability performance requirements specified in this standard shall be met. (IEEE 1547-2018, Clause 4.1, p. 27)

- **Load**: Devices and processes in a local EPS that use electrical energy for utilization, exclusive of devices or processes that store energy but can return some or all of the energy to the local EPS or Area EPS in the future. (IEEE 1547-2018, Clause 3.1, p. 24)

Additional Proposed Definitions in Draft TIIR (Sec. 3B)

Term	Definition	Source
Energy Storage System	An electric system that stores active power for later injection into the Local EPS or Area EPS.	Draft TIIR
ESS Operational Control Mode	Controls utilized in an energy storage system to restrict the source(s) of charging energy or the utilization of discharged energy	IREC edit
Inadvertent Export	The unscheduled [*and uncompensated*] export of [*active* (or) *real*] power [*from a DER Generating Facility* (or) *injected across the PCC from a Local EPS to an Area EPS*] [*exceeding a specified magnitude and for a limited duration, generally due to fluctuations in load-following behavior*].	Draft TIIR/Xcel/IREC [italics = differences]
Non-Export, Non-Exporting	When the DER is sized and designed such that the DER output is used for Host Load only and is designed to prevent the transfer of electrical energy from the DER to an Area EPS or TPS as defined by Section 11 of this document.	Draft TIIR
Control Limited Export	Non-Exporting systems are a special type of Control Limited Export system (i.e. limit of zero kW) and the concept of Inadvertent Export is applicable	Xcel edit

Additional Proposed Definitions in Draft TIIR (Sec. 3B)

To be addressed later in the meeting

Term	Definition	Source
Maximum AC Capacity (alternative to Maximum Export Capability)	The maximum rated capacity of the DER, except where the gross generating capacity of the DER is limited by any of the means in Section __, the maximum AC capacity shall be the maximum specified by the interconnection customer in the interconnection request. The maximum AC capacity specified by the interconnection customer in the interconnection request will subsequently be included as a limitation in the interconnection agreement.	IREC edit
Maximum Export Capability (alternative to Maximum AC Capacity)	maximum export kW which the DER system is capable of injecting into the Area EPS, considering any control or other systems which are able to limit the export	DEA edit
Control Limited Capacity	The resulting power capability when a DER or total of DER source(s) behind the point of interconnection are limited in active power production below the aggregate DER nameplate rating through the use of a control systems, including power control systems, power relays, or other similar device settings or adjustments. Mechanisms for control limited capacity are protective to the utility system and shall be secured or hardware limited. Technical evaluations shall address DER characteristics and capabilities that are not impacted by source limiting.	Xcel edit
Inadvertent Capacity Exceedance	the production of active power in excess of the Control Limited Capacity. Limitations related to inadvertent capacity exceedance are addressed in Section X.	Xcel edit

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Storage compared to Load and DER Generating Facilities

ENERGY STORAGE

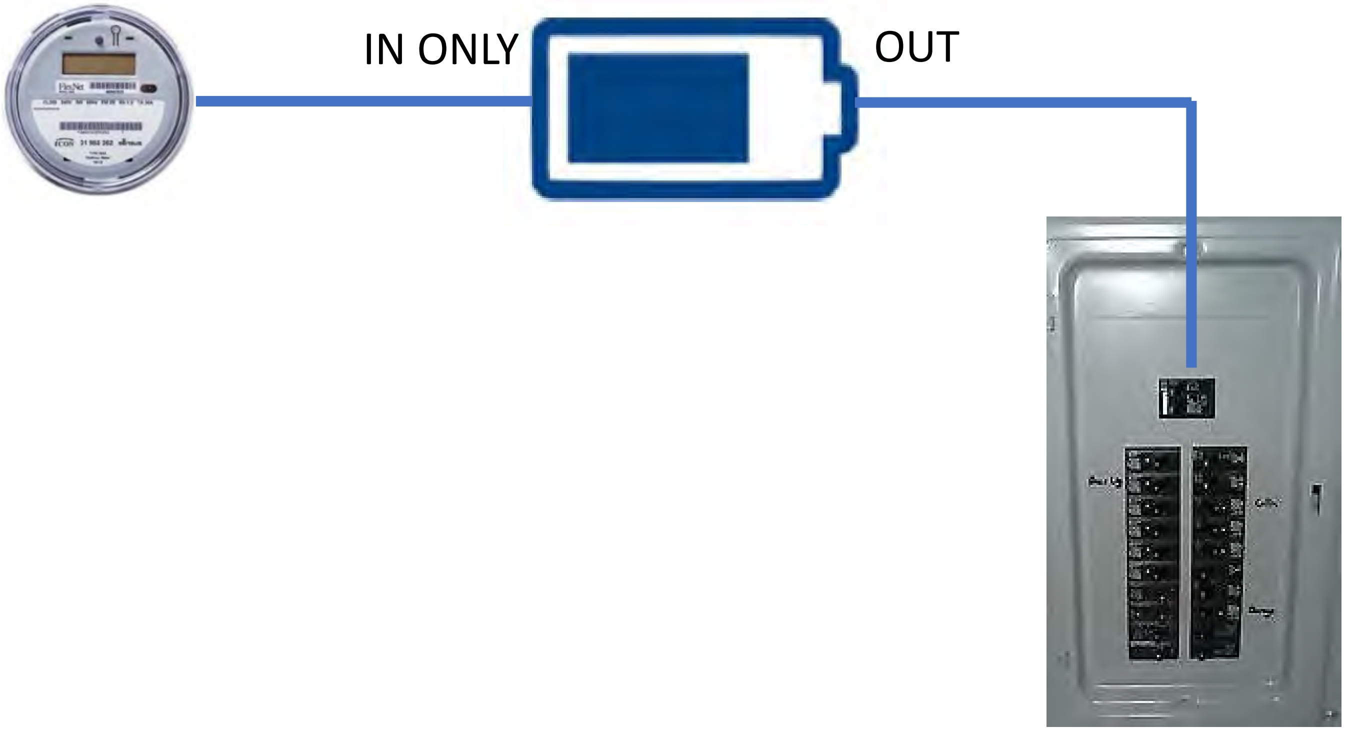
- AC-coupled

DC-coupled

@IRECUSA

ESS Usage Data

Thought Exercise: What info is needed by utility in this scenario?



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ESS Load Aspects Compared to Traditional Load

- **<u>Similarities</u>**
  - Absorbs real and reactive power

- **<u>Differences</u>**
  - ESS also sources real and reactive power, while load does not.
    - This causes a the potential for wider power swings (i.e. full absorption to full injection)
  - ESS typically has wider range of reactive power absorption capabilities when compared to load devices with a comparable apparent power rating.
  - Control of the power and energy being absorbed is the objective for ESS, while other load uses the energy as a means to an objective.
    - This impacts when and how the energy is absorbed in time and magnitude. Grid or market conditions could inadvertently align the charging of ESS within a very short time window, which could have outsized grid impacts, when compared to traditional load which tends to exhibit more temporal diversity.

ESS Source Aspects Compared to DER

- **Similarities**
  - Injects real and reactive power
  - Interconnection process and technical standards are applicable

- **Differences**
  - ESS is not reliant on a fuel source or prime mover and is inherently has more flexible real and reactive power injection characteristics.
    - Use cases such as frequency control capitalize on this capability to produce quick spikes of real power injection or absorption.
  - ESS operation is defined by control modes which are not standardized by industry or functionally tested by a nationally recognized testing laboratory.
    - The early stage of this technology means that the response of a given function may not comport with the manufacturer's stated functionality.
  - ESS firmware changes are frequent and can fundamentally change the operating characteristics.
  - Intentional or inadvertent coordination of wide area ESS response by may become a reality if market changes are implemented.
    - If these market conditions appear imminent, the impacts and questions surrounding mitigation policy should be addressed. The policy is out of scope for this working group, but we could discuss if the technical impact consideration is part of interconnection standards or should be enabled through a different process.

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Draft TIIR Section 10: Energy Storage

ESS Use Cases vs. Operational Control Mode

Use Case

- How/when does the customer charge/discharge their ESS, "profile"
- Protected or unprotected settings are used
- Customer must be allowed to alter how they use their equipment
- Added notification-only approach for use cases in 10.B.ii (could expand – in DIP? – notification to ongoing collection, voluntary)

Operational mode

- Generally wouldn't change – due to tariff restrictions
- Protected settings are used
- Added def for "ESS Operational Control Mode" in 3. Note difference to ride-through "operating mode."
- Should we add req's for non-importing ESS operational control mode?

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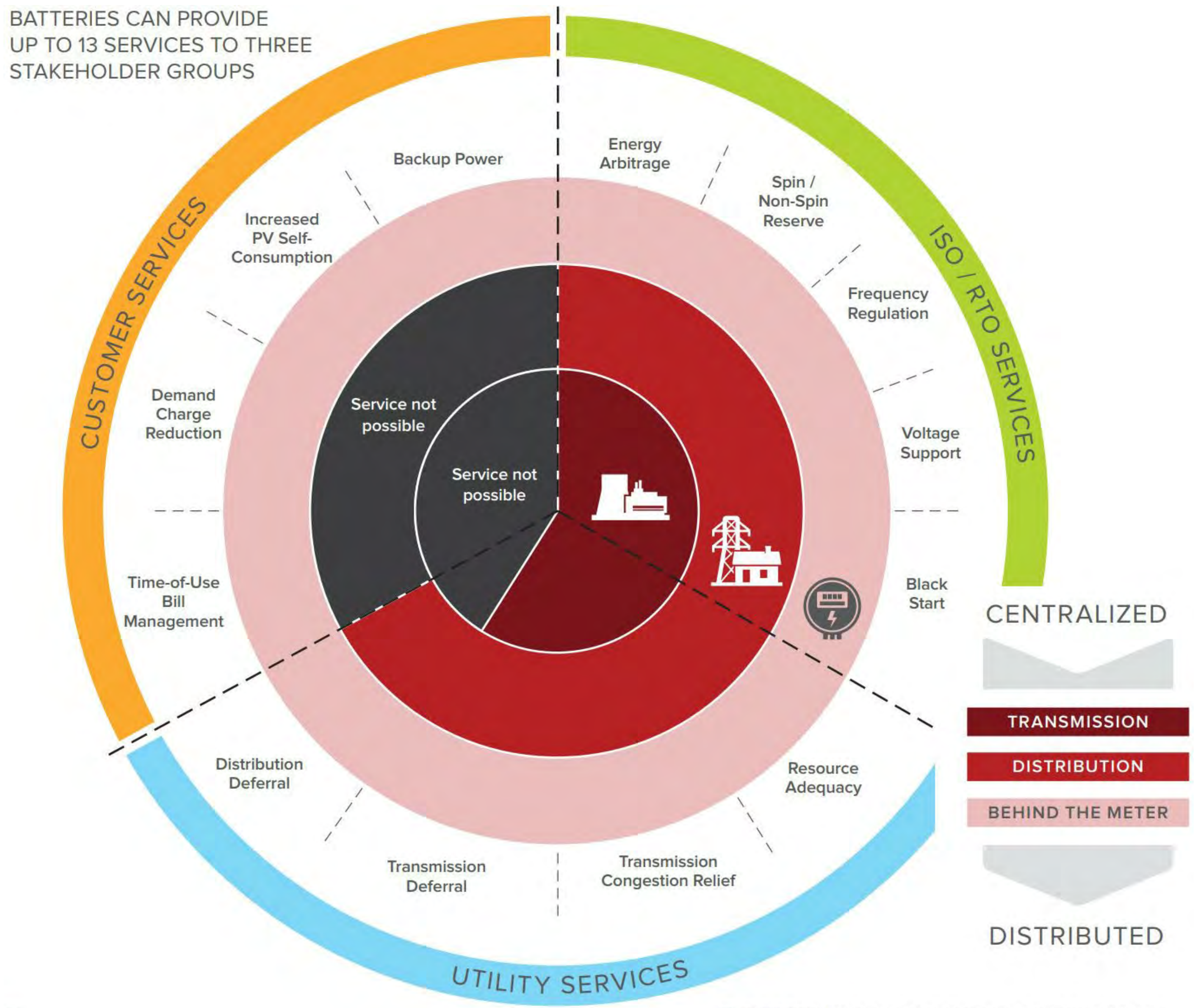
RMI Use Cases



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IREC Proposed Edits to Draft TIIR Sec. 10

- Deleted the following:

  At present time, for many commercially available systems, the ESS control modes are made easily accessible to the end user, which is a significant departure from the accessibility of inverter controls for other DER, which often require unique apparatus or secure technician passwords.

- Request to define ESS Operational Control Modes:

  " Controls utilized in an energy storage system to restrict the source(s) of charging energy or the utilization of discharged energy." (proposed in Definitions Section 3B)

- Proposed additional requirement:

  " Documenting at the time of application the charge/discharge profile(s) or use case(s) intended to be utilized by the ESS owner. This information may be collected through an Area EPS Operator specific document(*) or portion of the Company's online application portal. Profile or use case may change over time without altering or updating the interconnection agreement.

  Footnote (*): Upon publication of standards and certifications, this type of information will be well-suited to be included in statewide interconnection process documentation. Until that time, it is likely the type of ESS information needed could rapidly shift, depending on customer preferences and available technology. Continual shifts in technology, application of technology, and market place are occurring at a rapid pace at the time the TIIR is being written."

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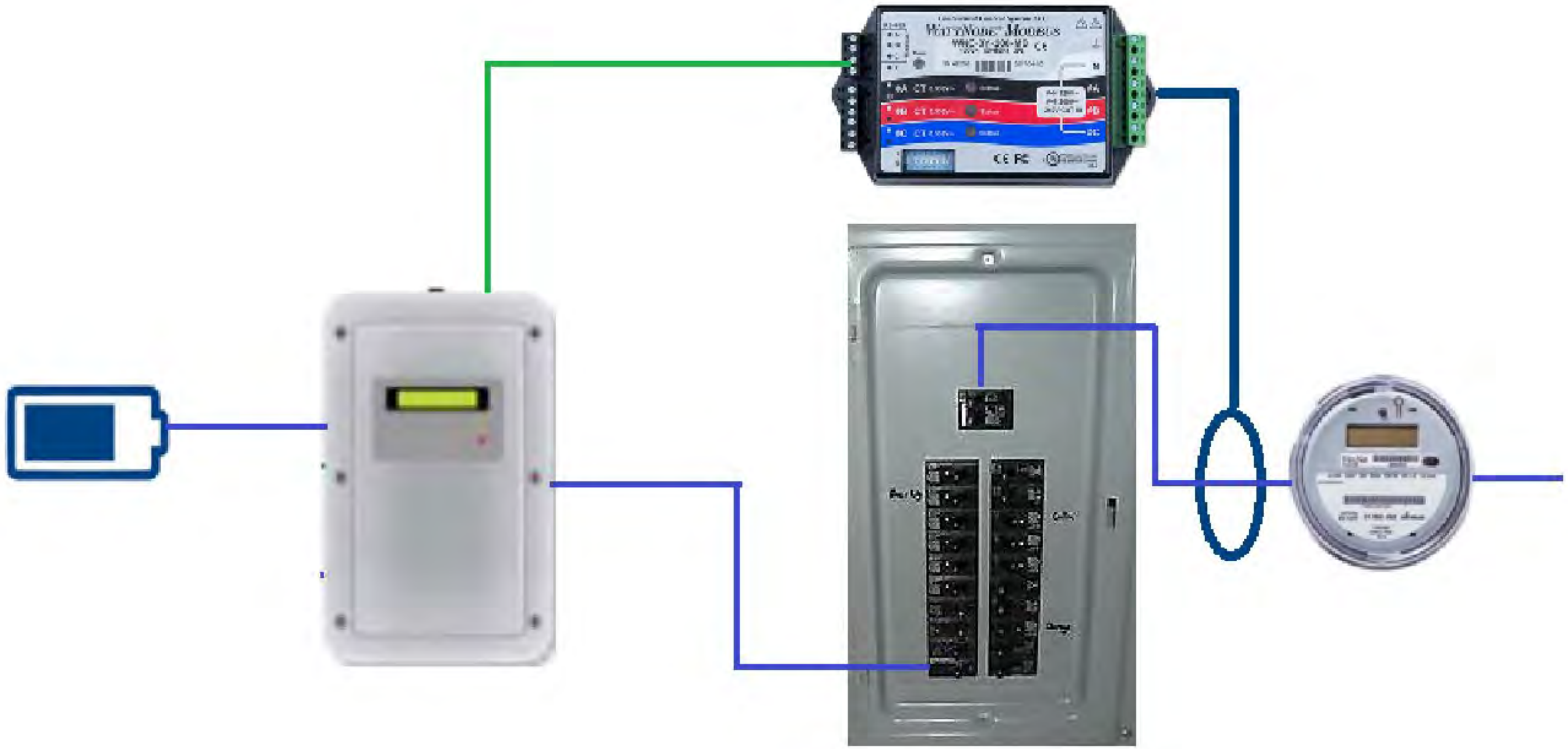
Non-Exporting or Limited Export DER

Export-limiting or non-export



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IEEE 1547 references

- *4.2.b* ***RPA***

"Annual average load demand of greater than 10% of the aggregate DER nameplate rating, and where the Local EPS is not capable of, or is prevented from, exporting more than 500 kVA for longer than 30 s."

- 4.6.2 **Limit Active Power:**

"In cases where the DER is supplying loads in the Local EPS, the active power limit set point may be implemented as a maximum active power export to the Area EPS."

- 5.4.2 fn 65 **volt-watt**:

"As permitted by 4.6.2, for cases where the DER is supplying loads in the Local EPS, the DER active power may be implemented as a maximum active power export limit set point. The DER shall not be required to reduce active power below the level needed to support local loads."

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Impacts of Non-Exporting Systems

Voltage	Thermal	Protection

- Impacts from Individual DER and Aggregate DER needs to be considered when contemplating process and technical review treatment of non-exporting systems
- Numerous Xcel Energy feeders have reached the existing hosting capacity

Voltage Impacts – Non-Exporting Systems

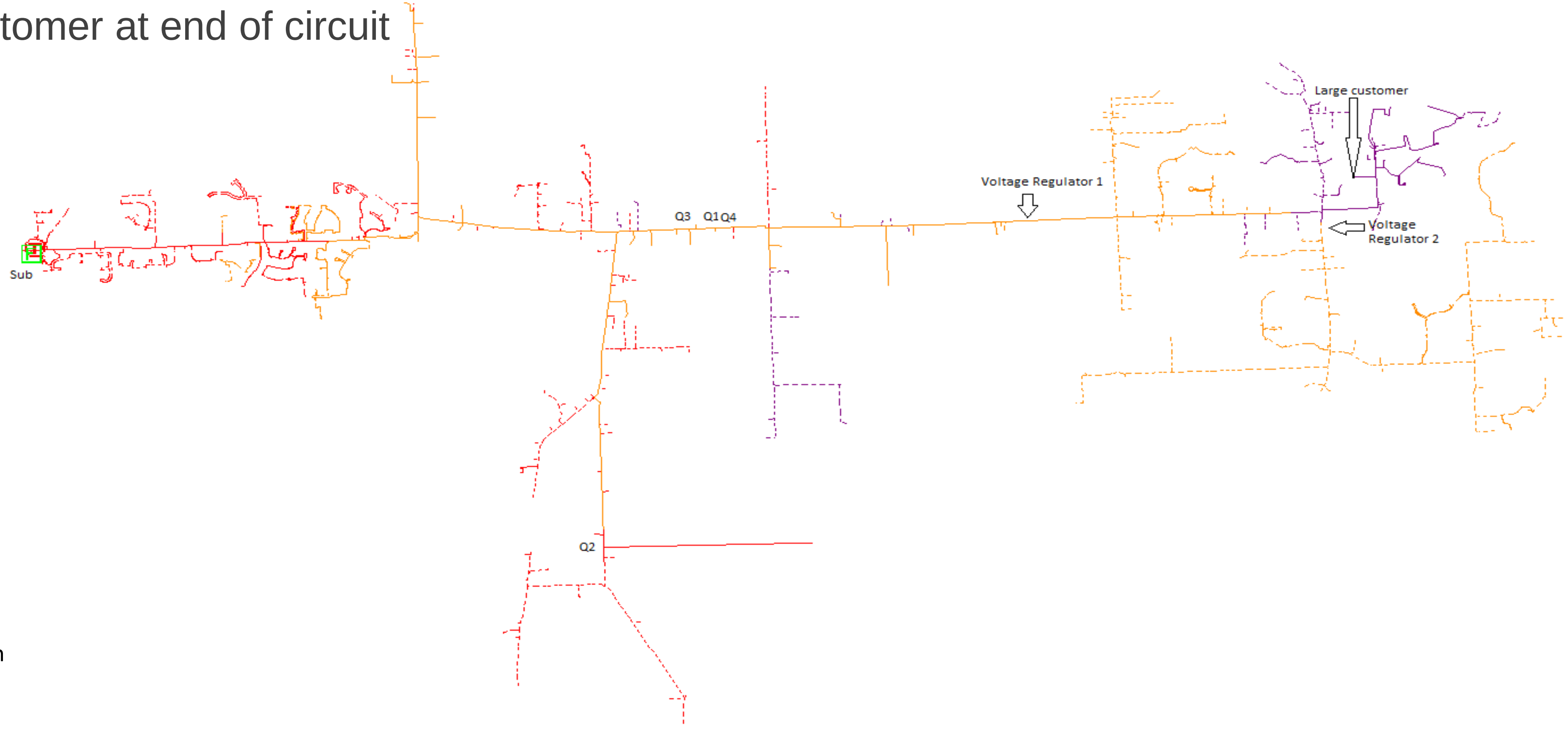
Steady State Overvoltage

- Real world feeder example:
  - 15 MW of PV existing on 34.5 kV circuit
  - Large 2 MW load customer at end of circuit

Base Case Voltages

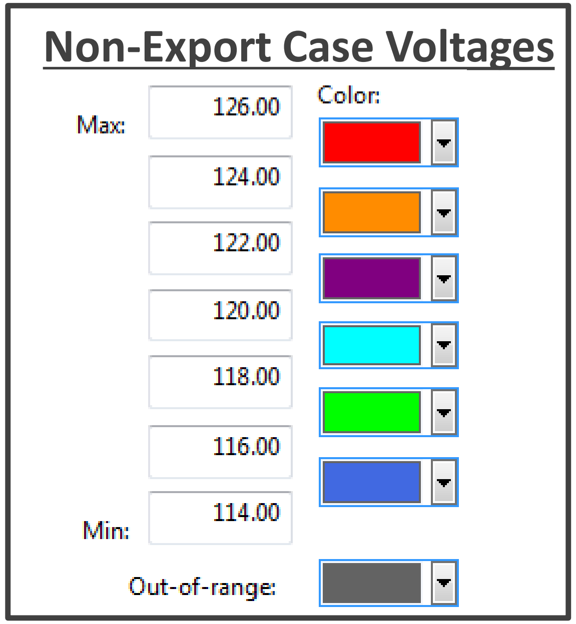
		Color:
Max:	126.00	Red
	124.00	Orange
	122.00	Purple
	120.00	Cyan
	118.00	Green
	116.00	Blue
Min:	114.00	
Out-of-range:		Gray

Note: Minimum daytime loading case is shown

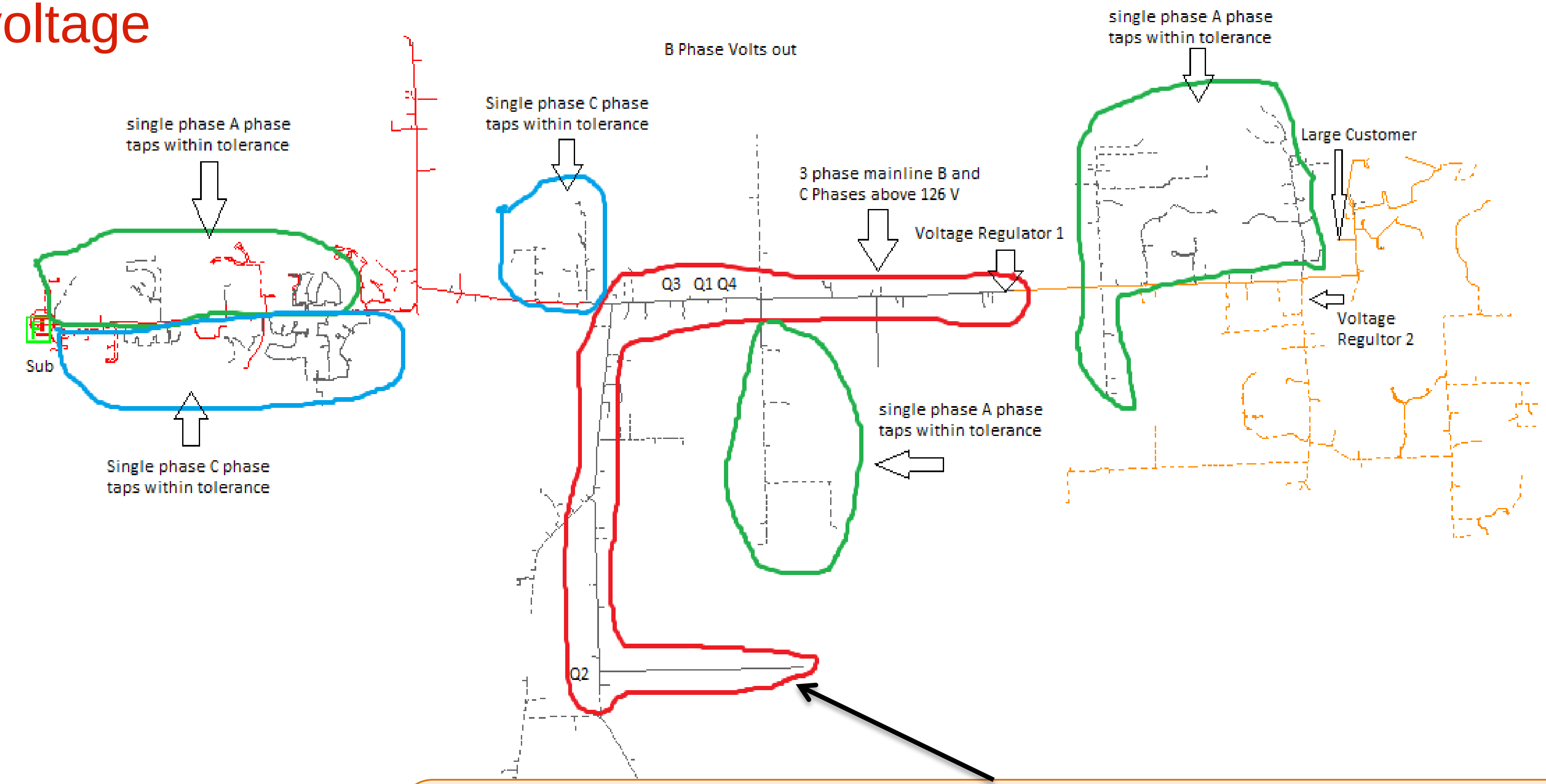


Voltage Impacts – Non-Exporting Systems

Steady State Overvoltage



Note: Minimum daytime loading case is shown

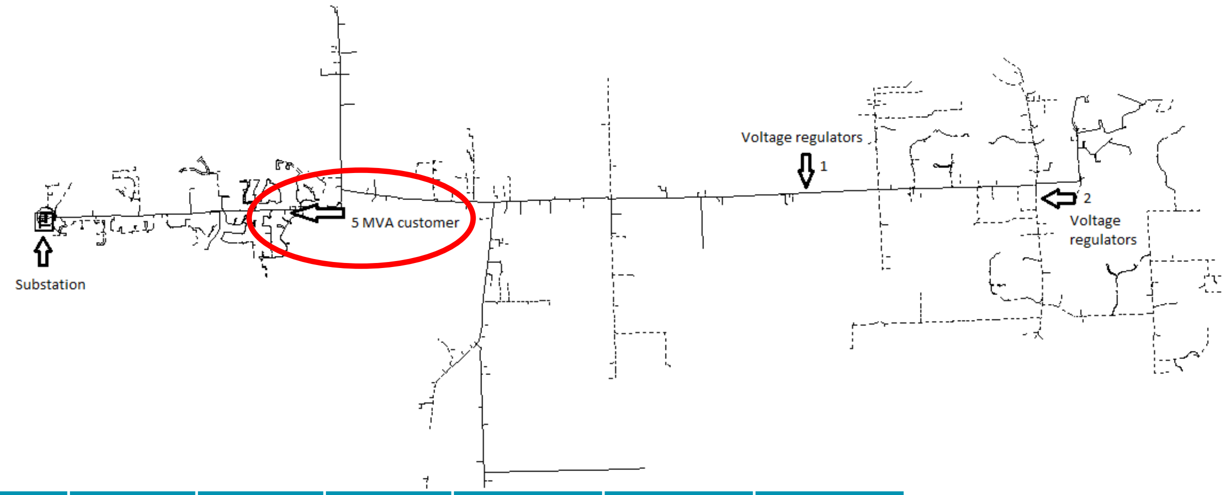


Many customers would experience steady state overvoltage near the feeder mid-point served by tap circuits.

Voltage Impacts – Non-Exporting Systems

Voltage Fluctuation

- Same feeder as previous example, but now with a new 5 MW non-exporting customer added (5 MW load and 5 MW of generation)
- Individual DER 3% limit and voltage regulator 1.5% limit for 75% output drop (2% full-on to full-off) are both exceeded in some locations

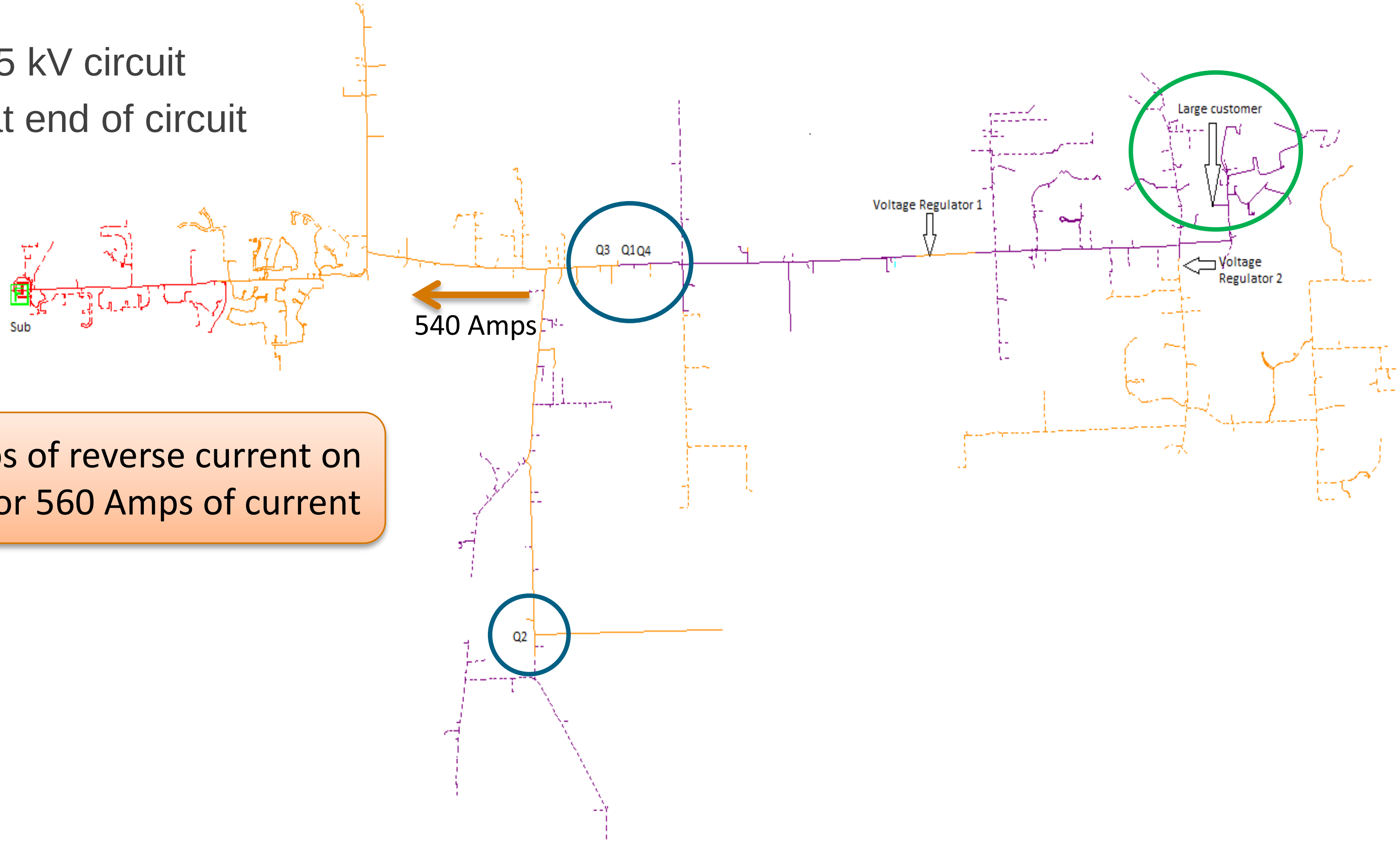


Location	A phase 5MVA on	B phase 5MVA on	C phase 5MVA on	A phase base	B phase base	C phase base	A % difference	B % difference	C % difference
Substation LTC	124.45	124.55	124.68	124.87	124.95	125.05	0.34%	0.32%	0.30%
5MVA spot load	117.51	118.83	120.26	120.69	122.9	123.51	2.67%	3.37%	2.67%
Voltage Regulators 1	118.67	118.12	119.64	122.07	122.28	122.92	2.82%	3.46%	2.70%
Voltage Regulators 2	---	115.82	---	---	120	---	---	3.55%	---

Note: red numbers indicate a voltage fluctuation limit violation

Thermal Impacts – Non-Exporting Systems

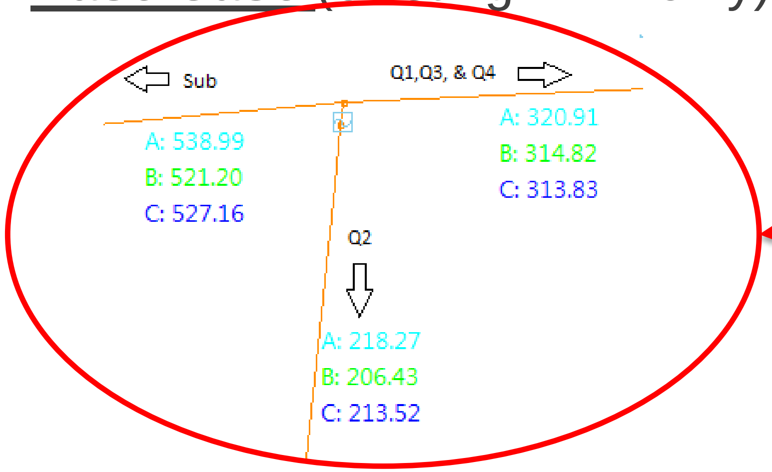
- Real world feeder example:
  - 15 MW of PV existing on 34.5 kV circuit
  - Large 2 MW load customer at end of circuit

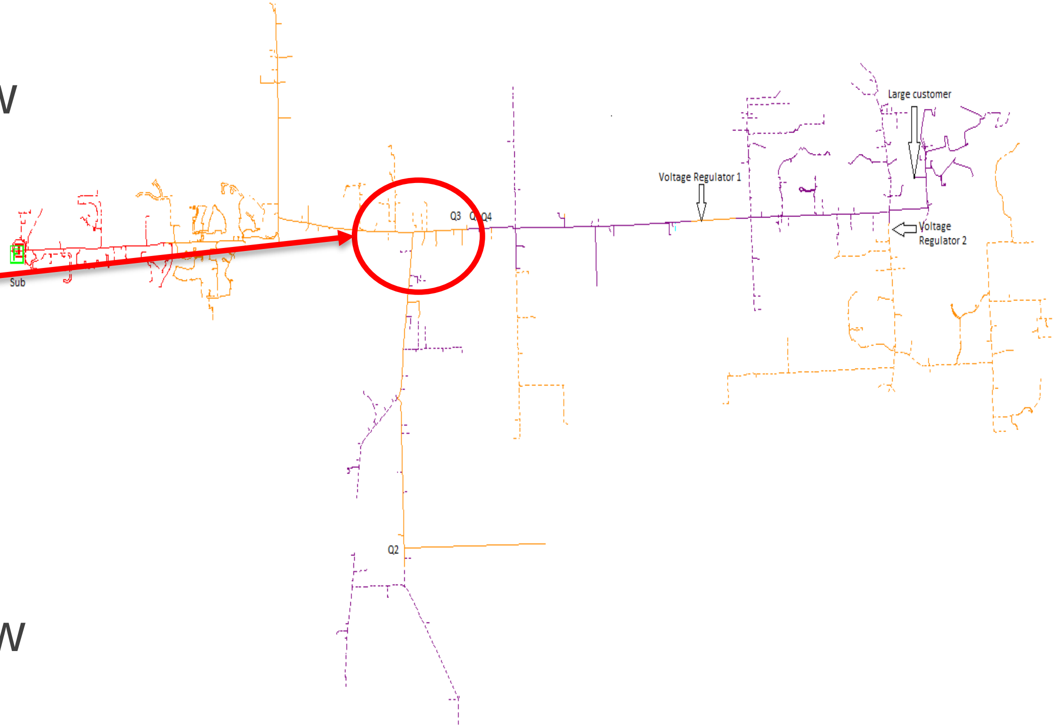


Currently 540 Amps of reverse current on 336 AL line rated for 560 Amps of current

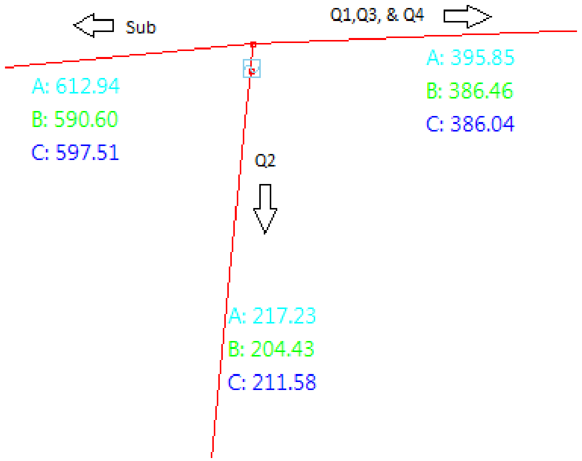
Thermal Impacts – Non-Exporting Systems

- **Base Case** (existing DER only) ~ 540 Amps of reverse flow





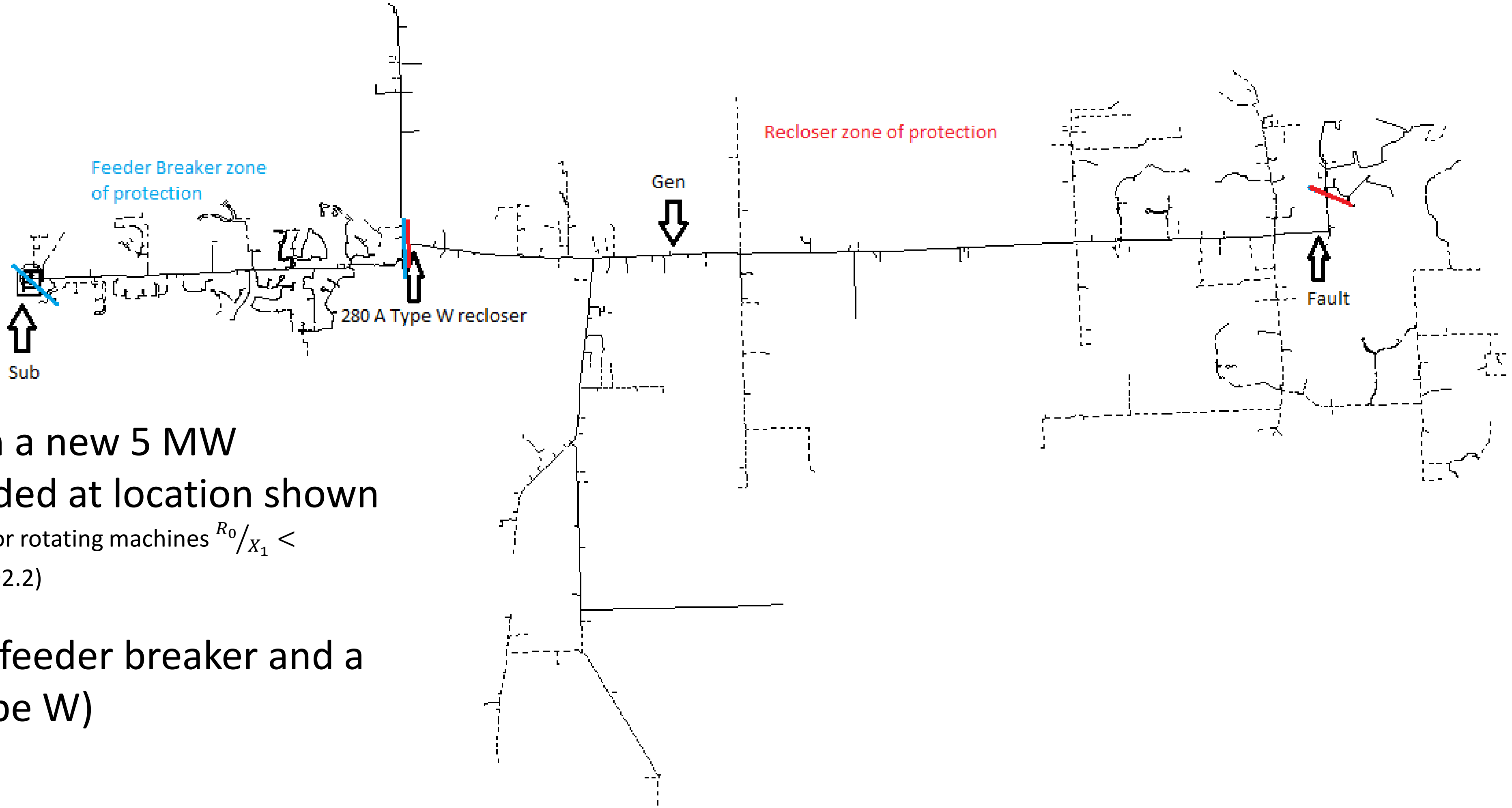
- **Non-Export Case** (2 MW DER) ~ 613 Amps of reverse flow



Non-export case shows 613 Amps on conductor rated for 560 Amps
→ **Thermal Overload**

Note: This case contemplated a 2 MW non-export DER system, but as little as 500 kW at this location, or aggregated at numerous locations, would lead to overload.

Protection Impacts – Non-Exporting Systems



- Consider same feeder with a new 5 MW synchronous generator added at location shown

  Note: Effective grounding requirements for rotating machines ${R_0}/{X_1} < 1 \ and \ 1.5 \leq {X_{0,DG}}/{X_{1,DG}} \leq 2.5$ (ANSI 62.92.2)

- Feeder protected by a the feeder breaker and a midline 280 A recloser (Type W)

Protection Impacts – Non-Exporting Systems

Base Case (DER disconnected)

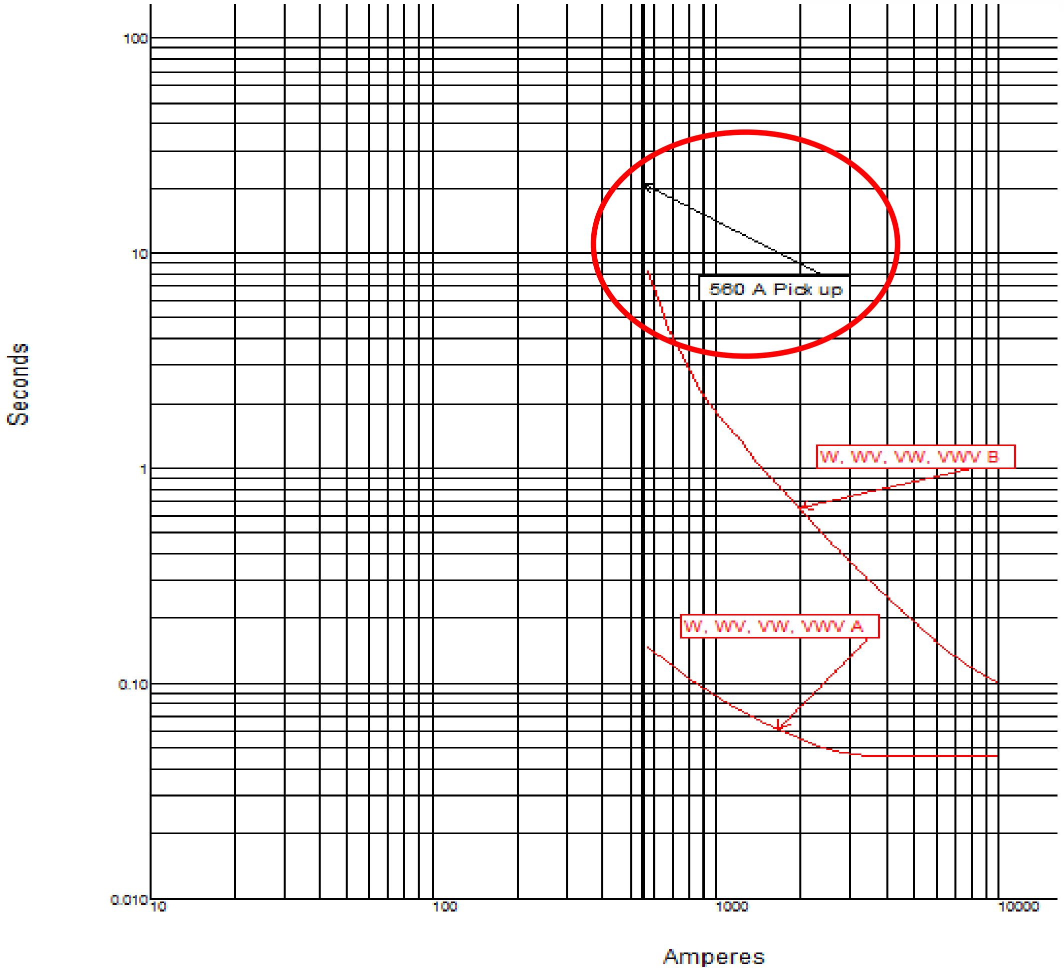
Gen off	3ph fault	SLG Fault	Distance from the sub
Substation	1348.66 A	750.37 A	.03 MI
recloser	1347.66 A	750.37 A	2.51 MI
generator	1347.66 A	750.37 A	4.03 MI
fault	1347.66 A	750.37 A	7.92 MI

Non-Export Case (DER connected)

Gen on	3ph fault	SLG Fault	Distance from the sub
Substation	1030.57 A	556.77 A	.03 MI
recloser	1030.57 A	**556.77 A**	2.51 MI
generator	1721.94 A	1069.35 A	4.03 MI
fault	1721.94 A	1069.35 A	7.92 MI

Relay desensitization occurs in non-export case such that the recloser is no longer able to detect SLG faults.

Recloser Time Coordination Curve - 280 A Type W



Non-Export Study Conclusions

- Real world feeders exist in Minnesota today that could be adversely impacted by forgoing technical review of non-export systems
  - Non-export systems should follow the standard process and technical review based on nameplate rating
  - The non-export designation should be used for contractual arrangement and not technical review or process eligibility

- While the size and generation type are indicative of grid impacts, aggregate DER can have the same impact and must be contemplated

- *Voltage* and *Thermal* impacts are more likely to occur when compared to *Protection* impacts

Capacity and Export Definitions

FERC SGIP & MN DIP on Capacity

5.14 **Capacity of the Distributed Energy Resource**

5.14.1 If the Interconnection Application is for an increase in capacity for an existing DER, the Interconnection Application shall be evaluated on the basis of the new total alternating current (“AC”) capacity of the Distributed Energy Resource. The maximum capacity of a Distributed Energy Resource shall be the Aggregate Nameplate Rating or may be limited as described in 5.14.3.

5.14.2 An Interconnection Application for a DER that includes a single or multiple energy production devices at a site for which the Interconnection Customer seeks a single Point of Common Coupling shall be evaluated on the basis of the aggregate Nameplate Rating of the multiple DERs unless 5.14.3 applies.

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 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 Distributed Energy Resource 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. aggregate Nameplate Rating), if the limitations do not provide adequate assurance, when evaluating system impacts. See Minnesota Technical Requirements for more detail.

(Source: Minnesota DER Interconnection Process. Consistent with FERC SGIP Section 4.10.1 – 4.10.3)

Relevance of Capacity to Engineering Screens and System Impact Study

- Capacity is part of determining what track, and consequently which engineering screens, occur in the DER Interconnection Process
- What are the specific analyses within a system impact study that could require nameplate rating (e.g. short circuit analysis)?

DER Impact Study Analysis

When is the full nameplate rating of DER needed?

- **It depends…**
  - on the size and type of the DER system
  - on how the control system operates
  - on the definition of the magnitude and duration of allowed power production above the *Control Limited Capacity*

- **Short circuit analysis** is the most clearly affected due to limitation in control system response time
  - The short circuit studies include device interrupting rating, coordination, and relay sensitivity.

- **Voltage impacts -** For larger systems, if the power magnitude and duration limit is comparable to definitions of inadvertent export (full nameplate for 30 seconds), impacts to steady state voltage and voltage fluctuation could be experienced.

Maximum Export Use Cases

Static (based on interconnection agreement)

- Agreed DER rating
    - Actual use (e.g. storage operating mode identified in documentation)
    - Study-based capacity restriction
    - Hosting Capacity restriction
- Storage NEM integrity (“green” vs “brown” electrons)
- Non-export expedited interconnection

Dynamic (based on controls or schedules)

- Load-following hosting capacity restriction
- Other operational curtailment (e.g. temporary thermal restrictions)
- Volt-watt?

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Proposed "Capacity" Definitions

Term	Definition	Source
Maximum AC Capacity **(alternative to Maximum Export Capability)**	The maximum rated capacity of the DER, except where the gross generating capacity of the DER is limited by any of the means in Section __, the maximum AC capacity shall be the maximum specified by the interconnection customer in the interconnection request. The maximum AC capacity specified by the interconnection customer in the interconnection request will subsequently be included as a limitation in the interconnection agreement.	IREC edit
Maximum Export Capability **(alternative to Maximum AC Capacity)**	maximum export kW which the DER system is capable of injecting into the Area EPS, considering any control or other systems which are able to limit the export	DEA edit
Control Limited Capacity	The resulting power capability when a DER or total of DER source(s) behind the point of interconnection are limited in active power production below the aggregate DER nameplate rating through the use of a control systems, including power control systems, power relays, or other similar device settings or adjustments. Mechanisms for control limited capacity are protective to the utility system and shall be secured or hardware limited. Technical evaluations shall address DER characteristics and capabilities that are not impacted by source limiting.	Xcel edit

Principles for Defining Capacity

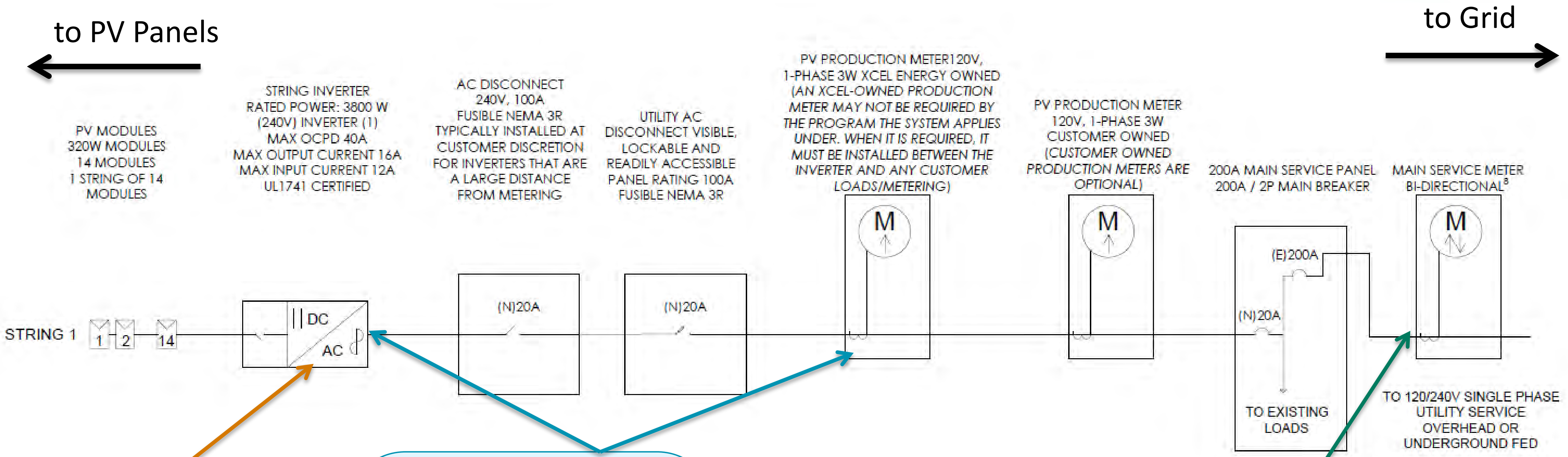
- Differentiate the new term of ***Control Limited Capacity*** from ***Nameplate Rating***.
  - *Nameplate Rating* is defined in IEEE 1547-2018, but the new term of *Control Limited Capacity* is not defined by national standards
  - The terms should not be used interchangeably to describe DER power capability
- *Nameplate Rating* dictates the review track eligibility, based on potential impact and complexity of review, while the *Control Limited Capacity* is used
  - Controls are not reviewed before eligibility is determined
- Use a qualifier to "capacity" for this use, such as "control limited" or "source limited", since the term "capacity" is used in a variety of situations (i.e. hosting capacity, load capacity),

Framework of Defined Terms

Terms	Nameplate Rating	Control Limited Capacity Inadvertent Capacity Exceedance	Control Limited Export Non-Export Control Limited Export Inadvertent Export Inadvertent Export Limit Exceedance
Purpose / Use	• Determines process track eligibility • Captures DER maximum capability for system records • Used in some aspects of technical review	• Captures steady state operation for Interconnection Agreements • Used in some aspects of technical review	• Non-export is currently useful for contractual considerations (i.e “NEM integrity”) in MN • Export limited is related and likely needed in the future (i.e. Hawaii example) • Need terms

Note: dashed lines around a box indicate the term has not yet been contemplated by MN interconnection standards update process

Relationship and Use of Terms



***Nameplate Rating** - Listed by manufacturer and inherent to DER capabilities*

***Control Limited Capacity** – Set by installer and can be internal or external to DER power conversion or production device. Must be limited prior to comingling of load*

→ ***Inadvertent Capacity Exceedance***

***Control Limited Export** – Set by installer and must use components external to the DER device in order to measure and limit export*

→ ***Non-export*** → ***Inadvertent Export***

→ ***Control Limited Export*** → ***Inadvertent Export Limit Exceedance***

Defined Terms – Nameplate Rating

MN DIP Definition

- **Nameplate Rating -** nominal voltage (V), current (A), maximum active power (kWac), apparent power (kVA), and reactive power (kvar) at which a DER is capable of sustained operation. For a Local EPS with multiple DER units, the aggregate nameplate rating is equal to the sum of all DERs nameplate rating in the Local EPS, not including aggregate capacity limiting mechanisms such as coincidence factors, plant controller limits, etc. that may be applicable for specific cases (Aggregate Nameplate Rating). The nameplate ratings referenced in the MN DIP are alternating current nameplate DER ratings. See Section .c on Capacity of the Distributed Energy Resource.

Defined Terms – Non-Export and Inadvertent Export

<u>Draft MN TIIR proposal</u>

- **Inadvertent Export :** the unscheduled and uncompensated export of real power injected across the PCC from a Local EPS to an Area EPS

- **Non-Export, Non-Exporting :** When the DER is sized and designed such that the DER output is used for Host Load only and is designed to prevent the transfer of electrical energy from the DER to an Area EPS or TPS as defined by Section 11 of this document.

<u>New Xcel Energy draft proposal</u>

- **Control Limited Export** : Non-Exporting systems are a special type of Control Limited Export systems (i.e. limit of zero kW) and the concept of Inadvertent Export is applicable.

Defined Terms – Control Limited Capacity

New Xcel Energy draft proposal

- **Control Limited Capacity :** The resulting power capability when a DER or total of DER source(s) behind the point of interconnection are limited in active power production below the aggregate DER nameplate rating through the use of a control systems, including power control systems, power relays, or other similar device settings or adjustments. Mechanisms for control limited capacity are protective to the utility system and shall be secured or hardware limited. Technical evaluations shall address DER characteristics and capabilities that are not impacted by source limiting.

- **Inadvertent Capacity Exceedance :** the production of active power in excess of the Control Limited Capacity. Limitations related to inadvertent capacity exceedance are addressed in Section X.

Feedback on Capacity Proposals from Stakeholders

- **Track eligibility –** Some proposals stated that eligibility should be determined by Control Limited Capacity rather than Nameplate Rating.
  - This proposal breaks the important and intentional screening function of the eligibility size limits.
- **Resulting Grid Impacts –** Given eligibility considerations, grid impacts may not be caught because the process may not allow the proper time or technical review.
- **Standards Considerations –** the IEEE1547-2018 standard ties capability requirements to the nameplate rating.

Xcel Energy's proposal is to use *Nameplate Rating* as the basis for application track eligibility and allow *Control Limited Capacity* to be used where applicable in technical review and agreements.

Anticipated we will pick up here for the August 3rd meeting

August 3rd Agenda (TSG #5)

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, 7/20 Recap
9:40 – 9:50	Meeting Goals & Definitions - Reminder
9:50 – 10:20	Control Limits and Inadvertent Exports • Overview of Inadvertent Export Adoption in Other States • Control Limit considerations
10:20 – 11:30	Draft TIIR Sec. 11: Non-Export or Limited Export • Walk through proposed edit side-by-side with rationales • Limited Capacity and Export definitions • Discussion
11:30 – 12:10	Draft TIIR Sec. 3B: Definitions • Non-Export or Limited Export • Inadvertent Export • Any definition follow up work from July 20 meeting
12:10 – 12:30	Meeting Evaluation & Next Steps

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Anticipated we will pick up here for the August 3rd meeting

Control Limits and Inadvertent Export

Inadvertent Export

Inadvertent *Export* is <u>not</u>

Inadvertent *energization*

Inadvertent Export Adoption

Evolution of Inadvertent Export definition & req's

MN – Max AC Capacity

CA – Rule 21

NV – Rule 15

AZ – Under discussion

HECO – Customer Self-Supply

Discuss: Control Limits

- How do the system characteristics of the Local EPS appear to the Area EPS in operations?
  - Which limiting characteristics can accidentally or purposefully change easily?
  - Which limiting characteristics would remain the same, even after an N-0 and N-1 event occurred (i.e., two fault conditions) occur within the system?

Inadvertent Changes to Control Limited Capacity
End Users Implementing Changes

- **Accessibility -** Systems most susceptible to unauthorized settings changes include any device with an accessible user interface or devices without strong security provisions.
  - Example 1: Energy storage systems or inverters with a mobile app user interface
  - Example 2: Utility grade relays that use default security passwords

- **Highly Configurable Devices –** When IEEE 1547-2018 compliant equipment is available, the list of points required in the Interoperability section provides an idea of the baseline number of settings that could potentially be changed.
  - Manufacturers may choose to offer additional functions that could impact real power production

Inadvertent Changes to Control Limited Capacity

Impacts of Changes

- **Equipment Impacts –** Damage can occur to customer and utility equipment from high-voltage, thermal overloads, or protection mis-operation.

- **Human Impacts –** Changes that impact the proper functioning of protection systems could pose a threat to the public safety and Company employees.

- **Wider Grid Impacts -** The settings changes could impact voltage, thermal, or protection constraints of the grid.

Inadvertent Changes to Control Limited Capacity

New Technology Carries Additional Considerations

- **Energy Storage User Accessibility –** The energy storage systems (ESS) being installed today at the residential level have more opportunity for inadvertent changes.
  - System interfaces are often more accessible.
  - Frequent and substantial firmware changes appear to be more common for ESS when compared to relatively mature PV inverter technology.

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Draft TIIR Section 11: Non-Exporting or Limited Export

Non-Export Eligibility (p. 35-37 full mark up)

Draft TIIR	IREC Proposal
All generation produced by onsite DER shall be interfaced through a UL 1741 certified inverter	The Generating Facility must utilize only UL 1741 certified non-islanding inverters
Total nameplate rating of all DER onsite is less than 100 kW – Based on HI Rule 14	(No size limit)
DER is not served from a Networked Secondary System	Limited Export may not be available for interconnection to Networked Secondary Systems.
	.. additional Protective Functions and equipment to detect Area EPS faults (per the Area EPS Operator’s standard practices) may be required. Protective Functions may include, but are not limited to, directional overcurrent/voltage-restraint overcurrent Protective Functions for line-to-line fault detection and overcurrent/overvoltage Protective Functions for line-to-ground detection. The addition of a ground bank or ground detector may also be necessary.
	The DER unit must utilize a NRTL-certified control system or NRTL-certified inverter system that meets following: **See Cease to Energy Requirements slide.**

Operational Requirements // Magnitude of Inadvertent Export (p. 35-37 full mark up)

Draft TIIR	IREC Proposal
50% of the DER nameplate capacity, or	Nameplate rating of the Generating Facility
10% of the continuous conductor rating in watts at 0.9 power factor for the lowest rated feeder conductor upstream of the DER, or	
110% of the largest load block in the facility, or	110% of the largest load block in the facility, or
100 kW or some other maximum level indicated by the Area EPS Operator	500 kW or some other maximum level indicated by the Area EPS Operator
	directional power protective function will be provided to trip the connected Generator(s) with a delay of two seconds and maximum clearing time of 10 cycles if the proposed maximum export limit is exceeded.
DER total energy export must not exceed nameplate rating (kW gross) multiplied by 3 hours, over a 30 day rolling period (e.g. 10 kW gross nameplate Generating Facility, max energy export for 30 day period is 30 kWh.) – based on CA RULE 21	The Generating Facility’s total Inadvertent Export energy must not exceed its nameplate rating (kVA-gross) multiplied by 0.1 hours per day over a rolling 30-day period (e.g., for a 100 kVA-gross nameplate Generating Facility, the maximum Inadvertent Export energy allowed for a 30-day period is 300 kWh).

Cease to Energize Requirements (p. 35-37 full mark up)

Draft TIIR:

Generation Source Nameplate Rating	Period of continuous Inadvertent Export	Clearing Time
> 100 kW	> 30 seconds	2 seconds

Monitoring on the total energy exported shall be furnished by the DER Operator which provides notification if the export limit is exceeded, unless waived by the Area EPS. The notification shall be available to the Area EPS. Failure of the control or inverter system for more than 30 seconds, resulting from loss of control signal, loss of control power, or a component failure or related control sensing, shall result in the DER entering into a *cease to energize* state.

IREC proposal:

Generation Source Nameplate Rating	Period of continuous Inadvertent Export	Clearing Time
≤ 500 kVA	> 30 seconds	2 seconds
> 500 kVA - ≤ 1 MVA	> 10 seconds	1 second
> 1 MVA	> 2 seconds	10 cycles

Failure of the control or inverter system for more than the applicable inadvertent export time limit in a., resulting from loss of control or measurement signal, or loss of control power, must result in the DER unit entering Non-Export operation where no energy is exported across to the PCC to the Area EPS.

IEEE 1547 references

- *4.2.b* ***RPA***

"Annual average load demand of greater than 10% of the aggregate DER nameplate rating, and where the Local EPS is not capable of, or is prevented from, exporting more than 500 kVA for longer than 30 s."

- 4.6.2 **Limit Active Power:**

"*In cases where the DER is supplying loads in the Local EPS, the active power limit set point may be implemented as a maximum active power export to the Area EPS."*

- 5.4.2 fn 65 **volt-watt**:

"As permitted by 4.6.2, for cases where the DER is supplying loads in the Local EPS, the DER active power may be implemented as a maximum active power export limit set point. The DER shall not be required to reduce active power below the level needed to support local loads."

IREC Limited Export Technical Req's

Insert the following:

B. Define how DER rating is determined – "Maximum Export" aka "Max AC Capacity" options

- A+B = A+B // A+B = A // A+B = <A+B

C. "Inadvertent Export" requirements for any large DER

D. "Inadvertent Export" requirements for inverter-based controls

E. Testing requirements for Inadvertent Export equipment acceptance

- Soon to be covered by UL Electronic Current Limiting standard

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Capacity Limitation Options (11. B)

1) Reverse Power Protection
2) Minimum Power Protection
3) DER is <25% of service equip, <50% xfmr rating, certified non-islanding
4) DER <50% host load
5) Limited export (study)
6) Certified limited export
7) Not in Draft (probably should be) – Inverter output control ("control limited capacity")

Next Steps

July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 2	Prep work due for Aug 10 meeting
Aug 3	*July 20 topics continued*
Aug 10	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 6	Prep work due for Sept 14 meeting
Sept 14	Test and Verification; Witness Test Protocol
Sept 21	In-Person TSG: Power Quality; Follow up items; TIIR edits discussion
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

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Thank You!

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Back Up Slides

Discussion: Scope for Statewide Technical Requirements

These topics have been proposed as **in scope**.
Bold have been flagged for discussion.

1. Scope/Overview
2. References
3. Definitions
4. **Performance Category Assignments**
5. **Reactive Power Capability and Voltage/Power Control (volt-var & volt-watt) Performance**
6. **Response to Abnormal Conditions (Ride-through)**
7. **Protection Requirements**
8. **Metering**
9. **Interoperability (Monitoring, Control, Info Exchange, Cyber security)**
10. **Energy Storage**
11. Non-Export; Inadvertent Export
12. **Test and Verification Requirements**
13. **Agreements**
14. **Consumer Protection** (IREC)
15. **Reporting** (IREC)

(Source: "Regulated Utilities" TIIR Draft Proposal)

Discussion: Scope for Statewide Technical Requirements

1. Process requirements
2. Cost allocation
3. Interconnection to transmission system
4. **Protection system details of Area EPS or DER**
5. **Requirements or specification of system impact or facilities studies**
6. **Application of real and reactive power control functions**
7. **Details of communication networks; including architecture, technology and protocols, or other specifications related to interoperability**
8. **Details of metering requirements or specifications**
9. **Planning or operational considerations associated with Affected Systems, Regional Transmission Operator or Transmission Owners**
10. **Intentional Area EPS islanding**

These topics have been proposed as **out of scope** by some participants. Bold are flagged for additional discussion.

(Source: TIIR Draft Proposal, p. 9)

Phase II Technical Subgroup Meetings #5

August 3, 2018

(Docket No. 16-521)

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https://mn.gov/puc

Aug. 3 Agenda (TSG #5)

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, Expectations, Recap
9:40 – 9:45	Meeting Goals & Definitions - Reminder
9:45 – 10:35	Capacity Definitions and Proposals
10:35 – 11:45	Draft TIIR Sec. 11: Non-Export or Limited Export
11:10-12:20	Draft TIIR Sec. 10; Energy Storage
12:20 – 12:30	Next Steps

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
June 8	Reactive Power and Voltage/Power Control Performance; Protection Requirements
July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 3	*July 20 topics continued*
Aug 10	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 14	Test and Verification; Witness Test Protocol
Sept 21	In-Person TSG: Power Quality; Follow up items; TIIR edits discussion
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

TSG #4 and TSG #5 Meeting Goals (7/20 & 8/3)

- Discuss and address draft TIIR language and proposed edits related to Draft TIIR Sections 10 & 11 and associated definitions.

Build shared understanding of:

- Energy storage & non-exporting DER compared to traditional loads
- Impacts a non-exporting DER may have on an Area EPS system; including inadvertent exports
- What is necessary to provide adequate assurance DER export limits will not be exceeded
- The allowable duration for inadvertent exports and why
- How the TIIR proposals compare to IEEE 1547-2018; and the rationale for any exceptions/differences
- Risks (technical and other) of either under-estimating or over-estimating capacity in a screening process

Recap from July 20

- Request to consider the following regarding capacity and interconnection
  - How does it influence eligibility/determine the process DER application goes through
  - What technical review DER application undergoes
  - Substance of a given interconnection agreement

More information is desired regarding utility studies of energy storage systems

- Xcel described current method of studying storage:
  - Nameplate rating and worst case rate of change between full load and full generation is used if an operational control mode is not specified, reviewed and documented in agreements;
  - Power generation/export other than nameplate rating if specified in operating agreement and if adequate controls are present;
  - Operational characteristics of load and generation other than worst case if specified in operating agreement (likely includes specification of voltage and reactive/active power control characteristics)
    - NOTE: Characteristics include charge/discharge rate, frequency of power swings, real and reactive power magnitude, power control functions, etc.

IEEE 1547 Definitions

- **nameplate ratings**: Nominal voltage (V), current (A), maximum active power (kW), apparent power (kVA), and reactive power (kvar) at which a DER is capable of sustained operation. NOTE—For Local EPS with multiple DER units, the aggregate DER nameplate rating is equal to the sum of all DERs nameplate rating in the Local EPS, not including aggregate capacity limiting mechanisms such as coincidence factors, plant controller limits, etc., that may be applicable for specific cases. (IEEE 1547-2018, Clause 3.1, p. 24)

- **distributed energy resource (DER):** A source of electric power that is not directly connected to a bulk power system. DER includes both generators and energy storage technologies capable of exporting active power to an EPS. An interconnection system or a supplemental DER device that is necessary for compliance with this standard is part of a DER. [23] (IEEE 1547-2018, Clause 3.1, p. 22)
  - [23] Equivalent to "distributed resources (DR)" as defined and used in IEEE Std 1547-2003.
  - This standard applies to interconnection based on the aggregate nameplate rating of all the DER units that are within the Local EPS. Supplemental DER devices other than DER units may be used to achieve compliance with the requirements of this standard at the applicable reference point per Clause 4. These devices are not required to be co-located with the DER units, but shall be within the Local EPS (IEEE Clause 1.4 p17).

IEEE 1547 Definitions (cont’d)

- **Point of DER connection (POC)**: The point where a DER unit is electrically connected in a Local EPS and meets the requirements of this standard exclusive of any load present in the respective part of the Local EPS.
  - Note 2: For (a) DER unit(s) that are not self-sufficient to meet the requirements without (a) supplemental DER device(s), the point of DER connection is the point where the requirements of this standard are met by DER (a) device(s) in conjunction with (a) supplemental DER device(s) exclusive of any load present in the respective part of the Local EPS. (IEEE 1547-2018, Clause 3.1, p. 25 and Draft TIIR p17-18)
- **Reference point of applicability**: The reference point of applicability (RPA) is the location where the interconnection and interoperability performance requirements specified in this standard shall be met. (IEEE 1547-2018, Clause 4.1, p. 27)
- **Load**: Devices and processes in a local EPS that use electrical energy for utilization, exclusive of devices or processes that store energy but can return some or all of the energy to the local EPS or Area EPS in the future. (IEEE 1547-2018, Clause 3.1, p. 24)

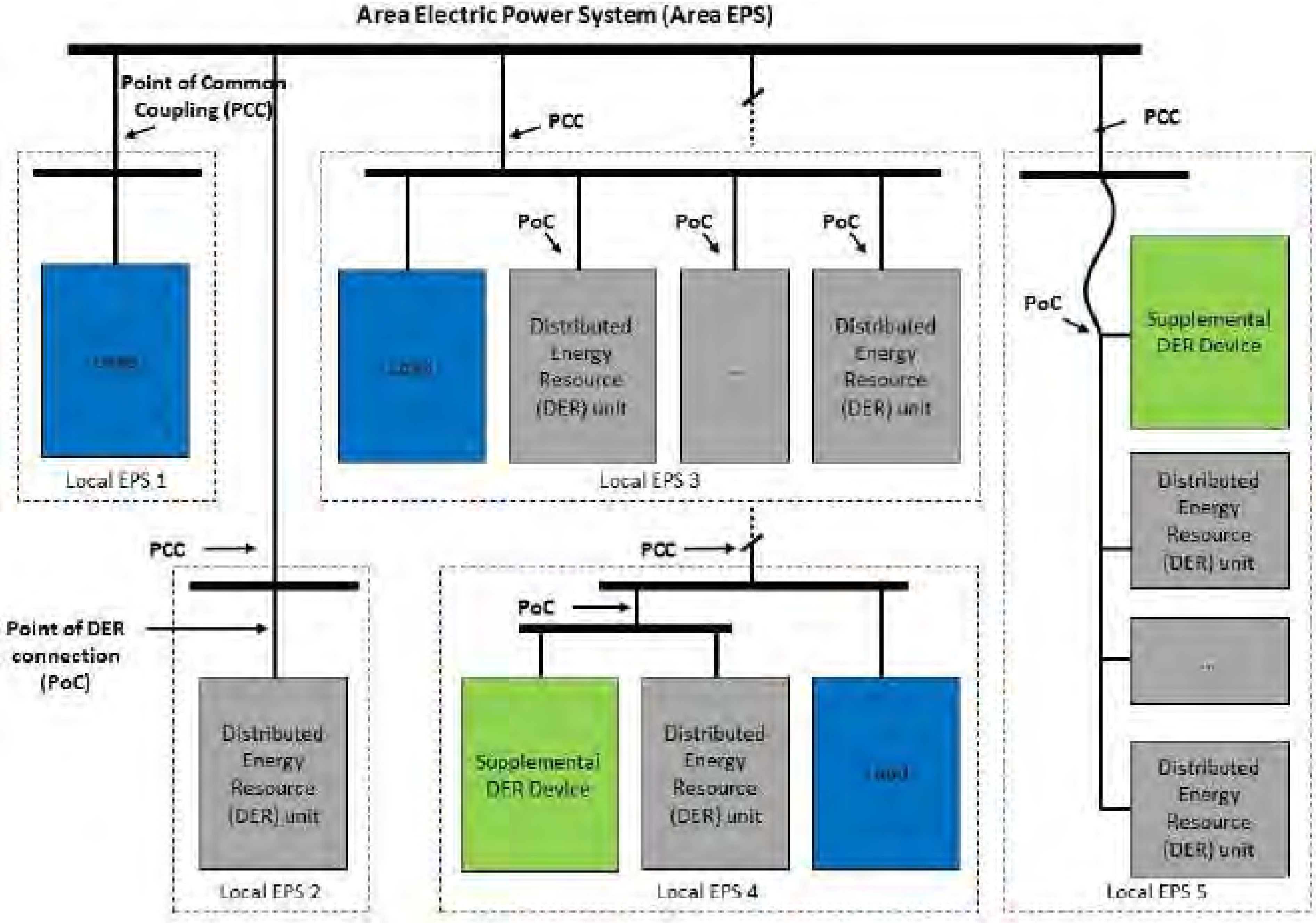

Table 2; IEEE 1547-2018, p. 18

IEEE 1547-2018 on Configuration Settings

Configuration setting; currently active values

Each rating in Table 28 (Nameplate information), may have an associated configuration setting that represents the as-configured value. If a configuration setting value is different from the corresponding nameplate value, the configuration setting value shall be used as the rating within the DER. Changes to the configuration setting shall be made with mutual agreement between the DER system operator and Area EPS operator. Configuration settings are not intended for continuous dynamic adjustment.

(IEEE 1547-2018, Table 28 and Clause 10.4, p. 70)

Table 28 —Nameplate information

Parameter	Description
Active power rating at unity power factor (nameplate active power rating)	Active power rating in watts at unity power factor
Active power rating at specified over-excited power factor	Active power rating in watts at specified over-excited power factor
Specified over-excited power factor	Over-excited power factor as described in 5.2
Active power rating at specified under-excited power factor	Active power rating in watts at specified under-excited power factor
Specified under-excited power factor	Under-excited power factor as described in 5.2
Apparent power maximum rating	Maximum apparent power rating in voltamperes
Normal operating performance category capability. (Category A/B as described in 1.4)	Indication of reactive power and voltage/power control
Abnormal operating performance category Category I, II, or III, as described in 1.4	Indication of voltage and frequency ride-through capability
Reactive power injected maximum rating	Maximum injected reactive power rating in vars
Reactive power absorbed maximum rating	Maximum absorbed reactive power rating in vars
Active power charge maximum rating	Maximum active power charge rating in watts
Apparent power charge maximum rating	Maximum apparent power charge rating in voltamperes. May differ from the apparent power maximum rating
AC voltage nominal rating	Nominal AC voltage rating in RMS volts
AC voltage maximum rating	Maximum AC voltage rating in RMS volts
AC voltage minimum rating	Minimum AC voltage rating in RMS volts
Supported control mode functions	Indication of support for each control mode function
Reactive susceptance that remains connected to the Area EPS in the *cease to energize* and trip state	Reactive susceptance that remains connected to the Area EPS in the *cease to energize* and trip state
Manufacturer	Manufacturer
Model	Model
Serial number	Serial number
Version	Version

Additional Proposed Definitions in Draft TIIR (Sec. 3B)

Term	Definition	Source
Energy Storage System	An electric system that stores active power for later injection into the Local EPS or Area EPS.	Draft TIIR
ESS Operational Control Mode	Controls utilized in an energy storage system to restrict the source(s) of charging energy or the utilization of discharged energy	IREC edit
Inadvertent Export	The unscheduled [*and uncompensated*] export of [*active* (or) *real*] power [*from a DER Generating Facility* (or) *injected across the PCC from a Local EPS to an Area EPS*] [*exceeding a specified magnitude and for a limited duration, generally due to fluctuations in load-following behavior*].	Draft TIIR/Xcel/IREC [italics = differences]
Non-Export, Non-Exporting	When the DER is sized and designed such that the DER output is used for Host Load only and is designed to prevent the transfer of electrical energy from the DER to an Area EPS or TPS as defined by Section 11 of this document.	Draft TIIR
Control Limited Export	Non-Exporting systems are a special type of Control Limited Export system (i.e. limit of zero kW) and the concept of Inadvertent Export is applicable	Xcel edit

Additional Proposed Definitions in Draft TIIR (Sec. 3B)

To be addressed later in the meeting

Term	Definition	Source
Maximum AC Capacity (alternative to Maximum Export Capability)	The maximum rated capacity of the DER, except where the gross generating capacity of the DER is limited by any of the means in Section __, the maximum AC capacity shall be the maximum specified by the interconnection customer in the interconnection request. The maximum AC capacity specified by the interconnection customer in the interconnection request will subsequently be included as a limitation in the interconnection agreement.	IREC edit
Maximum Export Capability (alternative to Maximum AC Capacity)	maximum export kW which the DER system is capable of injecting into the Area EPS, considering any control or other systems which are able to limit the export	DEA edit
Control Limited Capacity	The resulting power capability when a DER or total of DER source(s) behind the point of interconnection are limited in active power production below the aggregate DER nameplate rating through the use of a control systems, including power control systems, power relays, or other similar device settings or adjustments. Mechanisms for control limited capacity are protective to the utility system and shall be secured or hardware limited. Technical evaluations shall address DER characteristics and capabilities that are not impacted by source limiting.	Xcel edit
Inadvertent Capacity Exceedance	the production of active power in excess of the Control Limited Capacity. Limitations related to inadvertent capacity exceedance are addressed in Section X.	Xcel edit

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Capacity and Export Definitions

Proposed "Capacity" Definitions

Term	Definition	Source
Maximum AC Capacity (alternative to Maximum Export Capability)	The maximum rated capacity of the DER, except where the gross generating capacity of the DER is limited by any of the means in Section __, the maximum AC capacity shall be the maximum specified by the interconnection customer in the interconnection request. The maximum AC capacity specified by the interconnection customer in the interconnection request will subsequently be included as a limitation in the interconnection agreement.	IREC edit
Maximum Export Capability (alternative to Maximum AC Capacity)	maximum export kW which the DER system is capable of injecting into the Area EPS, considering any control or other systems which are able to limit the export	DEA edit
Control Limited Capacity	The resulting power capability when a DER or total of DER source(s) behind the point of interconnection are limited in active power production below the aggregate DER nameplate rating through the use of a control systems, including power control systems, power relays, or other similar device settings or adjustments. Mechanisms for control limited capacity are protective to the utility system and shall be secured or hardware limited. Technical evaluations shall address DER characteristics and capabilities that are not impacted by source limiting.	Xcel edit

Principles for Defining Capacity

- Differentiate the new term of ***Control Limited Capacity*** from ***Nameplate Rating***.
  - *Nameplate Rating* is defined in IEEE 1547-2018, but the new term of *Control Limited Capacity* is not defined by national standards
  - The terms should not be used interchangeably to describe DER power capability

- *Nameplate Rating* dictates the review track eligibility, based on potential impact and complexity of review, and some dynamic technical impacts while the *Control Limited Capacity* is used for steady-state impact evaluation
  - Controls are not reviewed before eligibility is determined

- Use a qualifier to “capacity” for this use, such as “control limited” or “source limited”, since the term “capacity” is used in a variety of situations (i.e. hosting capacity, load capacity),

Principles for Defining Framework of Terms

- Acknowledge wider framework of necessary defined terms
  - A working knowledge of potential future additions assists in future proofing defined terms

- Be cognizant of the evolving national industry standard framework
  - Moving ahead of standards in a measured manner may be necessary, but mechanisms for synchronizing state standards with future national standard publications should be written into state standards.

- Prioritize terms for inclusion in Phase II that are needed today for technical impact review and tariffed rate structures

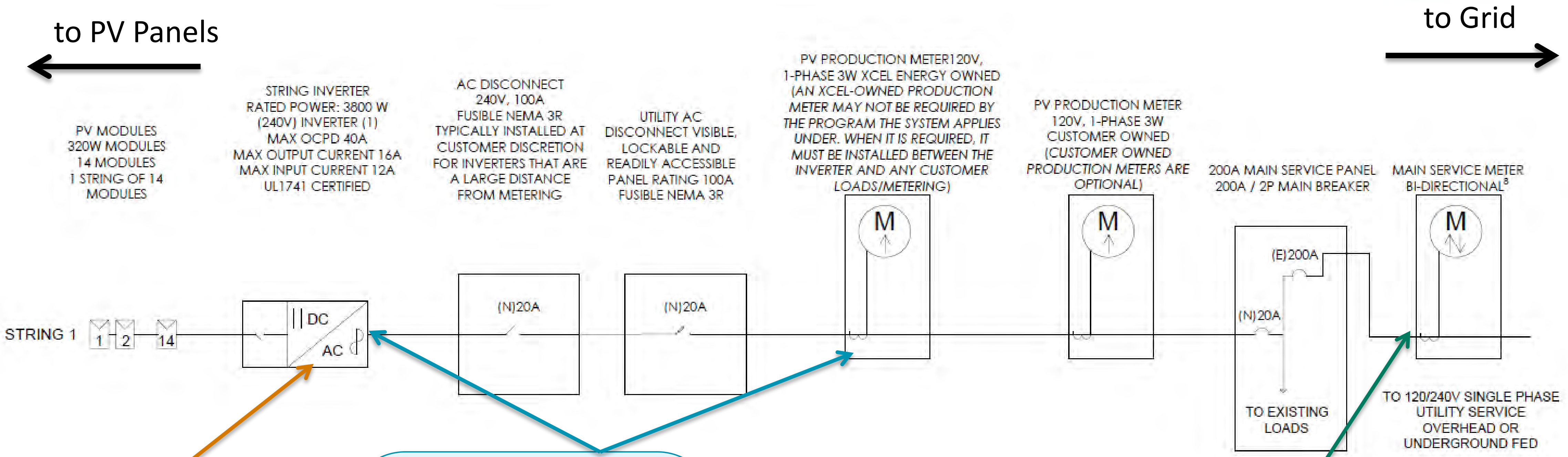
- Defer terms and concepts not yet needed in Minnesota to the standing working group

Framework of Defined Terms

Terms	Nameplate Rating	Control Limited Capacity → Inadvertent Capacity Exceedance	Control Limited Export → Non-Export → Inadvertent Export Control Limited Export → Control Limited Export (non-zero) → Inadvertent Export Limit Exceedance
Purpose / Use	• Determines **process track eligibility** • Captures **DER maximum capability** for system records • Used in **some aspects of technical review**	• New name proposed for MN DIP "Maximum Capacity" • Captures steady state operation for **Interconnection Agreements** • Used in **some aspects of technical review**	• Non-export and inadvertent export are currently useful for **contractual considerations** (i.e "NEM integrity") in MN • Control export limited is likely not needed until future updates

KEY: Phase II Scope | Future Revision

Relationship and Use of Terms



***Nameplate Rating** - Listed by manufacturer and inherent to DER capabilities*

***Control Limited Capacity** – Set by installer and can be internal or external to DER power conversion or production device. Must be limited prior to comingling of load*

→ ***Inadvertent Capacity Exceedance***

***Control Limited Export** – Set by installer and must use components external to the DER device in order to measure and limit export*

→ ***Non-export*** → ***Inadvertent Export***

→ ***Control Limited Export (non-zero)*** → ***Inadvertent Export Limit Exceedance***

Defined Terms – Nameplate Rating

MN DIP Definition

- **Nameplate Rating -** nominal voltage (V), current (A), maximum active power (kWac), apparent power (kVA), and reactive power (kvar) at which a DER is capable of sustained operation. For a Local EPS with multiple DER units, the aggregate nameplate rating is equal to the sum of all DERs nameplate rating in the Local EPS, not including aggregate capacity limiting mechanisms such as coincidence factors, plant controller limits, etc. that may be applicable for specific cases (Aggregate Nameplate Rating). The nameplate ratings referenced in the MN DIP are alternating current nameplate DER ratings. See Section .c on Capacity of the Distributed Energy Resource.

Defined Terms – Non-Export and Inadvertent Export

Draft MN TIIR proposal

- **Inadvertent Export :** the unscheduled and uncompensated export of real power injected across the PCC from a Local EPS to an Area EPS

- **Non-Export, Non-Exporting :** When the DER is sized and designed such that the DER output is used for Host Load only and is designed to prevent the transfer of electrical energy from the DER to an Area EPS or TPS as defined by Section 11 of this document.

Question: Should the currently primary use case of tariff/agreement compliance be mentioned in the definition?

Term for Future Consideration (after Phase II)

- **Control Limited Export** : Non-Exporting systems are a special type of Control Limited Export systems (i.e. limit of zero kW) and the concept of Inadvertent Export is applicable.

Defined Terms – Control Limited Capacity

New Xcel Energy draft proposal (replaces MN DIP “Maximum Capacity”)

- **Control Limited Capacity :** The resulting power capability when a DER or total of DER source(s) behind the point of interconnection are limited in active power production below the aggregate DER nameplate rating through the use of power control systems, power relays, or other similar device settings or adjustments. Mechanisms for control limited capacity are protective to the utility system and shall be secured or hardware limited. Technical evaluations shall address DER characteristics and capabilities that are not impacted by source limiting.

Term for future consideration (propose leaving compliance details to Area EPS Operator in Phase II)

- **Inadvertent Capacity Exceedance :** the production of active power in excess of the Control Limited Capacity. Limitations related to inadvertent capacity exceedance are addressed in Section X.
  - Note: Inadvertent Capacity Exceedance would need to be tailored for the reason of export limitation (i.e. Mitigation avoidance, contractual agreement, tariff compliance, etc.)

Feedback on Capacity Proposals from Stakeholders

- **Track eligibility –** Some proposals stated that eligibility should be determined by Control Limited Capacity rather than Nameplate Rating.
  - This proposal breaks the important and intentional screening function of the eligibility size limits.

- **Resulting Grid Impacts –** Given eligibility considerations, grid impacts may not be caught because the process may not allow the proper time or technical review.

- **Standards Considerations –** the IEEE1547-2018 standard ties capability requirements to the nameplate rating.

Xcel Energy's proposal is to use *Nameplate Rating* as the basis for application track eligibility and allow *Control Limited Capacity* to be used where applicable in technical review and agreements.

IEEE Std 1547-2018	Basis	Time Frame / Impacts	Draft TIIR	IREC edit	Xcel edit	DEA
nameplate ratings	kW, kVA, kvar	Planning, protection				
distributed energy resource (DER)	./.	planning	Energy Storage System			
Load	./.	planning				
Configuration setting per 10.4 (Configuration information) with regard to 10.3 (Nameplate information) apparent power maximum rating	kVA	planning		Maximum AC Capacity		
Configuration setting per 10.4 (Configuration information) with regard to 10.3 (Nameplate information) Active power rating at unity power factor (nameplate active power rating)	kW	planning			Control Limited Capacity	Maximum Export Capability (kW)
Configuration setting per 10.4 (Configuration information) with regard to 10.3 (Nameplate information) apparent power maximum rating equals zero	kVA	Planning, protection	Non-Export, Non-Exporting			
Failure to comply with 10.4 (Configuration information) with regard to 10.3 (Nameplate information) Active power rating at unity power factor (nameplate active power rating)	kW	Planning, protection			Inadvertent Capacity Exceedance	
4.6.2 (Capability to limit active power) with regard to a Maximum Active Power per 10.6.12 (Limit maximum active power)	kW	Quasi steady-state (approx. 30 s)			Control Limited Export	
Failure to comply with 4.6.3 (Execution of mode parameter changes) and 4.6.2 (Capability to limit active power) with regard to a Maximum Active Power per 10.6.12 (Limit maximum active power) equals zero	kW	Quasi steady-state (approx. 30 s)	Inadvertent Export			

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Draft TIIR Section 11: Non-Exporting or Limited Export

Capacity Limitation Options (11. B)

1) Reverse Power Protection
2) Minimum Power Protection
3) DER is <25% of service equip, <50% xfmr rating, certified non-islanding
4) DER <50% host load
5) Limited export (study)
6) Certified limited export
7) Not in Draft (probably should be) – Inverter output control (“control limited capacity”)

Inadvertent Export Adoption

Evolution of
Inadvertent Export
definition & req's

MN –
Max AC Capacity

CA – Rule 21

NV – Rule 15

AZ – Under discussion

HECO – Customer Self-Supply

Proposed “Inadvertent Export” Definition (Draft TIIR p. 15 full mark up)

Term	Definition	Source	Notes
Inadvertent Export	The unscheduled export of active power from a ~~DER~~ Generating Facility, exceeding a specified magnitude and for a limited duration, generally due to fluctuations in load-following behavior	IREC edit	Also submitted to MD
Inadvertent Export	The unscheduled and uncompensated export of real power injected across the PCC from a Local EPS to an Area EPS	Xcel edit	In line with CA Rule 21 and NV Rule 15

- IEEE 1547 does not define “Inadvertent Export”

Proposed Inadvertent Export Introduction (Draft TIIR p. 33 full mark up)

Draft TIIR	IREC Proposal
Section 11 Header: Non-Export, Non-Exporting and Inadvertent Export	Section 11 Header: Non-Export, ~~Non-Exporting~~ Limited Export and Inadvertent Export
DER Operators may choose to size systems and implement operating modes intended to avoid export of energy from the Local EPS to the Area EPS.	DER Operators may choose to size systems and implement operating modes intended to avoid export of energy from the Local EPS to the Area EPS above a certain power level.
Due to small time delays inherently associated with electrical control system responses, DER intended not to export beyond the PCC may at times inadvertently inject real power onto the Area EPS for a brief amount of time.	Due to small time delays inherently associated with electrical control system responses, DER intended not to export beyond a certain level ~~the PCC~~ may at times inadvertently inject ~~real~~ active power onto the Area EPS for a brief amount of time.
Parallel operation of a DER is the defining feature for determining if Area EPS impacts can result from DER operation, but defining non-exporting characteristics can be useful in determining compliance with agreements or tariffs that require non-exporting capabilities.	~~Parallel operation of a DER is the defining feature for determining if Area EPS impacts can result from DER operation, but defining non-exporting characteristics can be useful in determining compliance with agreements or tariffs that require non-exporting capabilities.~~
The terms "non-exporting" or "no export" shall allow for occasional de minimis inadvertent export as defined by this section.	The terms "non-exporting" or "~~no export~~ limited export" shall allow for occasional de minimis inadvertent export as defined by this section.

Inadvertent Export

Inadvertent *Export* is <u>not</u>

Inadvertent *energization*

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“Inadvertent Energization” Definition (IEEE 1547-2018 p. 33)

- **4.9 Inadvertent energization of the Area EPS**
- The DER shall not energize the Area EPS when the Area EPS is de-energized. Exceptions may be given for *intentional Area EPS islands* per 8.2 at the discretion of the Area EPS operator.

Concepts in Section 11 that appear to need resolution

- Should *limited export* be included in Phase II, or is that part of the future roadmap for MN TIIR?
  - If yes, is it part of, or alternatively, unique from
    - non-export?
    - Inadvertent export?
  - Is there broad agreement on the answers to above?
- With regards to UL-1741, should anti-islanding be referenced? Non-islanding?
- Should type testing be included in this version of the TIIR in advance of national standards?

Non-Export Eligibility (7-10-18 Draft TIIR p. 35-37 full mark up)

Draft TIIR	IREC Proposal
All generation produced by onsite DER shall be interfaced through a UL 1741 certified inverter	The Generating Facility must utilize only UL 1741 certified non-islanding inverters
Total nameplate rating of all DER onsite is less than 100 kW – Based on HI Rule 14	(No size limit)
DER is not served from a Networked Secondary System	Limited Export may not be available for interconnection to Networked Secondary Systems.
	.. additional Protective Functions and equipment to detect Area EPS faults (per the Area EPS Operator's standard practices) may be required. Protective Functions may include, but are not limited to, directional overcurrent/voltage-restraint overcurrent Protective Functions for line-to-line fault detection and overcurrent/overvoltage Protective Functions for line-to-ground detection. The addition of a ground bank or ground detector may also be necessary.
	The DER unit must utilize a NRTL-certified control system or NRTL-certified inverter system that meets following: **See Cease to Energy Requirements slide.**

Xcel Edit of IREC Edits to Draft TIIR Sec. 11 C

(7-26-18 Draft TIIR p. 35 full mark up)

- Discussion of protection devices.
  - Limited Export ~~may~~ is not ~~be~~ available for interconnections to Networked Secondary Systems.
- Discussion of export amounts and equipment life; Xcel proposes deleting or moving to footnote with additional explanation.
  - ~~The effect on equipment ratings can be mitigated by limiting the amount of inadvertent export allowed. To a large degree, Voltage Regulation may be similarly handled.~~
- Discussion of roles; Xcel proposes deleting "mutual agreement"
  - The permitted magnitude of inadvertent export shall be determined by ~~mutual agreement of~~ the Area EPS Operator ~~and the DER Operator~~ and should be limited to the lesser of one of the following values
- Discussion of scope: does a maximum export limit cover approved export + inadvertent export?

Operational Requirements // Magnitude of Inadvertent Export (p. 35-37 full mark up)

Draft TIIR	IREC Proposal
50% of the DER nameplate capacity, or	Nameplate rating of the Generating Facility
10% of the continuous conductor rating in watts at 0.9 power factor for the lowest rated feeder conductor upstream of the DER, or	
110% of the largest load block in the facility, or	110% of the largest load block in the facility, or
100 kW or some other maximum level indicated by the Area EPS Operator	500 kW or some other maximum level indicated by the Area EPS Operator
	directional power protective function will be provided to trip the connected Generator(s) with a delay of two seconds and maximum clearing time of 10 cycles if the proposed maximum export limit is exceeded.
DER total energy export must not exceed nameplate rating (kW gross) multiplied by 3 hours, over a 30 day rolling period (e.g. 10 kW gross nameplate Generating Facility, max energy export for 30 day period is 30 kWh.) – based on CA RULE 21	The Generating Facility’s total Inadvertent Export energy must not exceed its nameplate rating (kVA-gross) multiplied by 0.1 hours per day over a rolling 30-day period (e.g., for a 100 kVA-gross nameplate Generating Facility, the maximum Inadvertent Export energy allowed for a 30-day period is 300 kWh).

Cease to Energize Requirements (p. 35-37 full mark up)

Draft TIIR:

Generation Source Nameplate Rating	Period of continuous Inadvertent Export	Clearing Time
> 100 kW	> 30 seconds	2 seconds

Monitoring on the total energy exported shall be furnished by the DER Operator which provides notification if the export limit is exceeded, unless waived by the Area EPS. The notification shall be available to the Area EPS. Failure of the control or inverter system for more than 30 seconds, resulting from loss of control signal, loss of control power, or a component failure or related control sensing, shall result in the DER entering into a *cease to energize* state.

IREC proposal:

Generation Source Nameplate Rating	Period of continuous Inadvertent Export	Clearing Time
≤ 500 kVA	> 30 seconds	2 seconds
> 500 kVA - ≤ 1 MVA	> 10 seconds	1 second
> 1 MVA	> 2 seconds	10 cycles

Failure of the control or inverter system for more than the applicable inadvertent export time limit in a., resulting from loss of control or measurement signal, or loss of control power, must result in the DER unit entering Non-Export operation where no energy is exported across to the PCC to the Area EPS.

IEEE 1547 references

- *4.2.b **RPA***

"Annual average load demand of greater than 10% of the aggregate DER nameplate rating, and where the Local EPS is not capable of, or is prevented from, exporting more than 500 kVA for longer than 30 s."

- 4.6.2 **Limit Active Power:**

"In cases where the DER is supplying loads in the Local EPS, the active power limit set point may be implemented as a maximum active power export to the Area EPS."

- 5.4.2 fn 65 **volt-watt**:

"As permitted by 4.6.2, for cases where the DER is supplying loads in the Local EPS, the DER active power may be implemented as a maximum active power export limit set point. The DER shall not be required to reduce active power below the level needed to support local loads."

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IREC Limited Export Technical Req's

Insert the following:

B. Define how DER rating is determined – "Maximum Export" aka "Max AC Capacity" options

- A+B = A+B // A+B = A // A+B = <A+B

C. "Inadvertent Export" requirements for any large DER

D. "Inadvertent Export" requirements for inverter-based controls

E. Testing requirements for Inadvertent Export equipment acceptance

- Soon to be covered by UL Electronic Current Limiting standard

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Draft TIIR Section 10: Storage

IREC and Xcel Proposed Edits to Draft TIIR Sec. 10

- Delete or move to footnote for context the following:

  At present time, for many commercially available systems, the ESS control modes are made easily accessible to the end user, which is a significant departure from the accessibility of inverter controls for other DER, which often require unique apparatus or secure technician passwords.

- Request to define ESS Operational Control Modes:

  " Controls utilized in an energy storage system to restrict the source(s) of charging energy or the utilization of discharged energy." (proposed in Definitions Section 3B)

- Proposed additional requirement:

  " Documenting at the time of application the charge/discharge profile(s) or use case(s) intended to be utilized by the ESS owner. This information may be collected through an Area EPS Operator specific document(*) or portion of the Company's online application portal. (Xcel proposes deleting this IREC edit: Profile or use case may change over time without altering or updating the interconnection agreement.)

  ~~Footnote (*): Upon publication of standards and certifications, this type of information will be well-suited to be included in statewide interconnection process documentation. Until that time, it is likely the type of ESS information needed could rapidly shift, depending on customer preferences and available technology. Continual shifts in technology, application of technology, and market place are occurring at a rapid pace at the time the TIIR is being written."~~

Is ESS Operational Control Mode Sufficient?

IREC proposed definition of ESS Operational Control Mode: " Controls utilized in an energy storage system to restrict the source(s) of charging energy or the utilization of discharged energy."

- How does "ESS Operational Control Mode" differ from "use case" or "profile"?
- Are either ESS "operational control mode" or "use case" or "profile" from 7-26-18 Draft TIIR the same as "control modes" (IEEE 1547-2018 Clauses 4-5) or "configuration settings" (IEEE 1547-2018 Clause 10.4) as described in IEEE 1547?
  - Does this categorization allow us to differentiate between what is allowed to fluctuate day to day in operations within an interconnection or operating agreement vs. what requires (a new) agreement between Area EPS Operator and DER system operator?
- Is there a relationship between ESS operational control mode and IEEE 1547's "operating mode"?
  - **operating mode:** Mode of DER operation that determines the performance during normal or abnormal conditions. (IEEE 1547-2018, Clause 3.1, p. 25)
    - Examples from Tables 14, 15, 16 and 19 in Annex H include cease to energize, permissive operation, continuous operation and mandatory operation

Draft TIIR Section 10 Energy Storage edits

Keep or delete: Profile or use case may change over time without altering or updating the interconnection agreement.

- Technically, does the utility need to know the specific export capacity and/or modes of operation to complete technical review of the ESS interconnection application? Or, is there a tradeoff between studying the possible export capacity and/or modes of operation vs. a specific mode in an operating agreement related to customer use flexibility and hosting capacity?
  - If there is an operating agreement that specifies export capacity and/or modes of operation for purposes of interconnection study, what is required for the customer to change how they are operating their storage device?
  - Could the Interconnection agreement be a super-set of approved customer uses which may be changed at any time? Would those changes need to be captured in an updated operating agreement?

Considerations related to the roadmap for storage (MNSEIA)

- Peak Demand Management
  - Is there general agreement that ESS may export with an interconnection agreement?
  - Are limitations to the import of energy to charge an ESS envisioned?
    - a. Will the ESS be controlled to avoid importing energy during utility peak periods?
    - b. Alternatively to a. above, will utilities be able to interrupt charging an ESS for short blocks of time during peak demand periods, similar to AC saver switches?
- Non-Importing Storage
  - Will non-importing ESS be constrained from either importing or exporting?
- Storage plus on-site solar generation
  - Will the ESS be able to be charged by imported energy during periods of low solar output?
  - Should the threshold for detailed interconnection review be based on the respective size of the solar and storage system?
  - At what level might multiple DERs on a distribution feeder trigger an interconnection review if an owner of a DER adds storage?

Next Steps

July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 2	Prep work due for Aug 10 meeting
Aug 3	*July 20 topics continued*
Aug 10	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 6	Prep work due for Sept 14 meeting
Sept 14	Test and Verification; Witness Test Protocol
Sept 21	In-Person TSG: Power Quality; Follow up items; TIIR edits discussion
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

Thank You!

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Back Up Slides

Continuum of dynamic adjustment for storage operations with interconnection agreement

Configuration Settings (including control mode)

Services being utilized

Amount of power exported within allowable range

Least dynamic to most dynamic →

(based on IEEE 1547-2018, Table 28 and Clause 10.4, p. 70)

Anticipated we will pick up here for the August 3rd meeting

August 3rd Agenda (TSG #5)

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, 7/20 Recap
9:40 – 9:50	Meeting Goals & Definitions - Reminder
9:50 – 10:20	Draft TIIR Definitions: Capacity and Export • Role of Capacity in Interconnection Process and Technical Review; Other Uses • Limited Capacity and Export definitions • Discussion Control Limits and Inadvertent Exports • Overview of Inadvertent Export Adoption in Other States • Control Limit considerations
10:20 – 11:30	Draft TIIR Sec. 11: Non-Export or Limited Export • Walk through proposed edit side-by-side with rationales • Limited Capacity and Export definitions • Discussion
11:30 – 12:10	Draft TIIR Sec. 3B: Definitions • Non-Export or Limited Export • Inadvertent Export

Energy Storage is an Emerging Consumer Technology

- Customers with load only* do not agree ahead of time to specific load profiles/shapes for their household or business
- Customers may have financial incentives to adjust whatever load shapes they have
  - TOU billing
  - Demand charge
- Load has evolved over many years such that relevant models exist with generalized behavior assumptions used in forecasting
- Energy storage is a new concept and Area EPS Operator may need information about storage operations until patterns can be established in order for Area EPS Operator in partnership with DER Operators to proactively make adjustments to promote consistently nominal grid behavior
  - In some cases this information may lead to agreements to limit export

* With acknowledgement that many households and businesses have energy storage on their laptops and cell phones that they use regularly, but do not have interconnection agreements, and the devices are inherently non-exporting.

Discussion: Scope for Statewide Technical Requirements

These topics have been proposed as **in scope**.
Bold have been flagged for discussion.

1. Scope/Overview
2. References
3. Definitions
4. **Performance Category Assignments**
5. **Reactive Power Capability and Voltage/Power Control (volt-var & volt-watt) Performance**
6. **Response to Abnormal Conditions (Ride-through)**
7. **Protection Requirements**
8. **Metering**
9. **Interoperability (Monitoring, Control, Info Exchange, Cyber security)**
10. **Energy Storage**
11. Non-Export; Inadvertent Export
12. **Test and Verification Requirements**
13. **Agreements**
14. **Consumer Protection** (IREC)
15. **Reporting** (IREC)

(Source: “Regulated Utilities” TIIR Draft Proposal)

Discussion: Scope for Statewide Technical Requirements

1. Process requirements
2. Cost allocation
3. Interconnection to transmission system
4. **Protection system details of Area EPS or DER**
5. **Requirements or specification of system impact or facilities studies**
6. **Application of real and reactive power control functions**
7. **Details of communication networks; including architecture, technology and protocols, or other specifications related to interoperability**
8. **Details of metering requirements or specifications**
9. **Planning or operational considerations associated with Affected Systems, Regional Transmission Operator or Transmission Owners**
10. **Intentional Area EPS islanding**

These topics have been proposed as **out of scope** by some participants. Bold are flagged for additional discussion.

(Source: TIIR Draft Proposal, p. 9)

July 20th Agenda (TSG #4)

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, 6/8 TSG Recap
9:40 – 9:50	Meeting Goals & Definitions
9:50 – 10:40	Draft TIIR Sec 10: Energy Storage • Storage compared to load and DER generating facilities • IREC proposed edits to Sec. 10 • Discussion
10:40 – 12:10	Draft TIIR Definitions: Capacity and Export • Xcel Case Study • Role of Capacity in Interconnection Process and Technical Review; Other Uses • Limited Capacity and Export definitions • Discussion
12:10 – 12:30	Meeting Evaluation & Next Steps; including input on 8/3 Agenda

SEE SLIDE 43 for August 3rd TSG Meeting Agenda re: Limited Export and Inadvertent Export

Recap from June 8

- General consensus that Frequency Droop should be included in the TIIR as information, and that only default settings will be used. (Add page in TIIR here).
  - Suggestion that could say in the TIIR that Area EPS Operators won't make frequency droop settings unique in the TSM.
  - Acknowledgement that MISO could come back with something different on frequency than IEEE 1547-2018. Will deal with it at that time if so.
- We will meet in person September 21 to review/address red-lines provided to-date to TIIR
- We will e-file meeting slides and prep materials, but not TIIR redlines

Storage compared to Load and DER Generating Facilities

ENERGY STORAGE

- AC-coupled

DC-coupled

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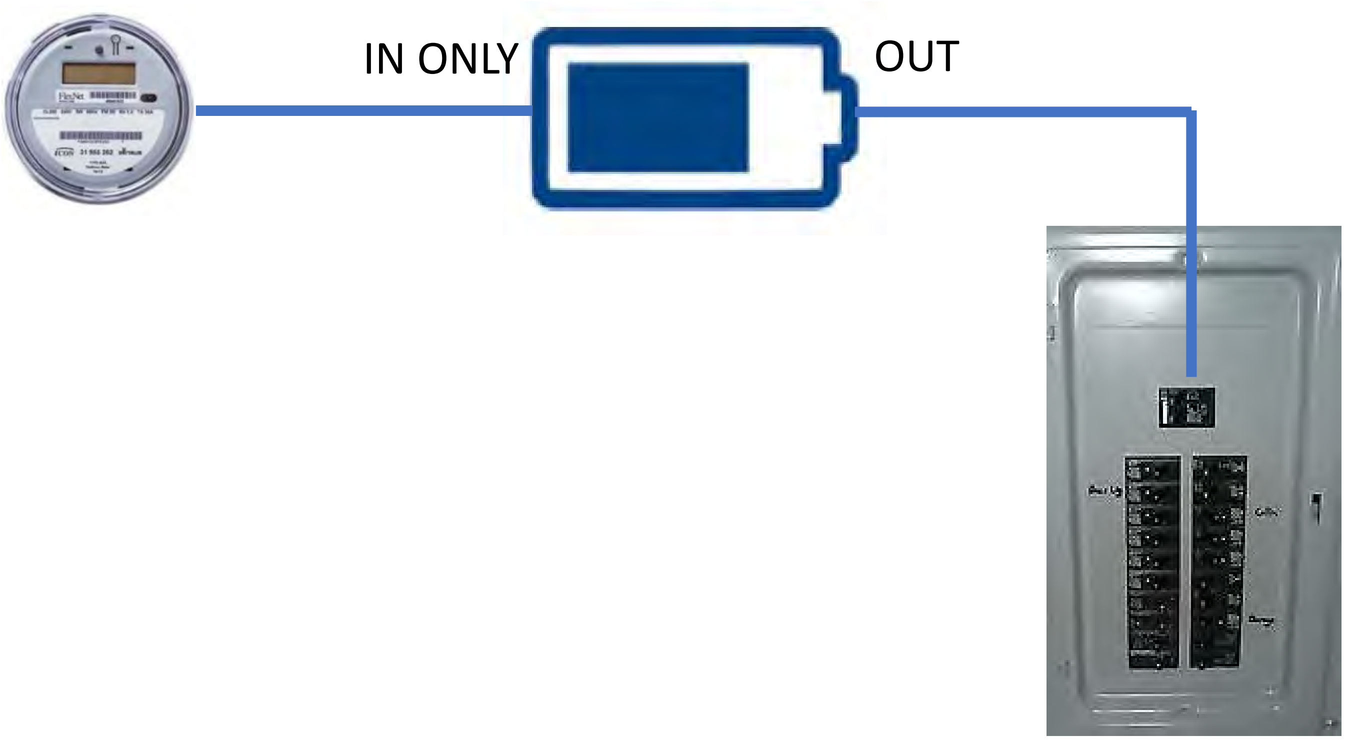
ESS Usage Data

Thought Exercise: What info is needed by utility in this scenario?



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ESS Load Aspects Compared to Traditional Load

- **Similarities**
  - Absorbs real and reactive power

- **Differences**
  - ESS also sources real and reactive power, while load does not.
    - This causes a the potential for wider power swings (i.e. full absorption to full injection)
  - ESS typically has wider range of reactive power absorption capabilities when compared to load devices with a comparable apparent power rating.
  - Control of the power and energy being absorbed is the objective for ESS, while other load uses the energy as a means to an objective.
    - This impacts when and how the energy is absorbed in time and magnitude. Grid or market conditions could inadvertently align the charging of ESS within a very short time window, which could have outsized grid impacts, when compared to traditional load which tends to exhibit more temporal diversity.

ESS Source Aspects Compared to DER

Xcel Energy

- **Similarities**
  - Injects real and reactive power
  - Interconnection process and technical standards are applicable

- **Differences**
  - ESS is not reliant on a fuel source or prime mover and is inherently has more flexible real and reactive power injection characteristics.
    - Use cases such as frequency control capitalize on this capability to produce quick spikes of real power injection or absorption.
  - ESS operation is defined by control modes which are not standardized by industry or functionally tested by a nationally recognized testing laboratory.
    - The early stage of this technology means that the response of a given function may not comport with the manufacturer’s stated functionality.
  - ESS firmware changes are frequent and can fundamentally change the operating characteristics.
  - Intentional or inadvertent coordination of wide area ESS response by may become a reality if market changes are implemented.
    - If these market conditions appear imminent, the impacts and questions surrounding mitigation policy should be addressed. The policy is out of scope for this working group, but we could discuss if the technical impact consideration is part of interconnection standards or should be enabled through a different process.

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Draft TIIR Section 10: Energy Storage

ESS Use Cases vs. Operational Control Mode

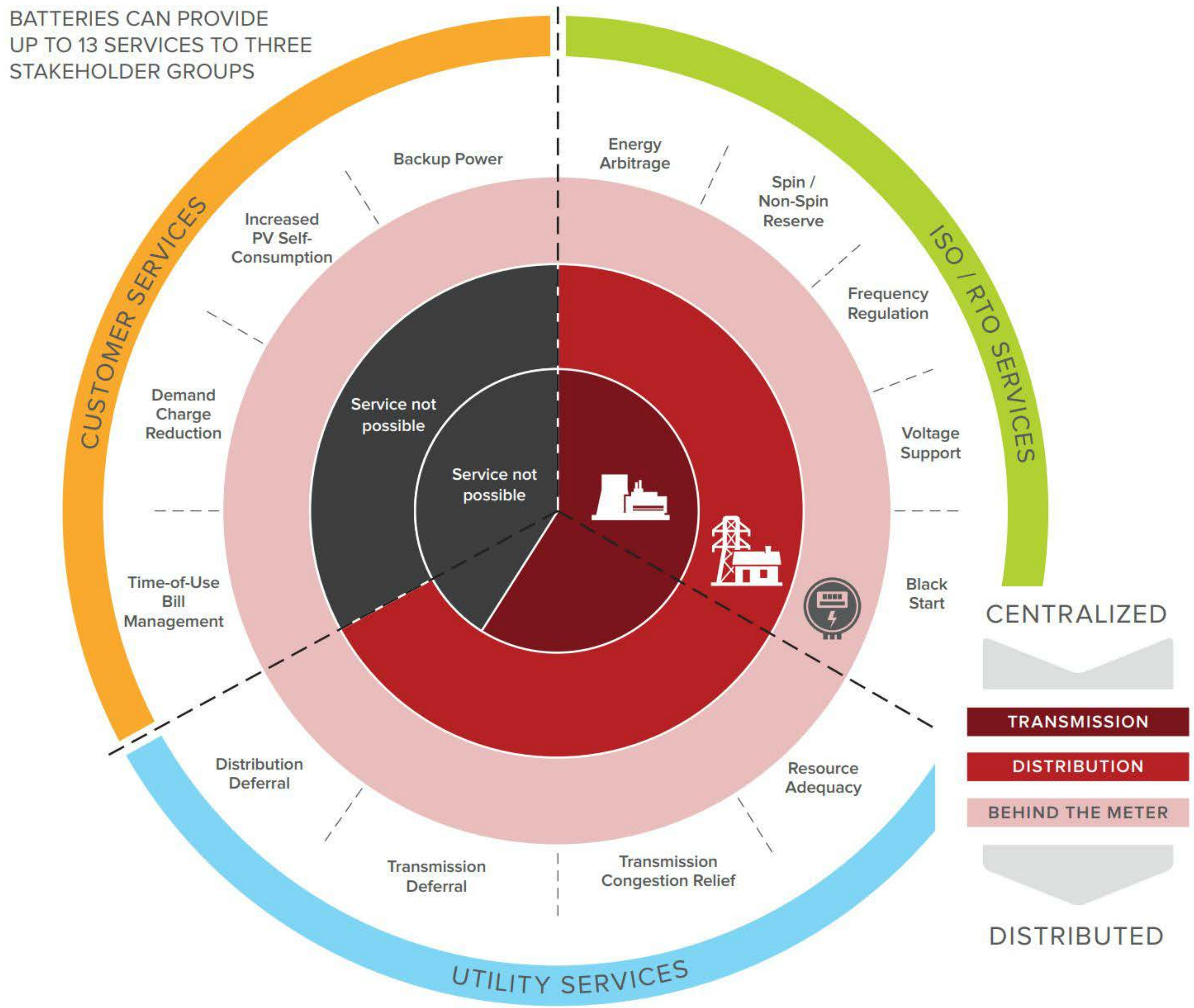
Use Case

- How/when does the customer charge/discharge their ESS, "profile"
- Protected or unprotected settings are used
- Customer must be allowed to alter how they use their equipment
- Added notification-only approach for use cases in 10.B.ii (could expand – in DIP? – notification to ongoing collection, voluntary)

Operational mode

- Generally wouldn't change – due to tariff restrictions
- Protected settings are used
- Added def for "ESS Operational Control Mode" in 3. Note difference to ride-through "operating mode."
- Should we add req's for non-importing ESS operational control mode?

RMI Use Cases



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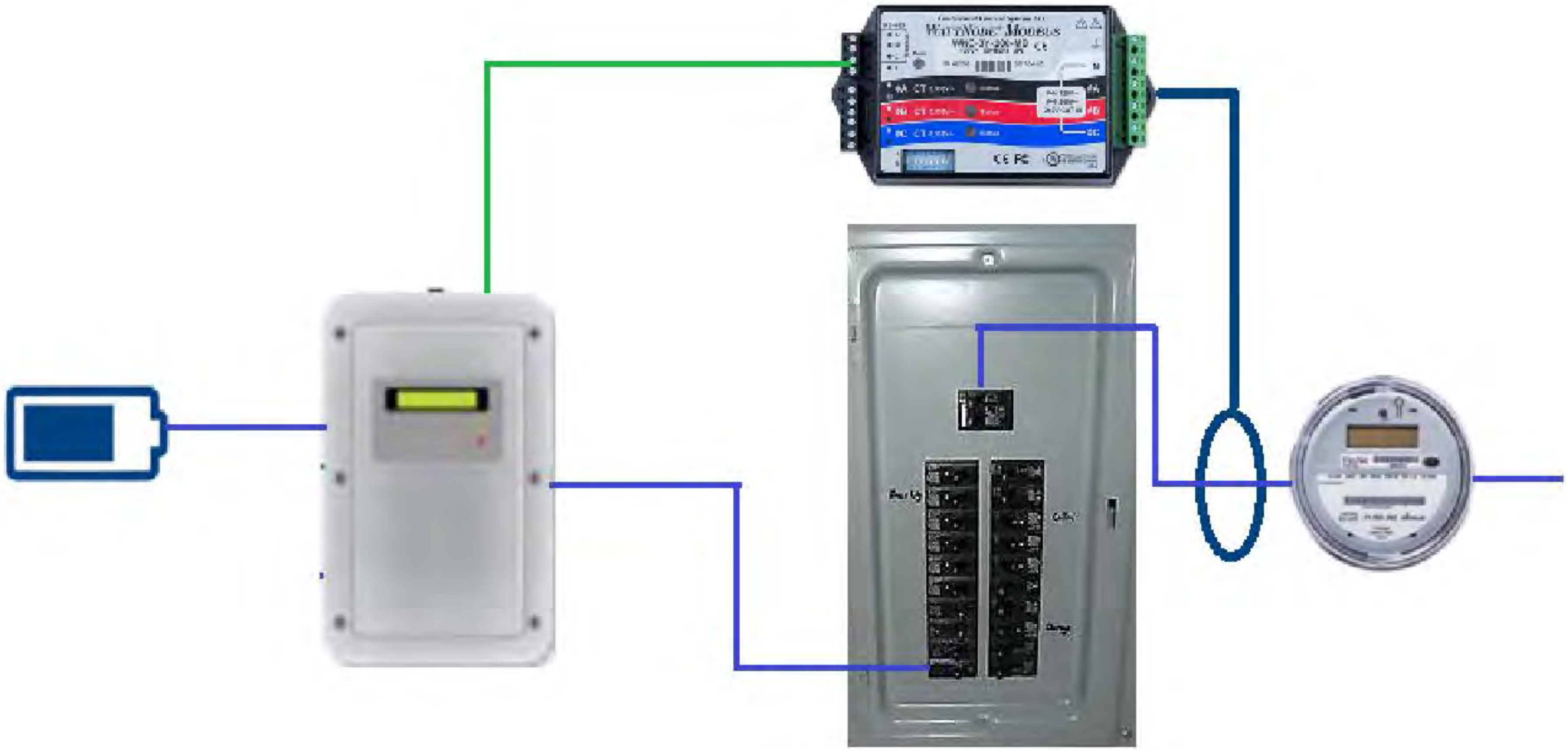
Non-Exporting or Limited Export DER

Export-limiting or non-export



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IEEE 1547 references

- *4.2.b* ***RPA***

“Annual average load demand of greater than 10% of the aggregate DER nameplate rating, and where the Local EPS is not capable of, or is prevented from, exporting more than 500 kVA for longer than 30 s.”

- 4.6.2 **Limit Active Power:**

“*In cases where the DER is supplying loads in the Local EPS, the active power limit set point may be implemented as a maximum active power export to the Area EPS.”*

- 5.4.2 fn 65 **volt-watt**:

“As permitted by 4.6.2, for cases where the DER is supplying loads in the Local EPS, the DER active power may be implemented as a maximum active power export limit set point. The DER shall not be required to reduce active power below the level needed to support local loads.”

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Impacts of Non-Exporting Systems

Voltage | Thermal | Protection

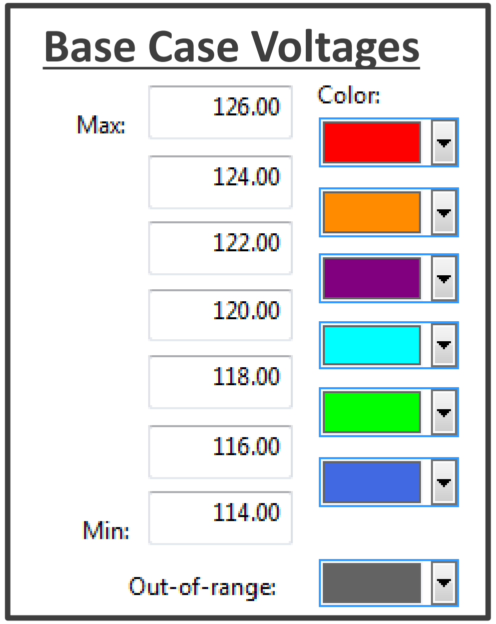
- Impacts from Individual DER and Aggregate DER needs to be considered when contemplating process and technical review treatment of non-exporting systems

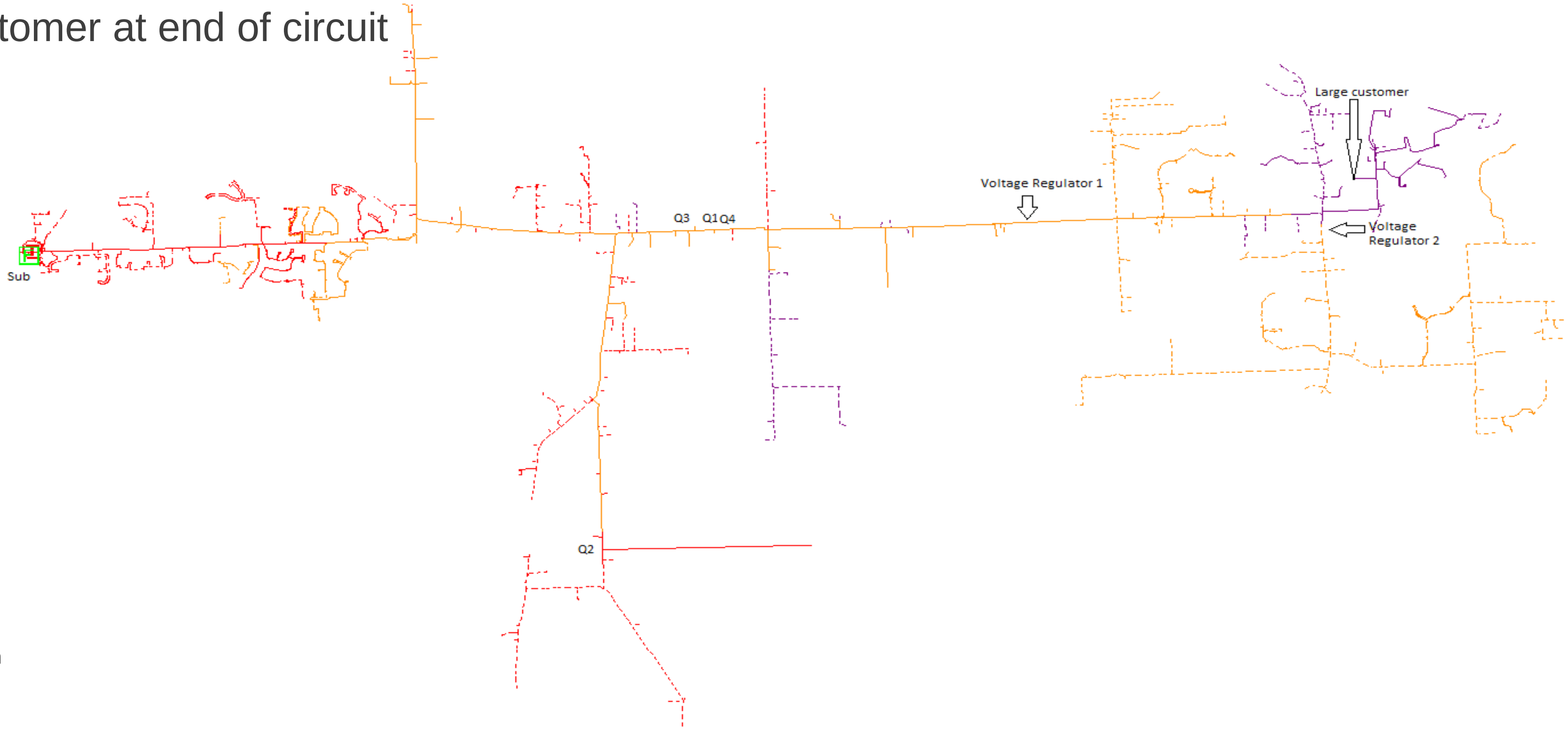
- Numerous Xcel Energy feeders have reached the existing hosting capacity

Voltage Impacts – Non-Exporting Systems

Steady State Overvoltage

- Real world feeder example:
  - 15 MW of PV existing on 13.8 kV circuit
  - Large 2 MW load customer at end of circuit

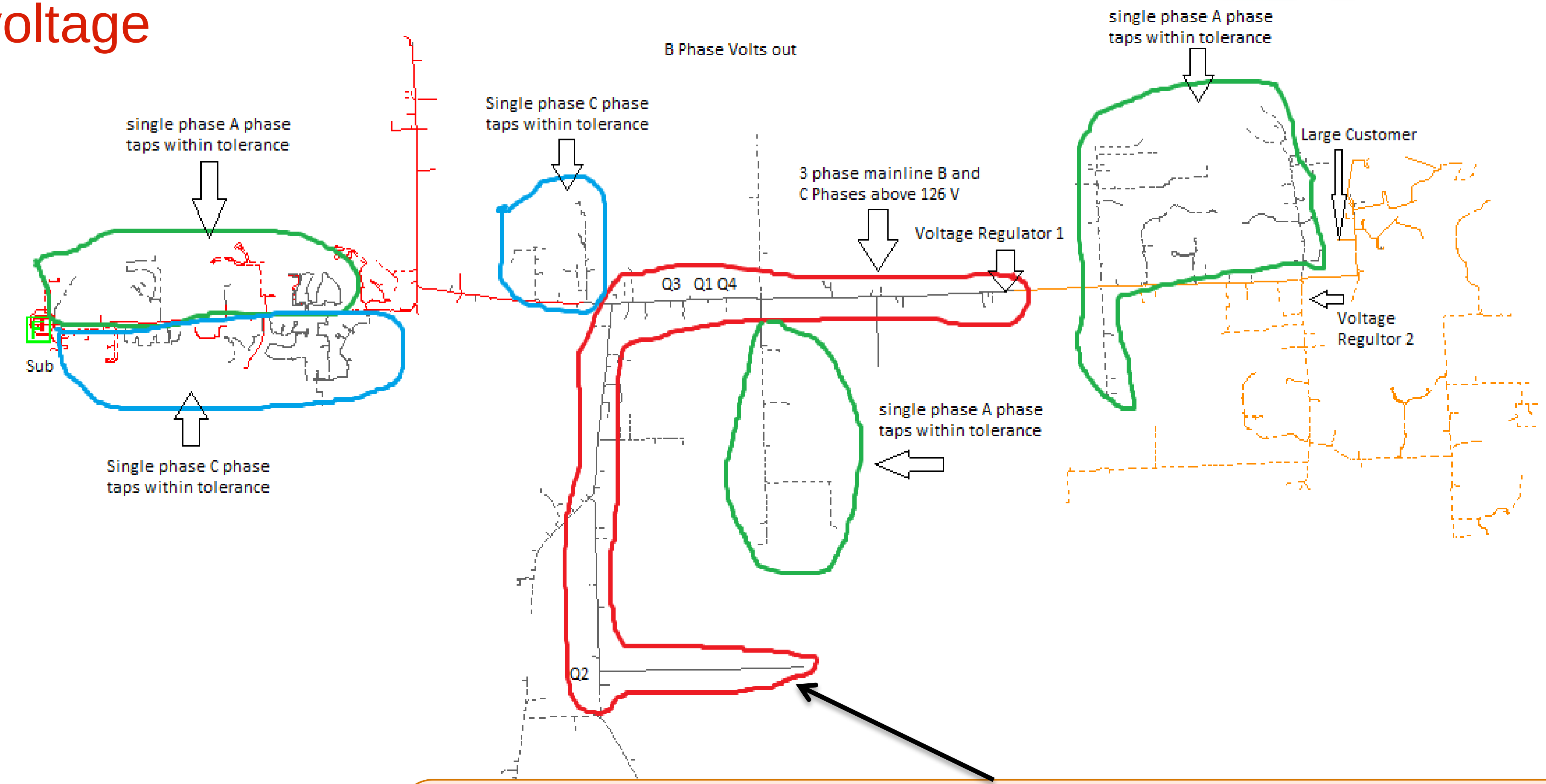




Note: Minimum daytime loading case is shown

Voltage Impacts – Non-Exporting Systems

Steady State Overvoltage



Non-Export Case Voltages

		Color
Max:	126.00	Red
	124.00	Orange
	122.00	Purple
	120.00	Cyan
	118.00	Green
	116.00	Blue
Min:	114.00	
Out-of-range:		Gray

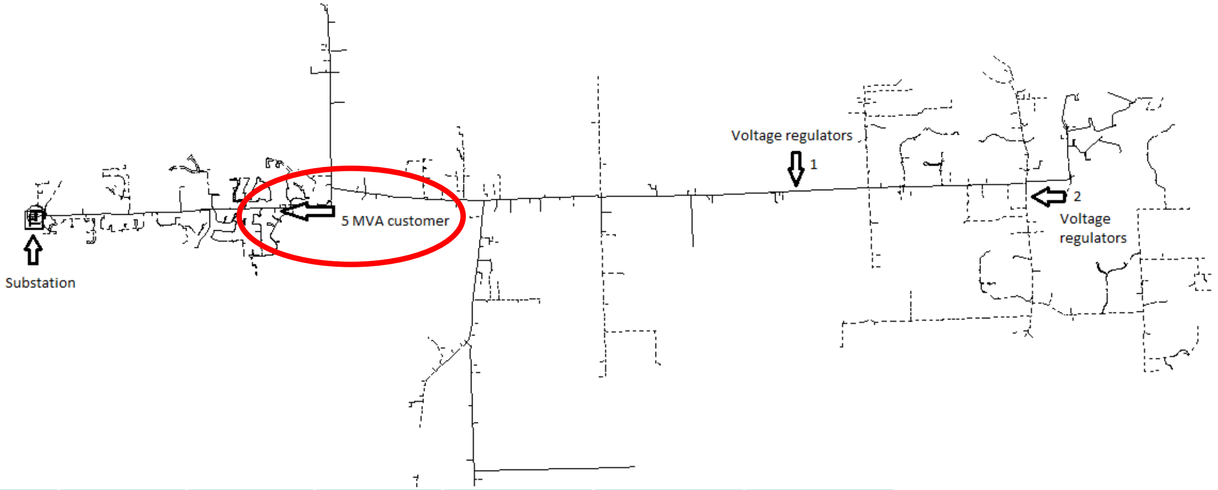
Note: Minimum daytime loading case is shown

Many customers would experience steady state overvoltage near the feeder mid-point served by tap circuits.

Voltage Impacts – Non-Exporting Systems

Voltage Fluctuation

- Same feeder as previous example, but now with a new 5 MW non-exporting customer added (5 MW load and 5 MW of generation)
- Individual DER 3% limit and voltage regulator 1.5% limit for 75% output drop (2% full-on to full-off) are both exceeded in some locations

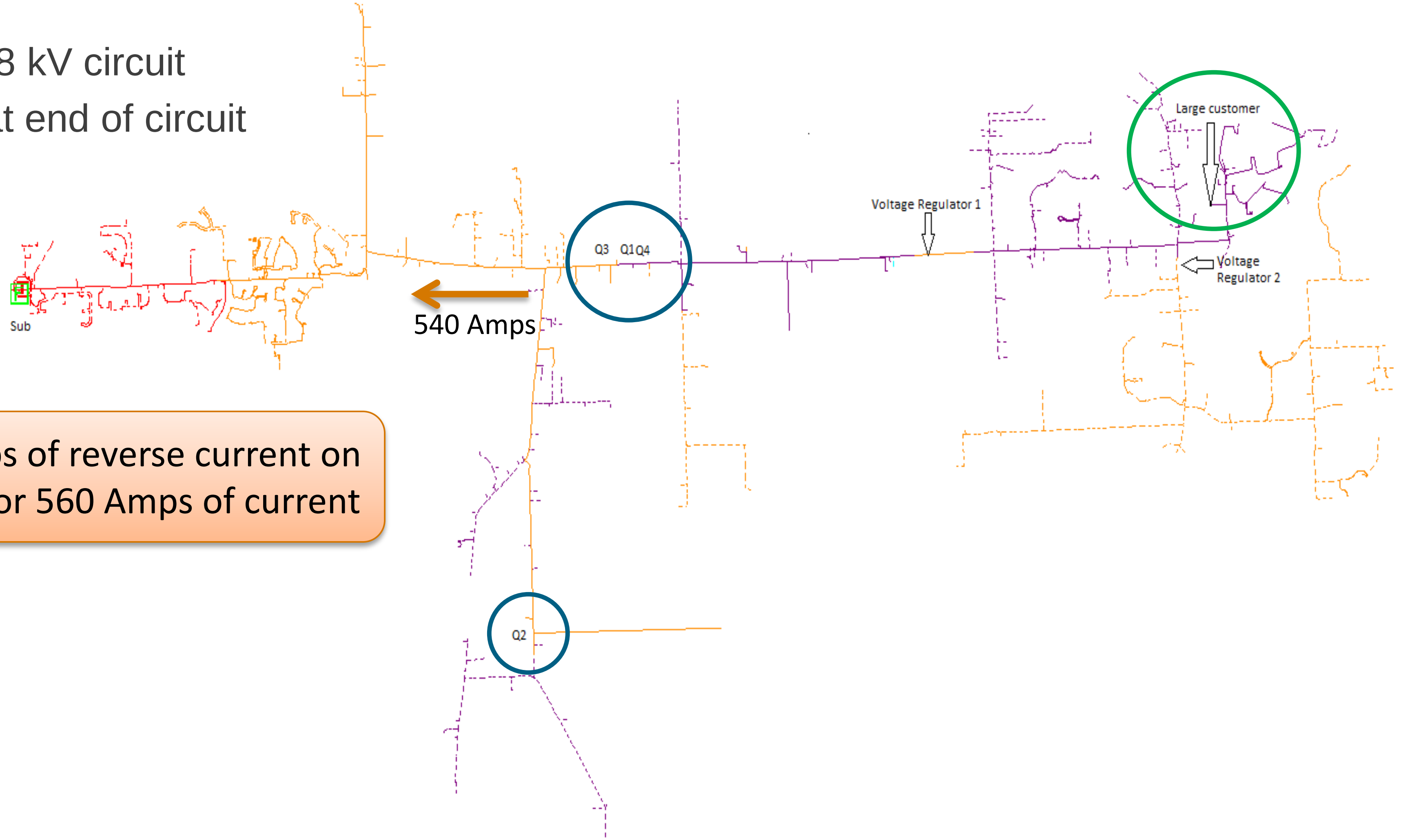


Location	A phase 5MVA on	B phase 5MVA on	C phase 5MVA on	A phase base	B phase base	C phase base	A % difference	B % difference	C % difference
Substation LTC	124.45	124.55	124.68	124.87	124.95	125.05	0.34%	0.32%	0.30%
5MVA spot load	117.51	118.83	120.26	120.69	122.9	123.51	2.67%	3.37%	2.67%
Voltage Regulators 1	118.67	118.12	119.64	122.07	122.28	122.92	2.82%	3.46%	2.70%
Voltage Regulators 2	---	115.82	---	---	120	---	---	3.55%	---

Note: red numbers indicate a voltage fluctuation limit violation

Thermal Impacts – Non-Exporting Systems

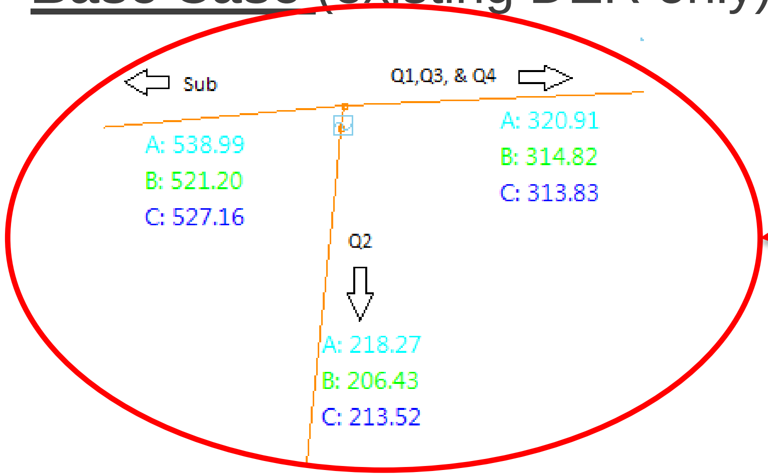
- Real world feeder example:
  - 15 MW of PV existing on 13.8 kV circuit
  - Large 2 MW load customer at end of circuit



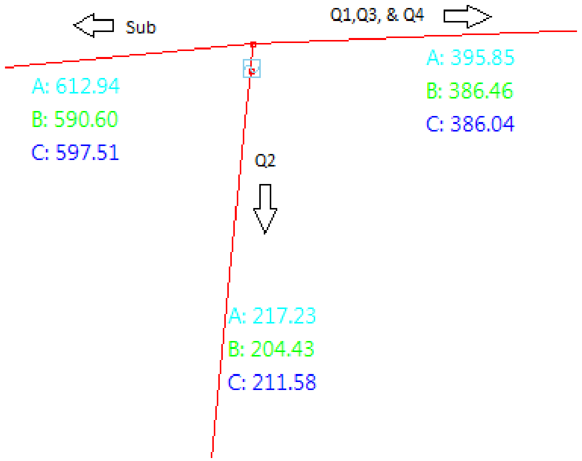
Currently 540 Amps of reverse current on 336 AL line rated for 560 Amps of current

Thermal Impacts – Non-Exporting Systems

- **Base Case** (existing DER only) ~ 540 Amps of reverse flow



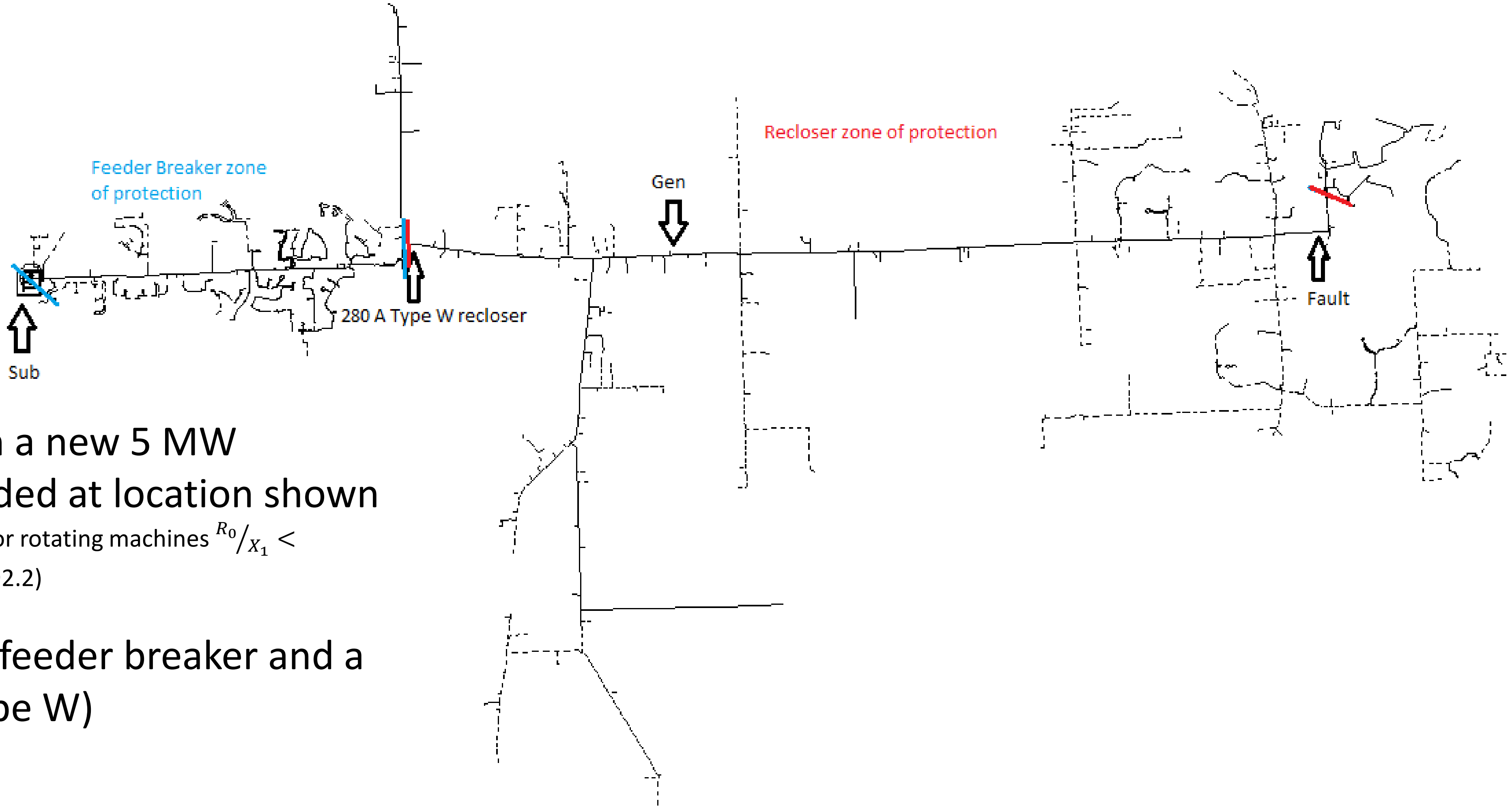
- **Non-Export Case** (2 MW DER) ~ 613 Amps of reverse flow



Non-export case shows 613 Amps on conductor rated for 560 Amps
→ **Thermal Overload**

Note: This case contemplated a 2 MW non-export DER system, but as little as 500 kW at this location, or aggregated at numerous locations, would lead to overload.

Protection Impacts – Non-Exporting Systems



- Consider same feeder with a new 5 MW synchronous generator added at location shown

  Note: Effective grounding requirements for rotating machines ${R_0}/{X_1} < 1 \;\; and\; 1.5 \leq {X_{0,DG}}/{X_{1,DG}} \leq 2.5$ (ANSI 62.92.2)

- Feeder protected by a the feeder breaker and a midline 280 A recloser (Type W)

Protection Impacts – Non-Exporting Systems

Base Case (DER disconnected)

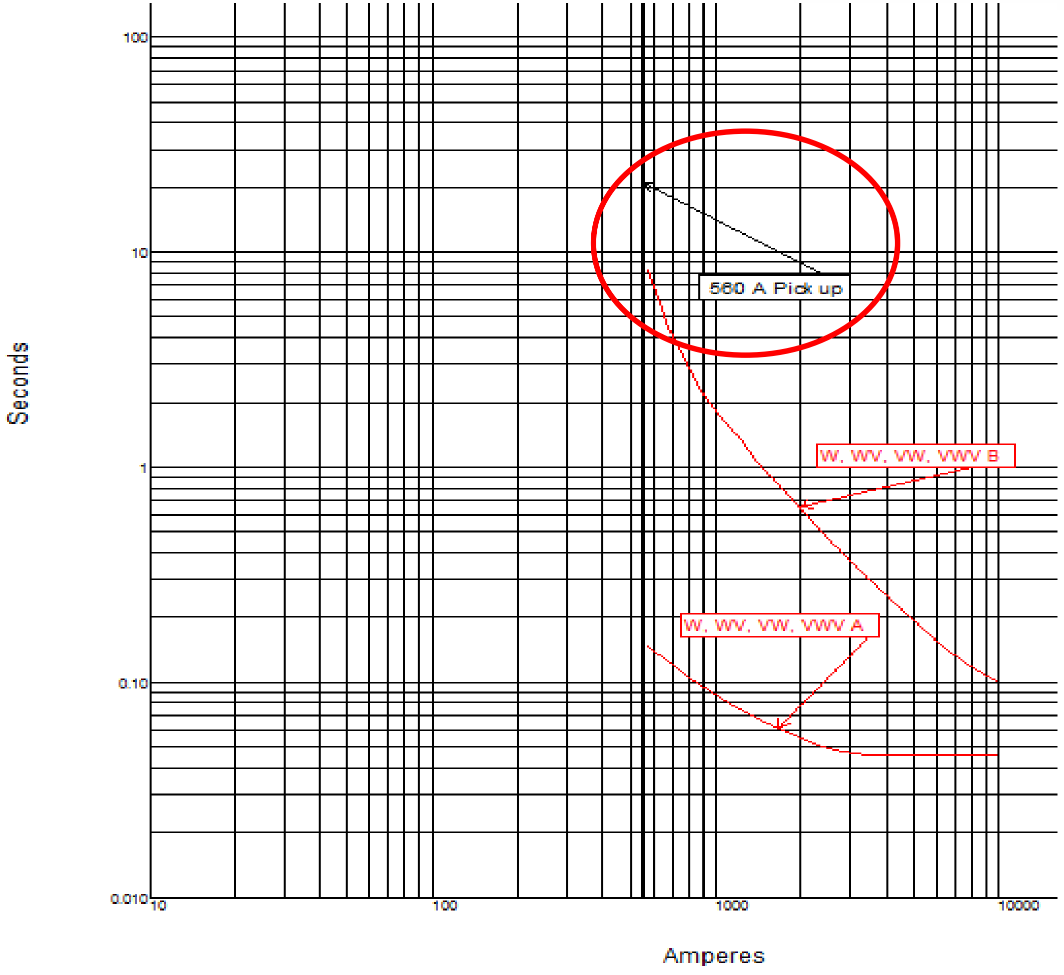
Gen off	3ph fault	SLG Fault	Distance from the sub
Substation	1348.66 A	750.37 A	.03 MI
recloser	1347.66 A	750.37 A	2.51 MI
generator	1347.66 A	750.37 A	4.03 MI
fault	1347.66 A	750.37 A	7.92 MI

Non-Export Case (DER connected)

Gen on	3ph fault	SLG Fault	Distance from the sub
Substation	1030.57 A	556.77 A	.03 MI
recloser	1030.57 A	**556.77 A**	2.51 MI
generator	1721.94 A	1069.35 A	4.03 MI
fault	1721.94 A	1069.35 A	7.92 MI

Relay desensitization occurs in non-export case such that the recloser is no longer able to detect SLG faults.

Recloser Time Coordination Curve - 280 A Type W



Non-Export Study Conclusions

- Real world feeders exist in Minnesota today that could be adversely impacted by forgoing technical review of non-export systems
  – Non-export systems should follow the standard process and technical review based on nameplate rating
  – The non-export designation should be used for contractual arrangement and not technical review or process eligibility

- Aggregate DER can have the same impact as a single large unit and must be reviewed whether it is exporting or not

- *Voltage* and *Thermal* impacts are more likely to occur when compared to *Protection* impacts

FERC SGIP & MN DIP on Capacity

5.14 **Capacity of the Distributed Energy Resource**

5.14.1 If the Interconnection Application is for an increase in capacity for an existing DER, the Interconnection Application shall be evaluated on the basis of the new total alternating current ("AC") capacity of the Distributed Energy Resource. The maximum capacity of a Distributed Energy Resource shall be the Aggregate Nameplate Rating or may be limited as described in 5.14.3.

5.14.2 An Interconnection Application for a DER that includes a single or multiple energy production devices at a site for which the Interconnection Customer seeks a single Point of Common Coupling shall be evaluated on the basis of the aggregate Nameplate Rating of the multiple DERs unless 5.14.3 applies.

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 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 Distributed Energy Resource 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. aggregate Nameplate Rating), if the limitations do not provide adequate assurance, when evaluating system impacts. See Minnesota Technical Requirements for more detail.

(Source: Minnesota DER Interconnection Process. Consistent with FERC SGIP Section 4.10.1 – 4.10.3)

Relevance of Capacity to Engineering Screens and System Impact Study

- Capacity is part of determining what track, and consequently which engineering screens, occur in the DER Interconnection Process
- What are the specific analyses within a system impact study that could require nameplate rating (e.g. short circuit analysis)?

DER Impact Study Analysis

When is the full nameplate rating of DER needed?

- **It depends…**
  - on the size and type of the DER system
  - on how the control system operates
  - on the definition of the magnitude and duration of allowed power production above the *Control Limited Capacity*

- **Short circuit analysis** is the most clearly affected due to limitation in control system response time
  - The short circuit studies include device interrupting rating, coordination, and relay sensitivity.

- **Voltage impacts -** For larger systems, if the power magnitude and duration limit is comparable to definitions of inadvertent export (full nameplate for 30 seconds), impacts to steady state voltage and voltage fluctuation could be experienced.

Maximum Export Use Cases

Static (based on interconnection agreement)

- Agreed DER rating
  - Actual use (e.g. storage operating mode identified in documentation)
  - Study-based capacity restriction
  - Hosting Capacity restriction
- Storage NEM integrity (“green” vs “brown” electrons)
- Non-export expedited interconnection

Dynamic (based on controls or schedules)

- Load-following hosting capacity restriction
- Other operational curtailment (e.g. temporary thermal restrictions)
- Volt-watt?

TSG #4 and TSG #5 Meeting Goals (7/20 & 8/3)

- Discuss and address draft TIIR language and proposed edits related to Draft TIIR Sections 10 & 11 and associated definitions.

Build shared understanding of:

- *Energy storage & non-exporting DER compared to traditional loads (TSG4)*
- *Impacts a non-exporting DER may have on an Area EPS system (TSG4)*; including inadvertent exports
- What is necessary to provide adequate assurance DER export limits will not be exceeded
- The allowable duration for inadvertent exports and why
- How the TIIR proposals compare to IEEE 1547-2018; and the rationale for any exceptions/differences
- Risks (technical and other) of either under-estimating or over-estimating capacity in a screening process

Discuss: Control Limits

- How do the system characteristics of the Local EPS appear to the Area EPS in operations?
  - Which limiting characteristics can accidentally or purposefully change easily?
  - Which limiting characteristics would remain the same, even after an N-0 and N-1 event occurred (i.e., two fault conditions) occur within the system?

Inadvertent Changes to Control Limited Capacity

End Users Implementing Changes

- **Accessibility -** Systems most susceptible to unauthorized settings changes include any device with an accessible user interface or devices without strong security provisions.
  - Example 1: Energy storage systems or inverters with a mobile app user interface
  - Example 2: Utility grade relays that use default security passwords

- **Highly Configurable Devices –** When IEEE 1547-2018 compliant equipment is available, the list of points required in the Interoperability section provides an idea of the baseline number of settings that could potentially be changed.
  - Manufacturers may choose to offer additional functions that could impact real power production and coincidental operation with other DER

Inadvertent Changes to Control Limited Capacity

Impacts of Changes

- **Equipment Impacts –** Damage can occur to customer and utility equipment from high-voltage, thermal overloads, or protection mis-operation.

- **Human Impacts –** Changes that impact the proper functioning of protection systems could pose a threat to the public safety and Company employees.

- **Wider Grid Impacts -** The settings changes could impact voltage, thermal, or protection constraints of the grid.

Inadvertent Changes to Control Limited Capacity

New Technology Carries Additional Considerations

- **Energy Storage User Accessibility –** The energy storage systems (ESS) being installed today at the residential level have more opportunity for inadvertent changes.
  - System interfaces are often more accessible.
  - Frequent and substantial firmware changes appear to be more common for ESS when compared to relatively mature PV inverter technology.

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PREP WORK for TSG #6, Aug. 10th from 9:30-12:30
Interoperability (Monitor and Control Criteria); Metering; Cyber security

Subgroup members review agenda and provide the following to staff by 8/3/18 COB.

1) **Propose edits to the Regulated Utilities' TIIR Draft Proposal and/or flag topics for discussion. Send as red-lines and comments using track changes to the 7-26-18 Draft TIIR.**
    a. Definitions in Section 3B
    b. Metering; Section 8
    c. Interoperability; Section 9
2) **Review and be prepared to reference IEEE 1547-2018**
    a. Definitions in Clause 3.1
    b. Interoperability, information exchange, information models, and protocols; Clause 10 (pages 69-76)
    c. Annex D (informative) DER communication and information concepts and guidelines (pages 109-114)
3) **Please provide input to the topics below, slides are encouraged**
    a. How is your organization using and planning to use communications to DER (monitoring, control, alarms, etc) and for what application or purpose?
    b. What is your organization currently utilizing or planning to use for each of the following?
        i. Communication protocols: such as IEEE 2030.5, DNP3, SunSpec Modbus or other protocols?
        ii. Information models: such as 61850-7-420, schemas in IEEE 2030.5, SunSpec's Modbus implementation or DNP3 Application Notes?
        iii. Are different protocol(s) used based on the scale/type of DER? (Our understanding is DNP3 has been used for large DER and for storage. SunSpec for PV or smaller systems)
        iv. Between what entities is a certain protocol used? (Our understanding is 2030.5 has been primarily applied between utilities and aggregators, DNP3 and Sunspec at the devices)
    c. Please share any first-hand strengths or challenges that stand out with regards to communication protocols or information models.
    d. How can statewide uniformity in communication protocols and information models be achieved and what would be the concerns and challenges in doing so?
    e. What metering functions are required in the technical standards and why? What changes should be made to the TIIR to appropriately describe functional metering requirements and needs while allowing specific information in the TSM? (See: Section 5 (pages 13-16) of Minnesota's existing Distributed Generation Interconnection Requirements)

f. How should the cyber security responsibilities be allotted and communicated between utility, interconnection customers and developers address before installation, during installation and commissioning, and on-going operations?
g. How do utilities envision roll out Draft TIIR Section 9D, Cyber Security? What types of responsibilities will the DER operators have?

-----------------------------End Of Prep Work --------------------------------

Technical Subgroup Meeting 6 DRAFT AGENDA
Friday, August 10th
9:30am – 12:30pm Central Time

https://global.gotomeeting.com/join/432598661
Phone: (571) 317-3112; Access Code: 432-598-661

Proposed Agenda

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, Expectations, Recap
9:40 – 10:25	Metering
10:25 – 11:45	Interoperability, including communication protocols
11:45 – 12:10	Cyber security
12:10-12:20	Meeting Evaluation
12:20 – 12:30	Next Steps

Phase II Technical Subgroup Roster

Craig Turner, Dakota Electric	Robert Jagusch, MMUA	Patrick Dalton/John Harlander/Alan Urban, Xcel Energy
Lise Trudeau, Dept of Commerce	Kevin McLean/Jenna Warmuth, MN Power	
~~Kevin Joyce~~/Katie Bell, EFCA	Kristi Robinson, MREA	John Dunlop/Chris Jarosch, MNSEIA
Brian Lydic/Sky Stanfield/Laura Hannah – Joint Movants	Dean Pawlowski, Otter Tail Power	Commissioner Matt Schuerger; Michelle Rosier; Cezar Panait
Professor Mahmoud Kabalan, St. Thomas Affiliation		Technical Assistance*: Michael Coddington and Michael Ingram, National Renewable Energy Laboratory Tom Key, Jens Boemer, Nadav Enbar; Electric Power Research Institute Pam Johnson, DOE Solar Energy Innovator Fellow

*Technical assistance is not a participant or party to the docket and does not advocate for specific outcomes in the proceeding. The role of technical assistance is to support Commission staff in the process for these proceedings, and to provide an objective source of information or data, as requested, by Commission staff to understand areas of disagreement amongst participants.

Draft Meeting Topics Proposal

<u>Date</u>	<u>Topic</u>
3/23/18	Meeting 1 Scope/Overview** (Walk-through with explanations: Red-lined TIIR; List of topics in scope of TSMs; Definitions
4/13/18	Meeting 2 Performance Categories**; Response to abnormal conditions; MISO Bulk Power System
5/18/18	No Meeting
6/1/18	Full DGWG Meeting Technical Subgroup update; Phase I Update/Next Steps
6/8/18	Meeting 3 Reactive Power and Voltage/Power Control Performance**; Protection Requirements
7/20/18	Meeting 4 Energy Storage**; Non-Export and Inadvertent Export**; Capacity**
8/3/18	Meeting 5 Meeting 4 topics continued
8/10/18	Meeting 6 Interoperability** (Monitor and Control Criteria); Metering**; Cyber security
9/14/18	Meeting 7 Test and Verification**; Witness Test Protocol
9/21/18	Full Day, In Person TSG Meeting – Power Quality; Follow up items; Review/Reconcile edits in the draft TIIR
10/19/18	Meeting 8 References; Definitions*; 1-line diagram requirements; Agreements*, Frequency Ride-through
11/9/18	Full DGWG Meeting 7

Phase II Technical Subgroup Meeting #6
August 24, 2018
(Docket No. 16-521)

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https://mn.gov/puc

Agenda

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, Expectations, Recap
9:40 – 10:20	Metering - MREA presentation - Xcel presentation - Metering requirements & Draft TIIR Sec. 8 Discussion
10:20 – 11:50	Interoperability, including communication protocols - Xcel presentation - IREC presentation - Interoperability requirements & Draft TIIR Sec. 9 Discussion
11:50 – 12:10	Cyber security
12:10-12:20	Meeting Evaluation
12:20 – 12:30	Next Steps

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
June 8	Reactive Power and Voltage/Power Control Performance; Protection Requirements
July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 3	*July 20 topics continued*
Aug 24	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 14	Test and Verification; Protocol to witness Testing
Sept 21	In-Person TSG: Power Quality; Follow up items; TIIR edits discussion
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

Recap from August 3

- TSG agrees definitions associated with capacity should:
  - follow national standards as closely as possible recognizing timing complications due to the pace of national working groups
  - not re-define a terms defined elsewhere
- Xcel offered a framework for understanding the various terms proposed by TSG re: capacity and export.
- EPRI offered IEEE 1547's configuration settings as a way to address MN DIP 5.14 language on a limited capacity less than "nameplate rating."
- TIIR edits of Section 10 should focus on non-export. Limited export may be addressed at a later time.
  - A majority of IREC's Section 10 edits were related to limited export.
- 7-26-2018 draft TIIR may be updated by stakeholders after this week in a manner that streamlines comments and edits

Goals for TSG #6 on Metering, Interoperability

- Discuss and address draft TIIR language and proposed edits related to Sections 8 Metering & 9 Interoperability.
- Build shared understanding of
  - What the Draft TIIR proposal and TSG edits mean for these sections
  - Detail on metering requirements that should be in the TIIR compared to a utility’s TSM
  - Considerations of statewide uniformity vs. differing utility system requirements regarding interoperability
  - Cyber security responsibilities

Glossary/Phrases germane to this presentation from IEEE 1547

- **interconnection system:** The collection of all interconnection and interoperability equipment and functions, taken as a group, used to interconnect a DER to an Area EPS. [24] [IEEE 1547-2018 p. 23 and 7-26-18 Draft TIIR p.16]

- **interoperability**: The capability of two or more networks, systems, devices, applications, or components to externally exchange and readily use information securely and effectively. (IEEE Std 2030®) [IEEE 1547-2018 p. 23 and 7-26-18 Draft TIIR p.16]

- **local DER communication interface:** A local interface capable of communicating to support the information exchange requirements specified in this standard for all applicable functions that are supported in the DER. [IEEE 1547-2018 p. 24 and 7-26-18 Draft TIIR p16]

  - [24] This term was frequently used in IEEE Std 1547-2003. Given the scope of the present standard, which may have implications to the design of the entirety of the DER, this standard uses the term "DER" in most places.

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Draft TIIR Section 8: Metering

Existing Requirements

- Minnesota's current (adopted 2004) Distributed Generation Interconnection Requirements, specifies the maximum expected metering, monitoring and control requirements.
- Additional metering requirements are found in specific programs or tariffs (e.g. production meters for REC purchases or incentives) and whether the customer or utility pays for the meter and expenses varies.
- Any metering requirements necessitated by the use of the DER shall be installed at the Interconnection Customer's expense. [MN DIP Section 5.4]
- Who pays is not in scope for the technical requirements

TABLE 5A
Metering, Monitoring and Control Requirements

Generation System Capacity at Point of Common Coupling	Metering	Generation Remote Monitoring	Generation Remote Control
< 40 kW with all sales to Area EPS	Bi-Directional metering at the point of common coupling	None Required	None Required
< 40 kW with Sales to a party other then the Area EPS	Recording metering on the Generation System and a separate recording meter on the load	Interconnection Customer supplied direct dial phone line.	None Required
40 – 250kW with limited parallel	Detented Area EPS Metering at the Point of Common Coupling	None Required	None Required
40 – 250kW with extended parallel	Recording metering on the Generation System and a separate recording meter on the load	Interconnection Customer supplied direct dial phone line. Area EPS to supply it's own monitoring equipment	None Required
250 – 1000 kW with limited parallel	Detented Area EPS Metering at the Point of Common Coupling	Interconnection Customer supplied direct dial phone line and monitoring points available. See B (i)	None Required
250 – 1000 kW With extended parallel operation	Recording metering on the Generation System and a separate recording meter on the load.	Required Area EPS remote monitoring system See B (i)	None Required
>1000 kW With limited parallel Operation	Detented Area EPS Metering at the Point of Common Coupling	Required Area EPS SCADA monitoring system. See B (i)	None required
>1000 kW With extended parallel operation	Recording metering on the Generation System and a separate recording meter on the load.	Required Area EPS SCADA monitoring system See B (i)	Direct Control via SCADA by Area EPS of interface breaker.

Source: Att 2. Technical Requirements, Sept 28, 2004 Order establishing interconnection standards

NERC Modeling Standards

NERC has transmission standards for the Bulk Electric System that require knowledge of the peak system load without DER netted with the load. Issue is that without a production meter, the ability to identify the "true" peak system load is not feasible.

Most NEM interconnections are not incorporating a production meter unless an incentive program is tied to the need for a production meter.

MREA

Minnesota Rural Electric Association

NERC Modeling Standards

MOD-032-01 : Model Building Standards

Transmission companies are to represent generation type(s) and load profiles at each of transmission interconnection points along with max load, max generation and net loading

MOD-032-1 — Data for Power System Modeling and Analysis

A. Introduction

1. **Title: Data for Power System Modeling and Analysis**
2. **Number: MOD-032-1**
3. **Purpose:** To establish consistent modeling data requirements and reporting procedures for development of planning horizon cases necessary to support analysis of the reliability of the interconnected transmission system.

MREA
Minnesota Rural Electric Association

NERC Modeling Standards

TPL-001-4: Transmission System Planning Performance Requirements

Requirements for planning, stability, contingency and other types of transmission analysis. Basically a stress test analysis for the transmission system.

Many references to system peak load modeled in a dynamic setting. Without the knowledge of how much load is being masked by DER, the true system peak load is not being modeled.

Standard TPL-001-4 — Transmission System Planning Performance Requirements

A. Introduction

1. **Title:** **Transmission System Planning Performance Requirements**
2. **Number:** **TPL-001-4**
3. **Purpose:** Establish Transmission system planning performance requirements within the planning horizon to develop a Bulk Electric System (BES) that will operate reliably over a broad spectrum of System conditions and following a wide range of probable Contingencies.

NERC Modeling Standards

Additional modeling guidelines recently release have expand the modeling inputs for aggregation of DER behind the substation meter, specifically calling out system peak load without DER, total amount of DER generating and net effect on load with DER.


NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Technical Brief on Data Collection Recommendations for Distributed Energy Resources

NATF Reference Document: Distributed Energy Resource Modeling and Study Practices

NERC Modeling Standards

For Transmission Operators, the following information may be needed:

- Accurate distribution load forecasts on an hourly basis at each load bus
- Accurate DER forecasts on an hourly basis at each load bus
- Accurate net load forecasts on an hourly basis at each load bus
- DER sensitivity to changing weather (cloud cover)
- Aggregate nameplate capacity of DERs is forecasted at each load bus for each year during the operational planning horizon
- Potential real-time changes in DER production due to weather, time of day, etc.
- Voltage and frequency ride through capabilities of DER (IEEE 1547 abnormal performance categories assignment)
- Category III DER momentary cessation voltage threshold
- Voltage control capabilities (IEEE 1547 abnormal performance categories assignment)

NERC Technical Brief on Data Collection Recommendations for Distributed Energy Resources

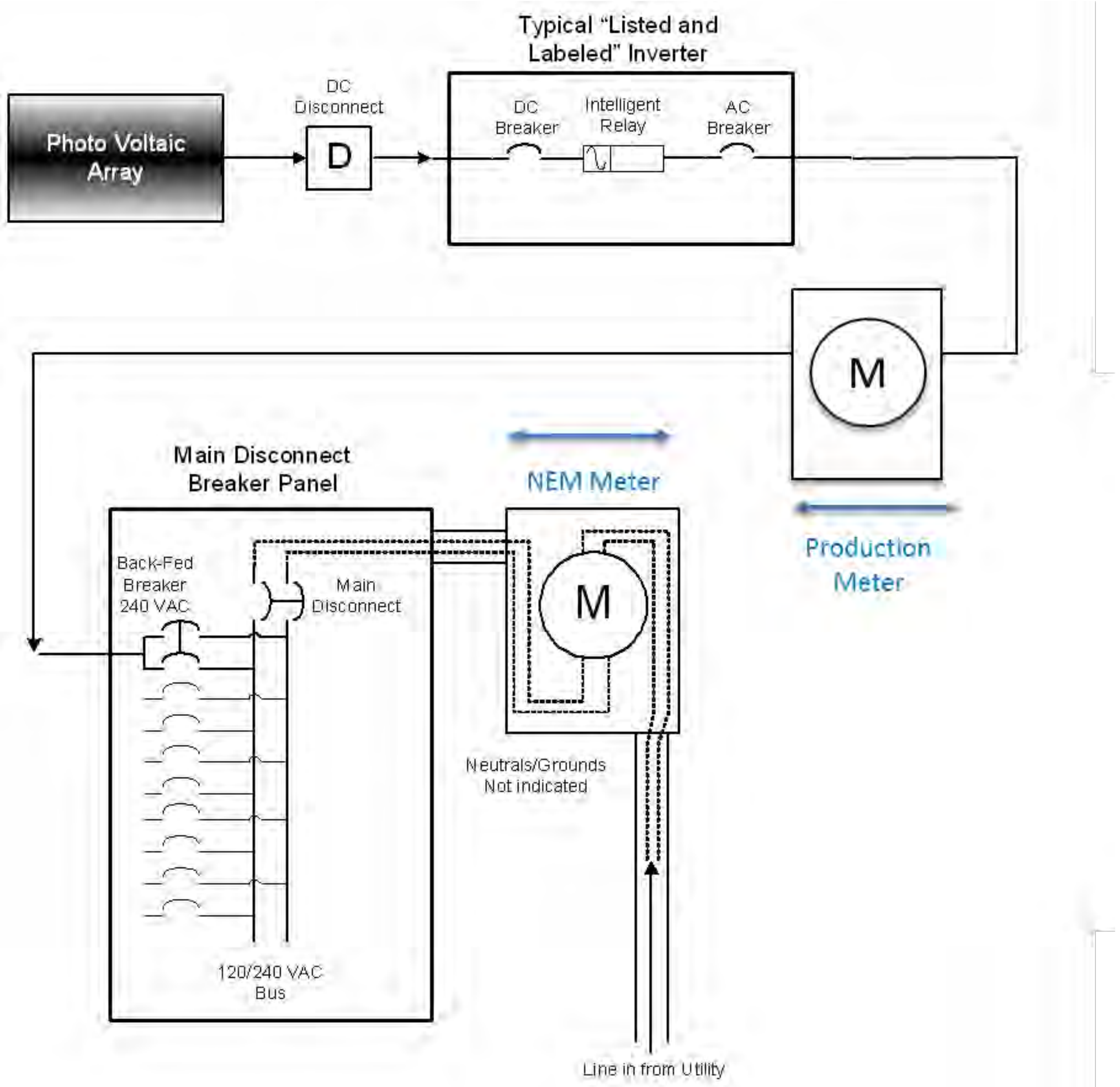
NERC Modeling Standards

To meet the NERC standards and guidelines production metering will need to become a requirement. On lightly loaded substations (<2 MW) a handful of NEM systems can easily masking 10%+ of the “true” peak load.

Discussion currently occurring on the ability to model “assumed” masked load for extremely small systems (< 10 kW). Not all transmission planners are comfortable with the assumption concept; especially if higher penetration of small DER systems are expected. Also are concerns for future additional transmission modeling requirement.

MREA
Minnesota Rural Electric Association

Example of DER with Production Meter



- Graphic credit: Michael Coddington, NREL

TIIR Section on Metering

The Area EPS Operator shall specify metering requirements in the Area EPS Operator's TSM

Functional characteristics:

- ***Operational*** – near-real-time information on the DER operating characteristics can be needed in order to perform certain actions such as reconfiguring a feeder or restoring a feeder after an outage.

- ***Planning*** – an archive of time-series information over multiple years of DER operation is required for Area EPS and TPS planning.

- ***Regulatory*** – The Area EPS may have obligations to track and report on the amount of energy produced from renewable energy DER. Specific incentive programs or tariffs can create additional metering needs.

- ***Billing*** – the Area EPS is responsible for accounting for energy transactions with the DER Operator and shall have access to revenue grade metering information.

Discuss: Draft TIIR Metering Requirements

- How are statewide metering requirements changing with the proposed TIIR language, and why?
- What are the benefits of production meters compared to inverters?

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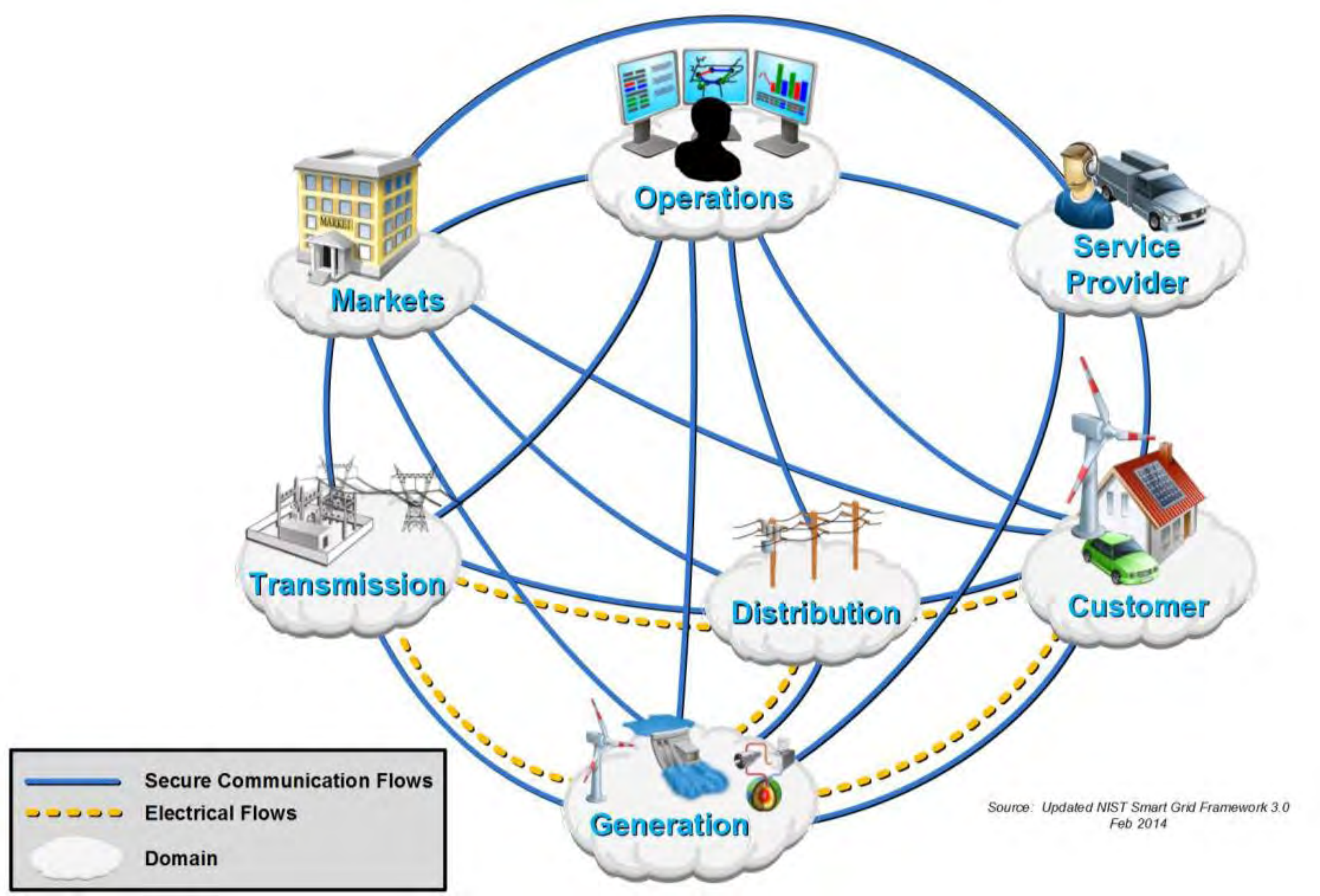
Draft TIIR Section 9: Interoperability

Actors within a smart grid (NIST report)



Source: Updated NIST Smart Grid Framework 3.0
Feb 2014

Current Remote Monitoring and Control Practices

Xcel Energy

- **Remote monitoring** for all DER at a site that in aggregate is equal or greater than 250 kW in AC nameplate capacity
- Majority of sites use cellular communications to production meter
  - Real power, apparent power, power factor, 3-ph voltage, 3-ph current.
- Some sites require SCADA for operational control or a communication based protection scheme
- Primary objective: Situational awareness for control center and field personnel

Remote Monitoring ≠ Interoperability

What is Interoperability?

- A requirement for a *Local DER Communications* interface which is active and responsive whenever the DER is in the *continuous operating region* or *mandatory operating region*

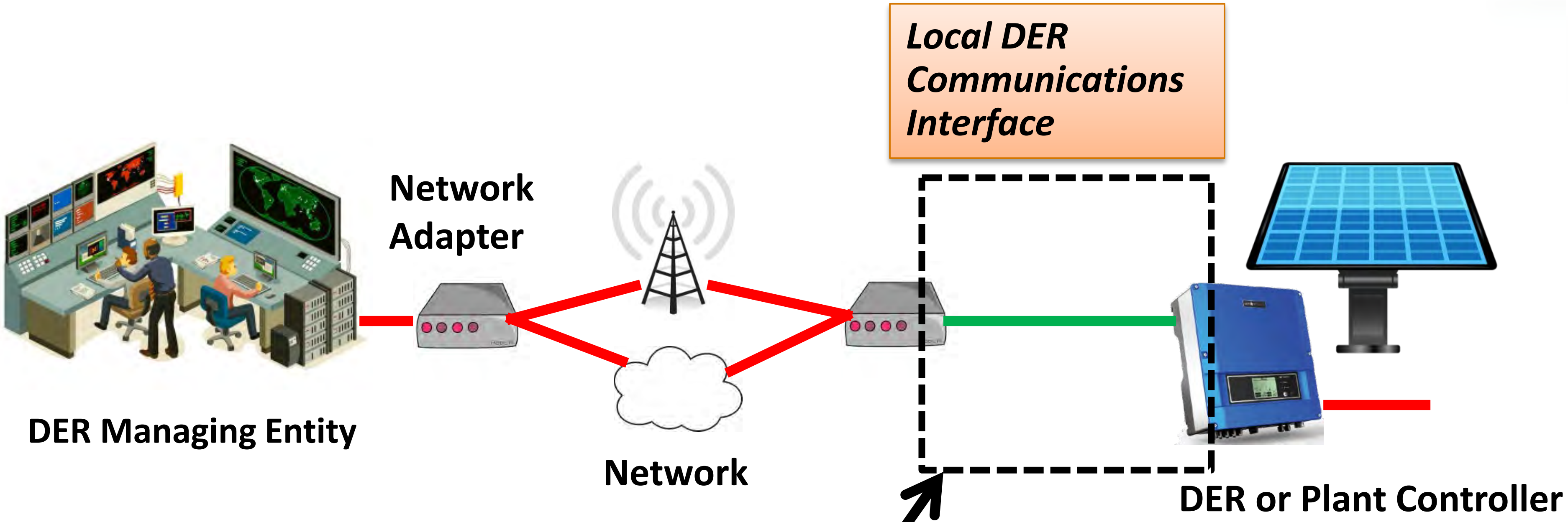
- A means of implementing specific DER functionality through standardized information elements as well as monitoring measurements and status information

interoperability: The capability of two or more networks, systems, devices, applications, or components to externally exchange and readily use information securely and effectively. (IEEE Std 2030® [B23])

local DER communication interface: A local interface capable of communicating to support the information exchange requirements specified in this standard for all applicable functions that are supported in the DER.

IEEE 1547-2018

What is in scope of Interoperability?



Information Read time requirments of 30 seconds or less

- **Information Exchange**
- **Information Models**
- **Protocols**

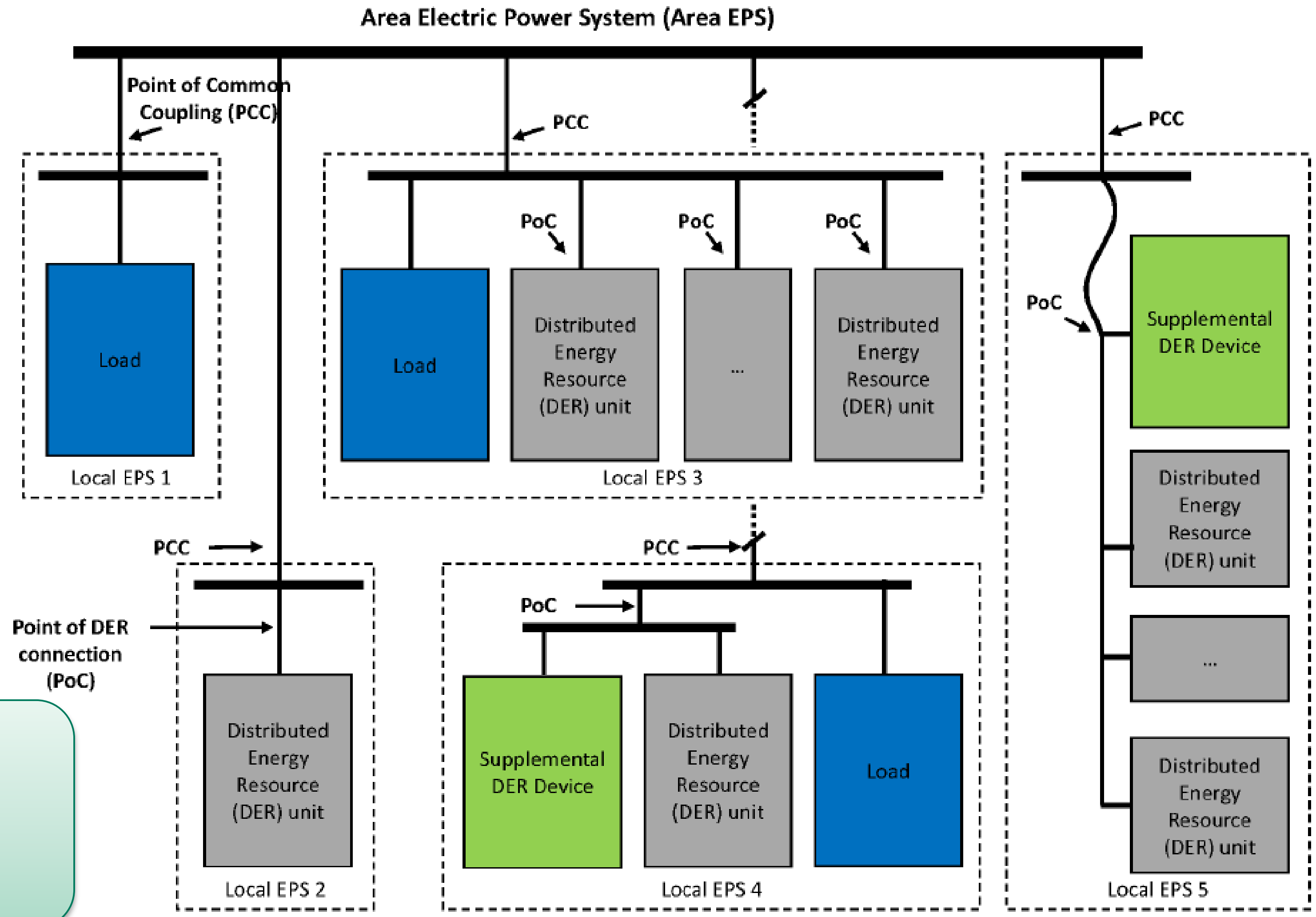
Key for IEEE 1547-2018

In Scope

Out of Scope

Where is the Local DER Communication Interface?

Application of *Local DER Interface* is at the *Reference Point of Applicability,* which may be the PCC or PoC or, under mutual agreement, a point in-between the PCC and PoC



reference point of applicability (RPA): The location where the interconnection and interoperability performance requirements specified in this standard apply.

What information can be exchanged?

Nameplate
- P at unity and specified pf
- S maximum rating
- +/- Q maximum
- Performance Category
  - Normal
  - Abnormal
- Voltage Ratings
- Supported Control Modes
- Make, Model, Version

Configuration
- Each rating in the Nameplate Information Table is configurable
- Not intended for continuous dynamic adjustment

Monitoring
- Active Power
- Reactive Power
- Voltage
- Frequency
- Operational Status
- Connection Status
- Alarm Status

Management
- P and Q control mode settings
- Voltage/frequency trip and momentary cessation parameters
- Enter service after trip parameters
- Cease to energize and trip
- Limit maximum active power

Draft TIIR: When information exchange through the *local DER communication interface* is required by the Area EPS, the Area EPS shall have read and write access to all parameters in the nameplate information, configuration information, monitoring information, and management information, as defined by IEEE 1547.

IEEE 1547-2018

How will information exchange be used in future?

- Real time data to improve power flow and state estimation in Advanced Distribution Management System (ADMS)
  - Information on DER production feeds into ADMS modules that forecast impacts of DER for planned or emergency switching
- *DER Monitoring Information for* situational awareness (similar to current use)
- *DER Nameplate Information* available through local DER communications interface provides path for data integrity
- *DER Configuration Information* is a static means of capacity limiting or modifying other nameplate characteristics
- *DER Management Information* for remote settings changes
  - Could be on a set schedule (i.e. seasonal) or based on actual conditions (i.e. contingency/emergency)

When is the Local Communication Interface Used?

IEEE 5147-2018, Clause 10.1, Paragraph 3

The decision to use the *local DER communication interface* or to deploy a communication system shall be determined by the Area EPS operator.

Draft TIIR

- “Per IEEE 1547 Section 10.1, the decision to use the *local DER communication interface* or to deploy a communications network is determined by the Area EPS.”
- Use of the *local DER communication interface* can be a complex decision dependent on the DER size and other factors such as penetration and Area EPS characteristics in the area.
- Process for determining use of *local DER communication interface* shall be outlined in the Area EPS Operators’ TSM.
- The DER Operator may be responsible for furnishing the communication channel
- Additional details of the channel and interface shall be in the Area EPS Operators’ TSM

Interoperability Protocol Options

Application Layer	IEEE 1815 (DNP3)	IEEE 2030.5 (SEP2)	SunSpec Modbus	
Transport Layer	TCP/IP	TCP/IP	TCP/IP	N/A
Physical Layer	Ethernet	Ethernet	Ethernet	RS-485

Communication Protocols Usage at Xcel Energy

- **Present:** Xcel Energy uses DNP3 for distribution field devices and communication to meters for DER remote monitoring
  - The other protocols are not currently in use at the distribution level.
  - Modbus is used within substations for communication between devices, but it is not SunSpec Modbus

- **Future:** We are evaluating the protocol options available in IEEE 1547-2018 to determine which will be implemented.
  - It is possible that different protocols will be used for different use cases based on the strengths and weaknesses of each protocol
    - Security features for a given application
  - Protocol translators are an option at the network adaptor interface

Industry Application of Communication Protocols

- ***SunSpec Modbus*** is the protocol supported now by most manufacturers
  – Historically ModBus was already internal to inverters

- Storage systems alignment around ***DNP3*** mapping
  – Largely driven by the open standards efforts for energy storage initiated by Modular Energy Storage Architecture (MESA)

- Rule 21 implementation results in ***IEEE 2030.5*** use between aggregators and utilities

Selecting a Single Protocol for Minnesota?

- Upside: The ***simplicity*** leads to better chances of success with implementing true interoperability and effective information exchange between all applicable DER and Area EPS Operators in the state.
  - Potential to streamline integration for Developers, Installers, and Area EPS Operators

- Downside: The ***timing*** of the MN update means that market forces have not begun to converge on one of the protocols
  - The IEEE 1547 working group had anticipated some consolidation over time.
  - Expectation is that many manufacturers will offer just one of the three protocols. This aligns with standard requirements

Working hypothesis: Standardizing under a single protocol may be practical in the longer term, and assists in effective interoperability, but we need to better understand vendors offerings and back-end system integrations for all affected parties before making this a statewide requirement.

Information Model Usage – IEC 61850

- **<u>Present:</u>** We do not currently use the implementation of 61850-7-420 for information exchange with DER.
  - Historically standard functions were not defined or available through a standard interface for certified equipment
  - Cellular communication with DNP3 protocol to production meter
  - Xcel's ADMS implementation of common information models is based on IEC 61850

- **<u>Future:</u>** The CIM from IEC 61850-7-420 is encoded in each of the protocols accepted by IEEE 1547-2018.
  - From the field device side, it will be used when future revised UL 1741 leads to compliant equipment

Other states are considering interoperability under 1547-2018

- California, via the Smart Inverter Working Group
  - Selected IEEE 2030.5 as the communication protocol and information model
  - Requires capability by (May 22, 2018) plus 9 months
- Hawaii is currently in discussions about communication models under Rule 14
  - Advanced Inverter Function Working Group hosted a webinar on 8/9 as part of their working group process as an educational meeting
- MISO stakeholder process on DER integration as related to 1547-2018 is just getting started

Communications

Brian Lydic

Regulatory Engineer

IREC

Communications Req’s Concepts

Basic Principles/Assumptions

- Different utilities will have different capabilities/infrastructure
- Hugely different costs can be incurred (by both utility and customer)
- Ubiquitous comms/control of DERs (large and small) is likely years away
- Actual TIIR requirements could vary based on utility capabilities/infrastructure – need to discuss (IREC proposal is dependent on MN utilities’ capabilities and future plans)
- Develop requirements for a “comms port” that can be widely applicable to all DER once utility infrastructure can support it
- Use “traditional telemetry” today for larger systems
- Consider cost cap for traditional telemetry due to varying costs

Comms Port Requirement

- Balance availability of monitoring and control with initial equipment cost (will it be used?)
- Could create penetration limit at which comms port equipment would be required – this allows evolution of each utility individually
- No requirement for comms port equipment at DER when utility is below penetration limit (and no retroactive requirement to add one)
- Future use of comms port and control may need further customer agreements/protections – note difference between equipment availability and agreement to utilize in TIIR
- Develop agreements at future time – should have a few years for market and equipment to develop in response to 1547 req's
- Requirement should be 1547-based
- Can require DER to accept comms/control in utility's preferred language, as long as it is one of the three 1547 options (translators may be used, e.g 2030.5 to SunSpec)

Example to help design Cost Cap

- The below is not a proposal, but an example under consideration in CA
    - CA IOUs have noted that traditional telemetry/ communications could likely be provided for $20,000 or less per DER
    - Whether this could/should apply at 250 kW or 1 MW is contested
    - (many details apply)

Discuss: is it in the best interest of MN to allow all combinations allowed by 1547-2018?

- Do organizations have rough order of magnitude cost and schedule estimates for changing from one protocol to a different one from their software architects?
- What will serve MN the best?
    - What will the impact be with regards to test and verification?

What will it take to properly safeguard and utilize smart inverters?

- Training beyond electrical expertise throughout the supply chain including engineers, installers and inspectors
- Updates to 1547.1 and associated standards, including UL 1741
- Certification by NRTLs in accordance with updated standards

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Draft TIIR Section 9D: Cyber Security

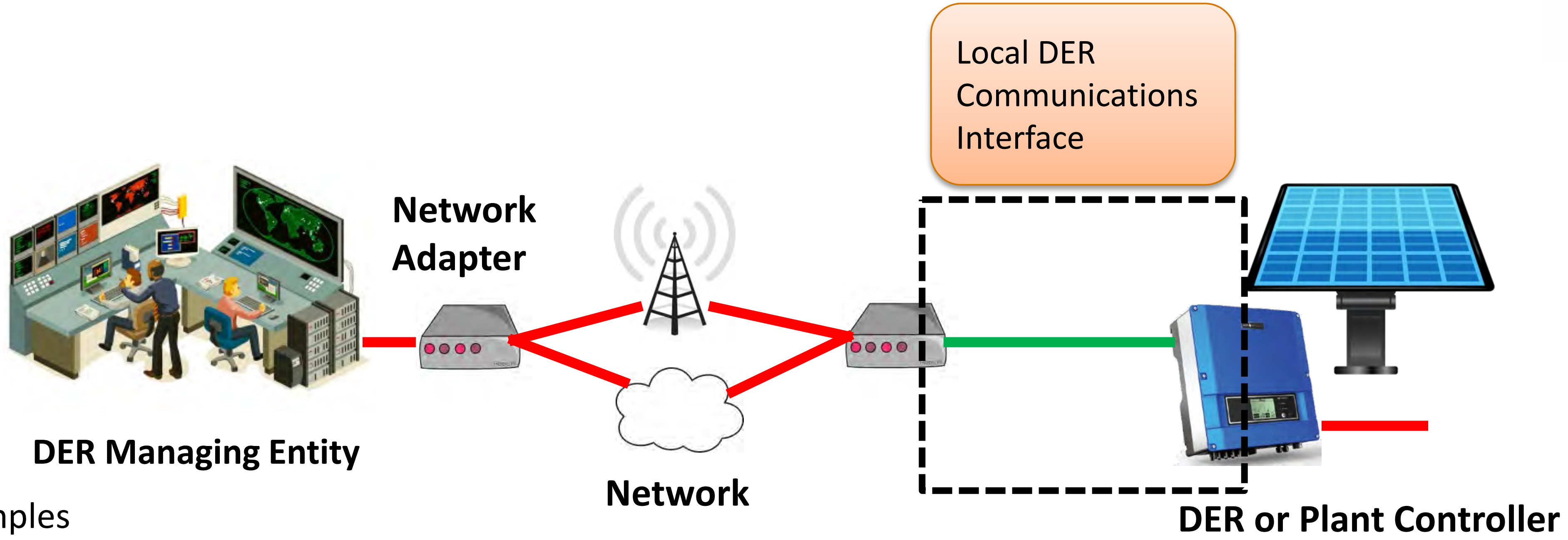
Other IEEE 1547-2018 statements for consideration (Annex D)

- Cyber security is a system-wide issue requiring a system-wide solution.
- This standard specifies the base functionality of a DER including the capability of exchanging specific information over a local DER communication interface.
- This standard cannot correctly address system level issues and should not constrain reasonable system solutions.
- The organization responsible for maintaining the reliability and security of the communications path to the DER must also be able to perform regular maintenance, upgrades, and changes to the network components, including the protocol and cyber security mechanisms.

Recent reporting rule-making will impact some stakeholders directly, others indirectly

- Under the current Critical Infrastructure Protection Reliability Standard CIP-008-5 (Cyber Security – Incident Reporting and Response Planning), incidents must be reported only if they have compromised or disrupted one or more reliability tasks.
- The final FERC rule dated July 19 directs NERC to modify the Standard within 6 months to expand the current reporting requirement, including
  - Reporting cyber security incidents that compromise, or attempt to compromise
  - Cyber Security Incident Reporting Reliability Standards; 164 FERC ¶ 61,033
    - Docket No. RM18-2-000; Order No. 848
- We include this for stakeholder awareness throughout the DER supply chain

Cyber Security in TIIR



Examples

- Network segmentation
- Intrusion detection systems
- Inline blocking devices
- Selective encryption
- Multi-Factor Authentication
- Patching
- Port security
- Strong user names and passwords
- Role based access

TIIR specifies that physical and network security requirments are in scope for Area EPS Operator TSM

Effective cyber security requires a system-wide solution.

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Cyber Security in TIIR

- TIIR leaves requirments to TSM for some of same reasons as 1547-2018: scope and complexity, system architecture flexibility, and testability
  - Standards should be used where available and applicable

- Recognizes a few areas of focus for Area EPS Operator’s TSM based on Annex D of IEEE 1547-2018
  - DER Physical and front panel security
    - Ex) access to settings or controls
  - DER network security
    - Ex) if communication is required, a firewall or other network security device may be required
  - Local DER communication interface
    - Ex) includes considerations that are applicable to the end-to-end network, such as system architecture

- Implementation of TIIR Section 9D will be a progression that is anticipated to track with device and network security practices being implemented for other advanced field devices

Next Steps

Aug 23	Sept 14 TSG Mtg #7 Draft Agenda and Prep Work Assignment from Staff to TSG
Sept 5	Prep work due for Sept 14 TSG meeting #7
Sept 14	Test and Verification; Protocol to witness Testing (TSG Mtg #7)
Sept 21	In-Person TSG: Power Quality; Follow up items; TIIR edits discussion
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

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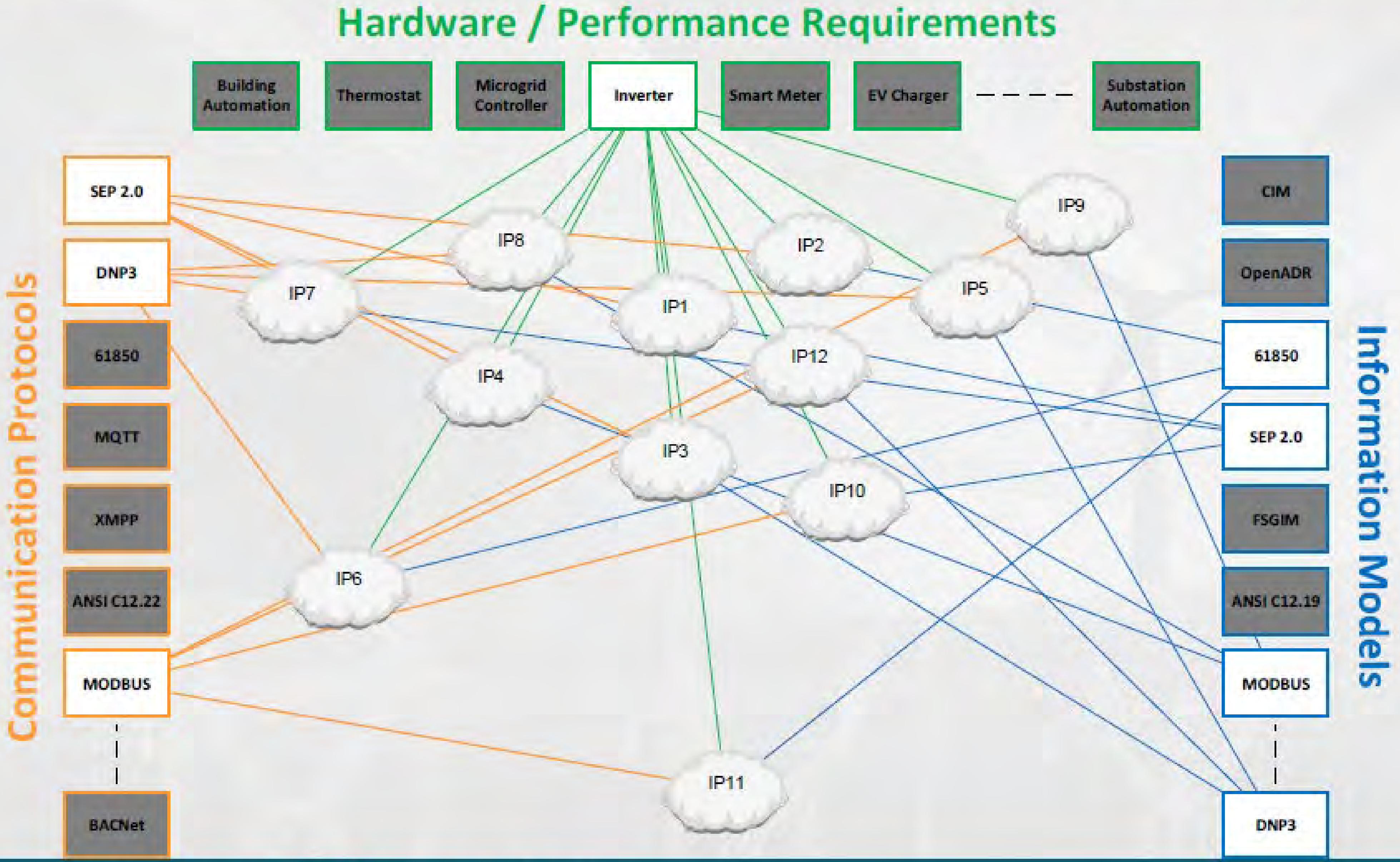
Thank You!

Back Up Slides

See next slide for graphical representation of what IEEE 1547 allows for interoperability in a given use case

Interoperability Profile: IEEE 1547 Case Study



This is not a comprehensive list; it is provided in the event you need a place to start looking at cyber security

- AEE report: Cybersecurity in a distributed energy future (Jan 2018): https://info.aee.net/hubfs/Cybersecurity_FINAL_WP_AEEInstitute_1.18.18.pdf

- NIST Cybersecurity Framework Home Page (generic, not grid specific) https://www.nist.gov/cyberframework

- Guidelines for Smart Grid Cybersecurity Volume 1 - Smart Grid Cybersecurity Strategy, Architecture, and High-Level Requirements http://dx.doi.org/10.6028/NIST.IR.7628r1

- Open Web Application Security Project (OWASP) Top 10 List (generic, not grid specific) https://www.owasp.org/images/7/72/OWASP_Top_10-2017_%28en%29.pdf.pdf

Discussion: Scope for Statewide Technical Requirements

These topics have been proposed as **in scope**.
Bold have been flagged for discussion.

1. Scope/Overview
2. References
3. Definitions
4. **Performance Category Assignments**
5. **Reactive Power Capability and Voltage/Power Control (volt-var & volt-watt) Performance**
6. **Response to Abnormal Conditions (Ride-through)**
7. **Protection Requirements**
8. **Metering**
9. **Interoperability (Monitoring, Control, Info Exchange, Cyber security)**
10. **Energy Storage**
11. Non-Export; Inadvertent Export
12. **Test and Verification Requirements**
13. **Agreements**
14. **Consumer Protection** (IREC)
15. **Reporting** (IREC)

(Source: "Regulated Utilities" TIIR Draft Proposal)

Discussion: Scope for Statewide Technical Requirements

1. Process requirements
2. Cost allocation
3. Interconnection to transmission system
4. **Protection system details of Area EPS or DER**
5. **Requirements or specification of system impact or facilities studies**
6. **Application of real and reactive power control functions**
7. **Details of communication networks; including architecture, technology and protocols, or other specifications related to interoperability**
8. **Details of metering requirements or specifications**
9. **Planning or operational considerations associated with Affected Systems, Regional Transmission Operator or Transmission Owners**
10. **Intentional Area EPS islanding**

These topics have been proposed as **out of scope** by some participants. Bold are flagged for additional discussion.

(Source: TIIR Draft Proposal, p. 9)

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PREP WORK for TSG #6, Aug. 10th from 9:30-12:30
Interoperability (Monitor and Control Criteria); Metering; Cyber security

Subgroup members review agenda and provide the following to staff by 8/3/18 COB.

1) **Propose edits to the Regulated Utilities' TIIR Draft Proposal and/or flag topics for discussion. Send as red-lines and comments using track changes to the 7-26-18 Draft TIIR.**
   a. Definitions in Section 3B
   b. Metering; Section 8
   c. Interoperability; Section 9
2) **Review and be prepared to reference IEEE 1547-2018**
   a. Definitions in Clause 3.1
   b. Interoperability, information exchange, information models, and protocols; Clause 10 (pages 69-76)
   c. Annex D (informative) DER communication and information concepts and guidelines (pages 109-114)
3) **Please provide input to the topics below, slides are encouraged**
   a. How is your organization using and planning to use communications to DER (monitoring, control, alarms, etc) and for what application or purpose?
   b. What is your organization currently utilizing or planning to use for each of the following?
      i. Communication protocols: such as IEEE 2030.5, DNP3, SunSpec Modbus or other protocols?
      ii. Information models: such as 61850-7-420, schemas in IEEE 2030.5, SunSpec's Modbus implementation or DNP3 Application Notes?
      iii. Are different protocol(s) used based on the scale/type of DER? (Our understanding is DNP3 has been used for large DER and for storage. SunSpec for PV or smaller systems)
      iv. Between what entities is a certain protocol used? (Our understanding is 2030.5 has been primarily applied between utilities and aggregators, DNP3 and Sunspec at the devices)
   c. Please share any first-hand strengths or challenges that stand out with regards to communication protocols or information models.
   d. How can statewide uniformity in communication protocols and information models be achieved and what would be the concerns and challenges in doing so?
   e. What metering functions are required in the technical standards and why? What changes should be made to the TIIR to appropriately describe functional metering requirements and needs while allowing specific information in the TSM? (See: Section 5 (pages 13-16) of Minnesota's existing Distributed Generation Interconnection Requirements)

f. How should the cyber security responsibilities be allotted and communicated between utility, interconnection customers and developers address before installation, during installation and commissioning, and on-going operations?
g. How do utilities envision roll out Draft TIIR Section 9D, Cyber Security? What types of responsibilities will the DER operators have?

-----------------------------End Of Prep Work --------------------------------

Technical Subgroup Meeting 6 DRAFT AGENDA
Friday, August 10th
9:30am – 12:30pm Central Time

https://global.gotomeeting.com/join/432598661
Phone: (571) 317-3112; Access Code: 432-598-661

Proposed Agenda

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, Expectations, Recap
9:40 – 10:25	Metering
10:25 – 11:45	Interoperability, including communication protocols
11:45 – 12:10	Cyber security
12:10-12:20	Meeting Evaluation
12:20 – 12:30	Next Steps

Phase II Technical Subgroup Roster

Craig Turner, Dakota Electric	Robert Jagusch, MMUA	Patrick Dalton/John Harlander/Alan Urban, Xcel Energy
Lise Trudeau, Dept of Commerce	Kevin McLean/Jenna Warmuth, MN Power	
~~Kevin Joyce~~/Katie Bell, EFCA	Kristi Robinson, MREA	John Dunlop/Chris Jarosch, MNSEIA
Brian Lydic/Sky Stanfield/Laura Hannah – Joint Movants	Dean Pawlowski, Otter Tail Power	Commissioner Matt Schuerger; Michelle Rosier; Cezar Panait
Professor Mahmoud Kabalan, St. Thomas Affiliation		Technical Assistance*: Michael Coddington and Michael Ingram, National Renewable Energy Laboratory Tom Key, Jens Boemer, Nadav Enbar; Electric Power Research Institute Pam Johnson, DOE Solar Energy Innovator Fellow

*Technical assistance is not a participant or party to the docket and does not advocate for specific outcomes in the proceeding. The role of technical assistance is to support Commission staff in the process for these proceedings, and to provide an objective source of information or data, as requested, by Commission staff to understand areas of disagreement amongst participants.

Draft Meeting Topics Proposal

Date	Topic
3/23/18	Meeting 1 Scope/Overview** (Walk-through with explanations: Red-lined TIIR; List of topics in scope of TSMs; Definitions
4/13/18	Meeting 2 Performance Categories**; Response to abnormal conditions; MISO Bulk Power System
5/18/18	No Meeting
6/1/18	Full DGWG Meeting Technical Subgroup update; Phase I Update/Next Steps
6/8/18	Meeting 3 Reactive Power and Voltage/Power Control Performance**; Protection Requirements
7/20/18	Meeting 4 Energy Storage**; Non-Export and Inadvertent Export**; Capacity**
8/3/18	Meeting 5 Meeting 4 topics continued
8/10/18	Meeting 6 Interoperability** (Monitor and Control Criteria); Metering**; Cyber security
9/14/18	Meeting 7 Test and Verification**; Witness Test Protocol
9/21/18	Full Day, In Person TSG Meeting – Power Quality; Follow up items; Review/Reconcile edits in the draft TIIR
10/19/18	Meeting 8 References; Definitions*; 1-line diagram requirements; Agreements*, Frequency Ride-through
11/9/18	Full DGWG Meeting 7

Phase II Technical Subgroup Meeting #6
August 24, 2018
(Docket No. 16-521)

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https://mn.gov/puc

Agenda

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, Expectations, Recap
9:40 – 10:20	Metering - MREA presentation - Xcel presentation - Metering requirements & Draft TIIR Sec. 8 Discussion
10:20 – 11:50	Interoperability, including communication protocols - Xcel presentation - IREC presentation - Interoperability requirements & Draft TIIR Sec. 9 Discussion
11:50 – 12:10	Cyber security
12:10-12:20	Meeting Evaluation
12:20 – 12:30	Next Steps

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
June 8	Reactive Power and Voltage/Power Control Performance; Protection Requirements
July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 3	*July 20 topics continued*
Aug 24	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 14	Test and Verification; Protocol to witness Testing
Sept 21	In-Person TSG: Power Quality; Follow up items; TIIR edits discussion
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

Recap from August 3

- TSG agrees definitions associated with capacity should:
  - follow national standards as closely as possible recognizing timing complications due to the pace of national working groups
  - not re-define a terms defined elsewhere
- Xcel offered a framework for understanding the various terms proposed by TSG re: capacity and export.
- EPRI offered IEEE 1547's configuration settings as a way to address MN DIP 5.14 language on a limited capacity less than "nameplate rating."
- TIIR edits of Section 10 should focus on non-export. Limited export may be addressed at a later time.
  - A majority of IREC's Section 10 edits were related to limited export.
- 7-26-2018 draft TIIR may be updated by stakeholders after this week in a manner that streamlines comments and edits

Goals for TSG #6 on Metering, Interoperability

- Discuss and address draft TIIR language and proposed edits related to Sections 8 Metering & 9 Interoperability.
- Build shared understanding of
  - What the Draft TIIR proposal and TSG edits mean for these sections
  - Detail on metering requirements that should be in the TIIR compared to a utility's TSM
  - Considerations of statewide uniformity vs. differing utility system requirements regarding interoperability
  - Cyber security responsibilities

Glossary/Phrases germane to this presentation from IEEE 1547

- **interconnection system:** The collection of all interconnection and interoperability equipment and functions, taken as a group, used to interconnect a DER to an Area EPS. [24] [IEEE 1547-2018 p. 23 and 7-26-18 Draft TIIR p.16]

- **interoperability**: The capability of two or more networks, systems, devices, applications, or components to externally exchange and readily use information securely and effectively. (IEEE Std 2030®) [IEEE 1547-2018 p. 23 and 7-26-18 Draft TIIR p.16]

- **local DER communication interface:** A local interface capable of communicating to support the information exchange requirements specified in this standard for all applicable functions that are supported in the DER. [IEEE 1547-2018 p. 24 and 7-26-18 Draft TIIR p16]

  - [24] This term was frequently used in IEEE Std 1547-2003. Given the scope of the present standard, which may have implications to the design of the entirety of the DER, this standard uses the term "DER" in most places.

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Draft TIIR Section 8: Metering

Existing Requirements

- Minnesota's current (adopted 2004) Distributed Generation Interconnection Requirements, specifies the maximum expected metering, monitoring and control requirements.
- Additional metering requirements are found in specific programs or tariffs (e.g. production meters for REC purchases or incentives) and whether the customer or utility pays for the meter and expenses varies.
- Any metering requirements necessitated by the use of the DER shall be installed at the Interconnection Customer's expense. [MN DIP Section 5.4]
- Who pays is not in scope for the technical requirements

TABLE 5A
Metering, Monitoring and Control Requirements

Generation System Capacity at Point of Common Coupling	Metering	Generation Remote Monitoring	Generation Remote Control
< 40 kW with all sales to Area EPS	Bi-Directional metering at the point of common coupling	None Required	None Required
< 40 kW with Sales to a party other then the Area EPS	Recording metering on the Generation System and a separate recording meter on the load	Interconnection Customer supplied direct dial phone line.	None Required
40 – 250kW with limited parallel	Detented Area EPS Metering at the Point of Common Coupling	None Required	None Required
40 – 250kW with extended parallel	Recording metering on the Generation System and a separate recording meter on the load	Interconnection Customer supplied direct dial phone line. Area EPS to supply it's own monitoring equipment	None Required
250 – 1000 kW with limited parallel	Detented Area EPS Metering at the Point of Common Coupling	Interconnection Customer supplied direct dial phone line and monitoring points available. See B (i)	None Required
250 – 1000 kW With extended parallel operation	Recording metering on the Generation System and a separate recording meter on the load.	Required Area EPS remote monitoring system See B (i)	None Required
>1000 kW With limited parallel Operation	Detented Area EPS Metering at the Point of Common Coupling	Required Area EPS SCADA monitoring system. See B (i)	None required
>1000 kW With extended parallel operation	Recording metering on the Generation System and a separate recording meter on the load.	Required Area EPS SCADA monitoring system See B (i)	Direct Control via SCADA by Area EPS of interface breaker.

Source: Att 2. Technical Requirements, Sept 28, 2004 Order establishing interconnection standards

NERC Modeling Standards

NERC has transmission standards for the Bulk Electric System that require knowledge of the peak system load without DER netted with the load. Issue is that without a production meter, the ability to identify the "true" peak system load is not feasible.

Most NEM interconnections are not incorporating a production meter unless an incentive program is tied to the need for a production meter.

NERC Modeling Standards

MOD-032-01 : Model Building Standards

Transmission companies are to represent generation type(s) and load profiles at each of transmission interconnection points along with max load, max generation and net loading

MOD-032-1 — Data for Power System Modeling and Analysis

A. Introduction

1. **Title: Data for Power System Modeling and Analysis**
2. **Number:** **MOD-032-1**
3. **Purpose:** To establish consistent modeling data requirements and reporting procedures for development of planning horizon cases necessary to support analysis of the reliability of the interconnected transmission system.

NERC Modeling Standards

TPL-001-4: Transmission System Planning Performance Requirements

Requirements for planning, stability, contingency and other types of transmission analysis. Basically a stress test analysis for the transmission system.

Many references to system peak load modeled in a dynamic setting. Without the knowledge of how much load is being masked by DER, the true system peak load is not being modeled.

Standard TPL-001-4 — Transmission System Planning Performance Requirements

A. Introduction

1. **Title:** **Transmission System Planning Performance Requirements**
2. **Number:** **TPL-001-4**
3. **Purpose:** Establish Transmission system planning performance requirements within the planning horizon to develop a Bulk Electric System (BES) that will operate reliably over a broad spectrum of System conditions and following a wide range of probable Contingencies.

MREA
Minnesota R

NERC Modeling Standards

Additional modeling guidelines recently release have expand the modeling inputs for aggregation of DER behind the substation meter, specifically calling out system peak load without DER, total amount of DER generating and net effect on load with DER.

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Technical Brief on Data Collection Recommendations for Distributed Energy Resources

NATF Reference Document: Distributed Energy Resource Modeling and Study Practices

MREA
Minnesota Rural Electric Association

NERC Modeling Standards

For Transmission Operators, the following information may be needed:

- Accurate distribution load forecasts on an hourly basis at each load bus
- Accurate DER forecasts on an hourly basis at each load bus
- Accurate net load forecasts on an hourly basis at each load bus
- DER sensitivity to changing weather (cloud cover)
- Aggregate nameplate capacity of DERs is forecasted at each load bus for each year during the operational planning horizon
- Potential real-time changes in DER production due to weather, time of day, etc.
- Voltage and frequency ride through capabilities of DER (IEEE 1547 abnormal performance categories assignment)
- Category III DER momentary cessation voltage threshold
- Voltage control capabilities (IEEE 1547 abnormal performance categories assignment)

NERC Technical Brief on Data Collection Recommendations for Distributed Energy Resources

MREA
Minnesota Rural Electric Association

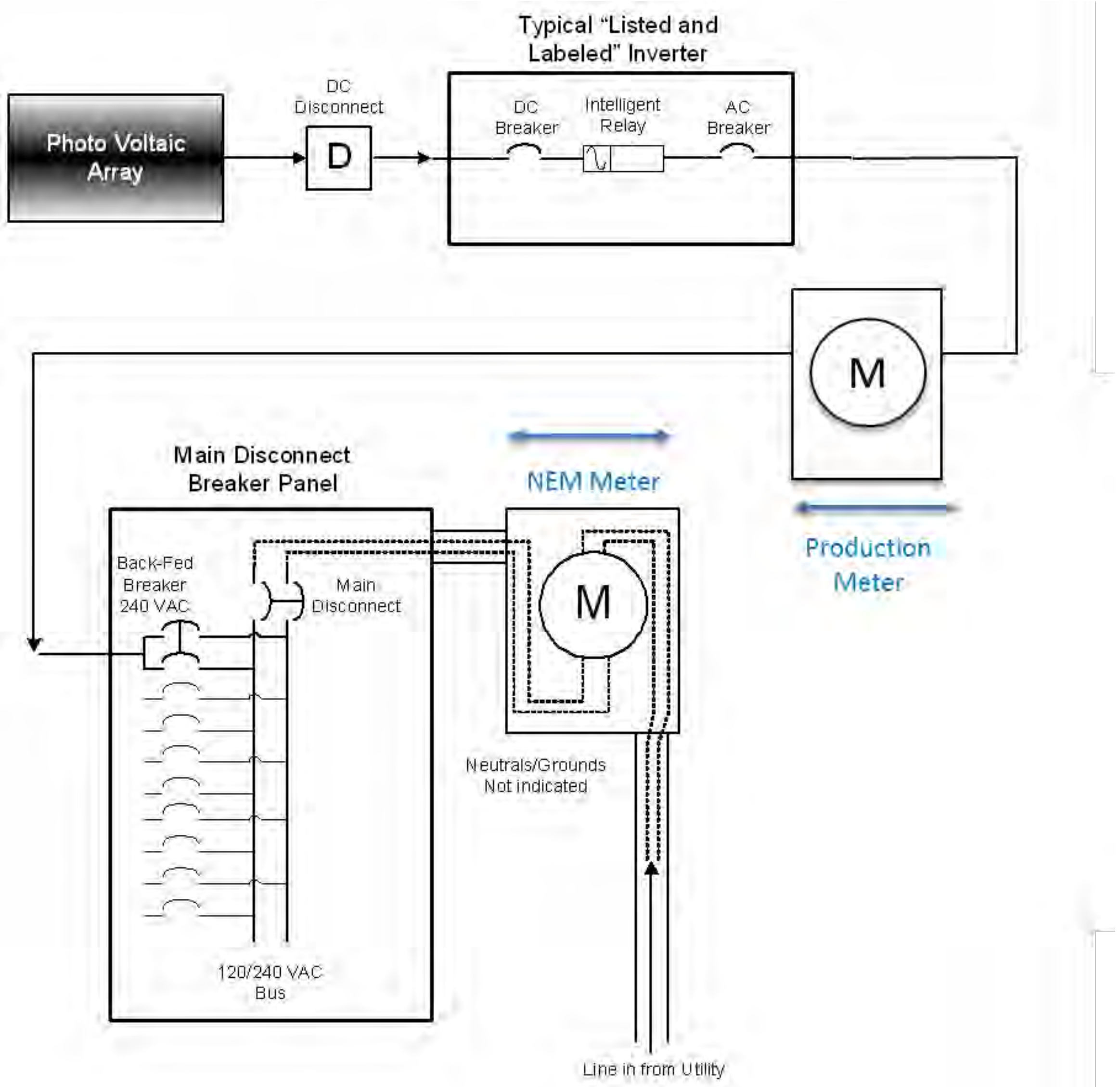
NERC Modeling Standards

To meet the NERC standards and guidelines production metering will need to become a requirement. On lightly loaded substations (<2 MW) a handful of NEM systems can easily masking 10%+ of the “true” peak load.

Discussion currently occurring on the ability to model “assumed” masked load for extremely small systems (< 10 kW). Not all transmission planners are comfortable with the assumption concept; especially if higher penetration of small DER systems are expected. Also are concerns for future additional transmission modeling requirement.

MREA
Minnesota Rural Electric Association

Example of DER with Production Meter



- Graphic credit: Michael Coddington, NREL

TIIR Section on Metering

Xcel Energy

The Area EPS Operator shall specify metering requirements in the Area EPS Operator's TSM

Functional characteristics:

- ***Operational*** – near-real-time information on the DER operating characteristics can be needed in order to perform certain actions such as reconfiguring a feeder or restoring a feeder after an outage.
- ***Planning*** – an archive of time-series information over multiple years of DER operation is required for Area EPS and TPS planning.
- ***Regulatory*** – The Area EPS may have obligations to track and report on the amount of energy produced from renewable energy DER. Specific incentive programs or tariffs can create additional metering needs.
- ***Billing*** – the Area EPS is responsible for accounting for energy transactions with the DER Operator and shall have access to revenue grade metering information.

Discuss: Draft TIIR Metering Requirements

- How are statewide metering requirements changing with the proposed TIIR language, and why?
- What are the benefits of production meters compared to inverters?

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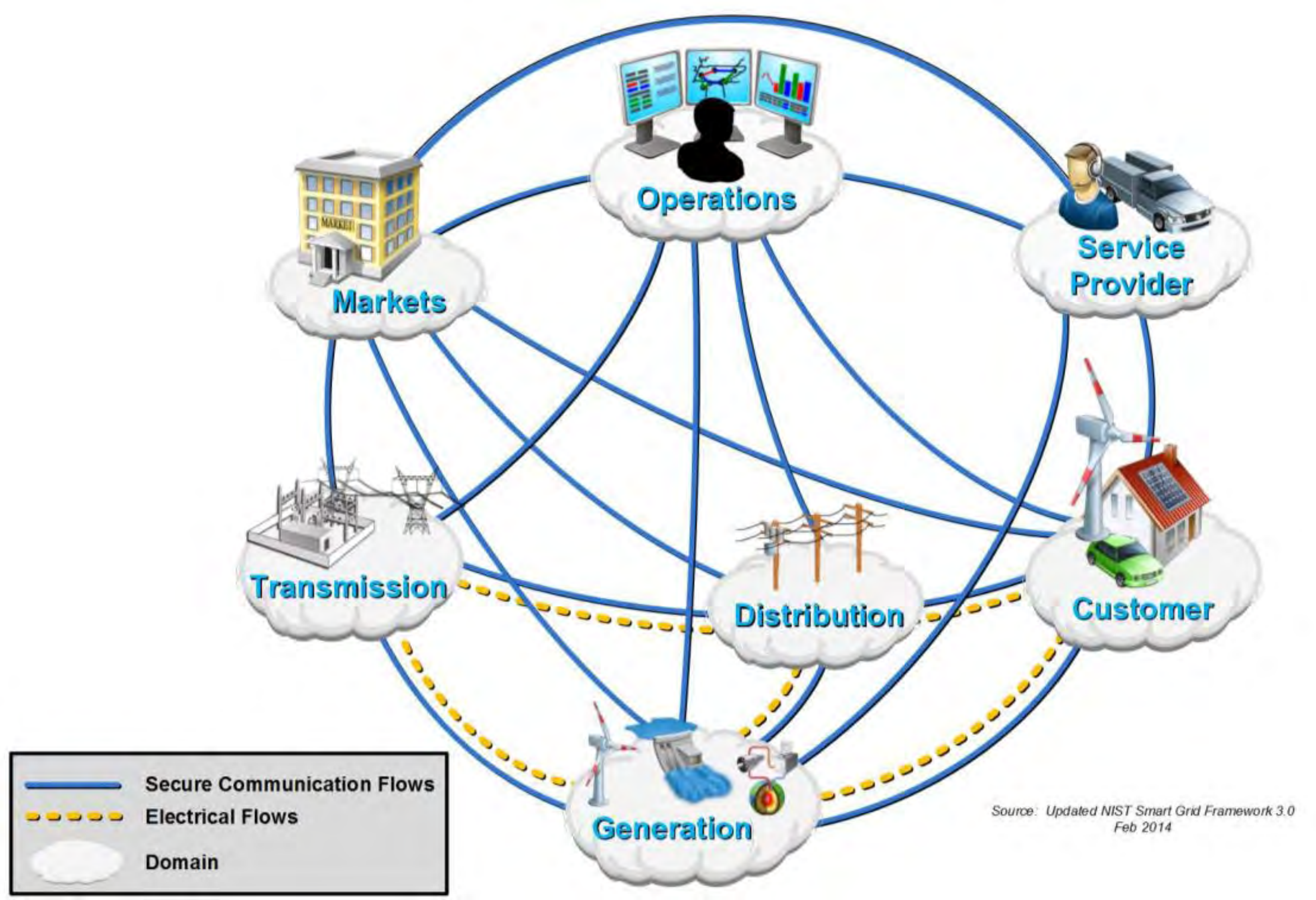
Draft TIIR Section 9: Interoperability

Actors within a smart grid (NIST report)



Source: Updated NIST Smart Grid Framework 3.0
Feb 2014

Current Remote Monitoring and Control Practices

- **Remote monitoring** for all DER at a site that in aggregate is equal or greater than 250 kW in AC nameplate capacity

- Majority of sites use cellular communications to production meter
  - Real power, apparent power, power factor, 3-ph voltage, 3-ph current.

- Some sites require SCADA for operational control or a communication based protection scheme

- Primary objective: Situational awareness for control center and field personnel

Remote Monitoring ≠ Interoperability

What is Interoperability?

- A requirement for a *Local DER Communications* interface which is active and responsive whenever the DER is in the *continuous operating region* or *mandatory operating region*

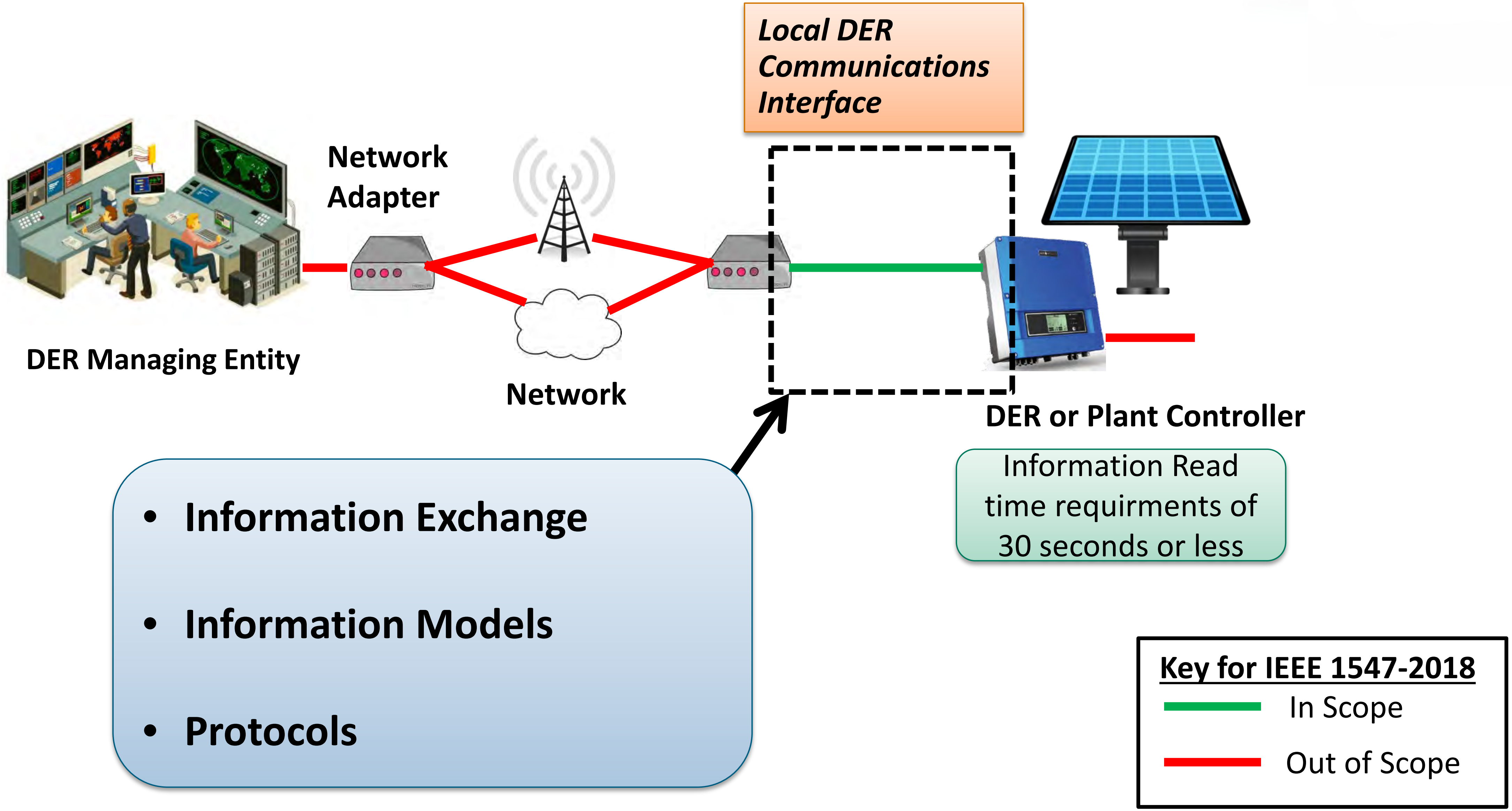
- A means of implementing specific DER functionality through standardized information elements as well as monitoring measurements and status information

interoperability: The capability of two or more networks, systems, devices, applications, or components to externally exchange and readily use information securely and effectively. (IEEE Std 2030® [B23])

local DER communication interface: A local interface capable of communicating to support the information exchange requirements specified in this standard for all applicable functions that are supported in the DER.

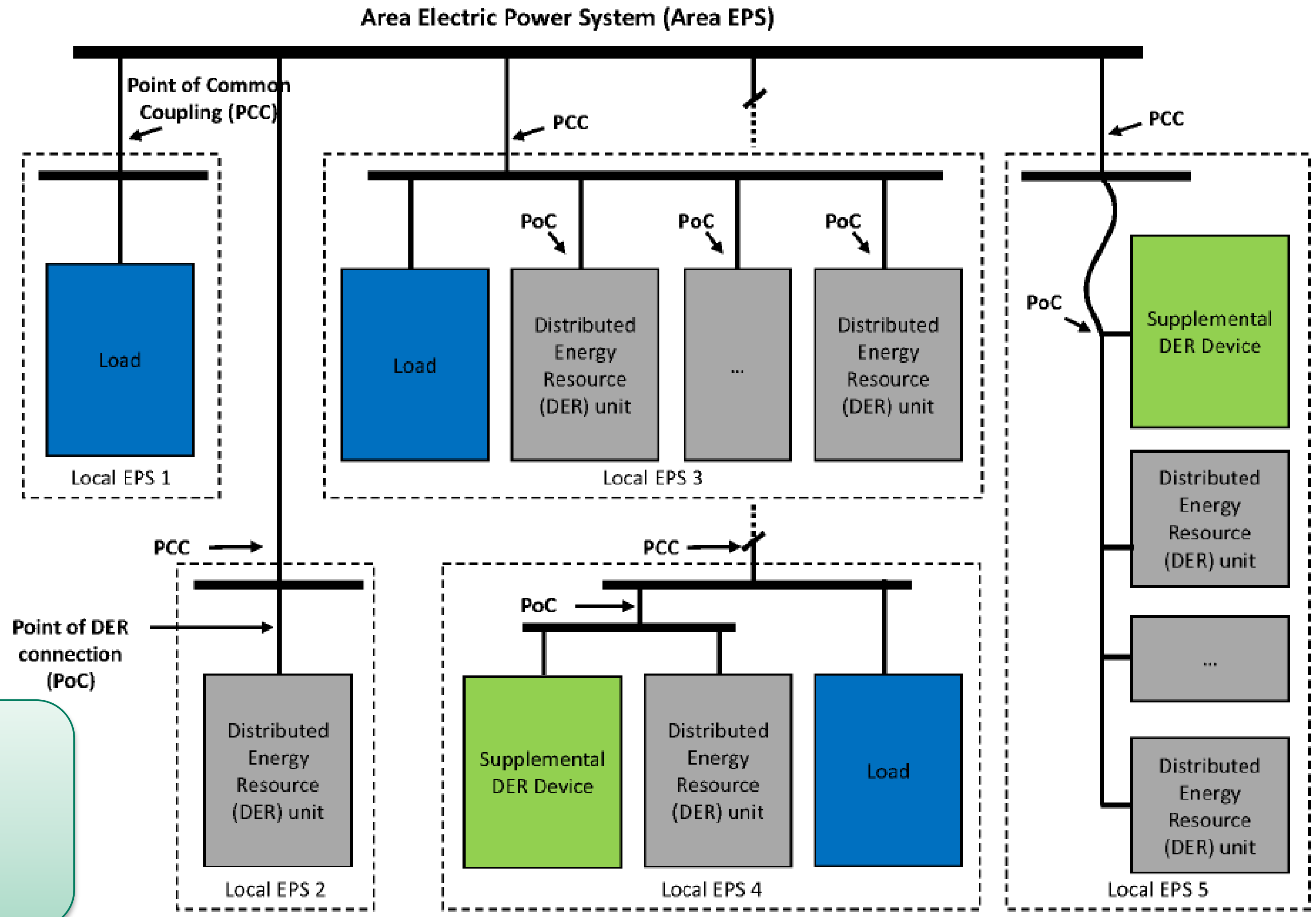
IEEE 1547-2018

What is in scope of Interoperability?



Where is the Local DER Communication Interface?

Application of *Local DER Interface* is at the *Reference Point of Applicability,* which may be the PCC or PoC or, under mutual agreement, a point in-between the PCC and PoC



reference point of applicability (RPA): The location where the interconnection and interoperability performance requirements specified in this standard apply.

What information can be exchanged?

Xcel Energy

Nameplate

- P at unity and specified pf
- S maximum rating
- +/- Q maximum
- Performance Category
  - Normal
  - Abnormal
- Voltage Ratings
- Supported Control Modes
- Make, Model, Version

Configuration

- Each rating in the Nameplate Information Table is configurable
- Not intended for continuous dynamic adjustment

Monitoring

- Active Power
- Reactive Power
- Voltage
- Frequency
- Operational Status
- Connection Status
- Alarm Status

Management

- P and Q control mode settings
- Voltage/frequency trip and momentary cessation parameters
- Enter service after trip parameters
- Cease to energize and trip
- Limit maximum active power

Draft TIIR: When information exchange through the *local DER communication interface* is required by the Area EPS, the Area EPS shall have read and write access to all parameters in the nameplate information, configuration information, monitoring information, and management information, as defined by IEEE 1547.

IEEE 1547-2018

How will information exchange be used in future?

- Real time data to improve power flow and state estimation in Advanced Distribution Management System (ADMS)
  - Information on DER production feeds into ADMS modules that forecast impacts of DER for planned or emergency switching

- *DER Monitoring Information for* situational awareness (similar to current use)

- *DER Nameplate Information* available through local DER communications interface provides path for data integrity

- *DER Configuration Information* is a static means of capacity limiting or modifying other nameplate characteristics

- *DER Management Information* for remote settings changes
  - Could be on a set schedule (i.e. seasonal) or based on actual conditions (i.e. contingency/emergency)

When is the Local Communication Interface Used?

IEEE 5147-2018, Clause 10.1, Paragraph 3

The decision to use the *local DER communication interface* or to deploy a communication system shall be determined by the Area EPS operator.

Draft TIIR

- "Per IEEE 1547 Section 10.1, the decision to use the *local DER communication interface* or to deploy a communications network is determined by the Area EPS."
- Use of the *local DER communication interface* can be a complex decision dependent on the DER size and other factors such as penetration and Area EPS characteristics in the area.
- Process for determining use of *local DER communication interface* shall be outlined in the Area EPS Operators' TSM.
- The DER Operator may be responsible for furnishing the communication channel
- Additional details of the channel and interface shall be in the Area EPS Operators' TSM

Interoperability Protocol Options

<table>
<tr><td>Application Layer</td><td>IEEE 1815 (DNP3)</td><td>IEEE 2030.5 (SEP2)</td><td colspan="2">SunSpec Modbus</td></tr>
<tr><td>Transport Layer</td><td>TCP/IP</td><td>TCP/IP</td><td>TCP/IP</td><td>N/A</td></tr>
<tr><td>Physical Layer</td><td>Ethernet</td><td>Ethernet</td><td>Ethernet</td><td>RS-485</td></tr>
</table>

Communication Protocols Usage at Xcel Energy

- **Present:** Xcel Energy uses DNP3 for distribution field devices and communication to meters for DER remote monitoring
  - The other protocols are not currently in use at the distribution level.
  - Modbus is used within substations for communication between devices, but it is not SunSpec Modbus

- **Future:** We are evaluating the protocol options available in IEEE 1547-2018 to determine which will be implemented.
  - It is possible that different protocols will be used for different use cases based on the strengths and weaknesses of each protocol
    - Security features for a given application
  - Protocol translators are an option at the network adaptor interface

Industry Application of Communication Protocols

- ***SunSpec Modbus*** is the protocol supported now by most manufacturers
  - Historically ModBus was already internal to inverters
- Storage systems alignment around ***DNP3*** mapping
  - Largely driven by the open standards efforts for energy storage initiated by Modular Energy Storage Architecture (MESA)
- Rule 21 implementation results in ***IEEE 2030.5*** use between aggregators and utilities

Selecting a Single Protocol for Minnesota?

- Upside: The ***simplicity*** leads to better chances of success with implementing true interoperability and effective information exchange between all applicable DER and Area EPS Operators in the state.
  - Potential to streamline integration for Developers, Installers, and Area EPS Operators

- Downside: The ***timing*** of the MN update means that market forces have not begun to converge on one of the protocols
  - The IEEE 1547 working group had anticipated some consolidation over time.
  - Expectation is that many manufacturers will offer just one of the three protocols. This aligns with standard requirements

Working hypothesis: Standardizing under a single protocol may be practical in the longer term, and assists in effective interoperability, but we need to better understand vendors offerings and back-end system integrations for all affected parties before making this a statewide requirement.

Information Model Usage – IEC 61850

- **<u>Present:</u>** We do not currently use the implementation of 61850-7-420 for information exchange with DER.
  - Historically standard functions were not defined or available through a standard interface for certified equipment
  - Cellular communication with DNP3 protocol to production meter
  - Xcel's ADMS implementation of common information models is based on IEC 61850

- **<u>Future:</u>** The CIM from IEC 61850-7-420 is encoded in each of the protocols accepted by IEEE 1547-2018.
  - From the field device side, it will be used when future revised UL 1741 leads to compliant equipment

Other states are considering interoperability under 1547-2018

- California, via the Smart Inverter Working Group
  - Selected IEEE 2030.5 as the communication protocol and information model
  - Requires capability by (May 22, 2018) plus 9 months
- Hawaii is currently in discussions about communication models under Rule 14
  - Advanced Inverter Function Working Group hosted a webinar on 8/9 as part of their working group process as an educational meeting
- MISO stakeholder process on DER integration as related to 1547-2018 is just getting started

Communications

Brian Lydic

Regulatory Engineer

IREC

Communications Req's Concepts

Basic Principles/Assumptions

- Different utilities will have different capabilities/infrastructure
- Hugely different costs can be incurred (by both utility and customer)
- Ubiquitous comms/control of DERs (large and small) is likely years away
- Actual TIIR requirements could vary based on utility capabilities/infrastructure – need to discuss (IREC proposal is dependent on MN utilities' capabilities and future plans)
- Develop requirements for a "comms port" that can be widely applicable to all DER once utility infrastructure can support it
- Use "traditional telemetry" today for larger systems
- Consider cost cap for traditional telemetry due to varying costs

Comms Port Requirement

- Balance availability of monitoring and control with initial equipment cost (will it be used?)
- Could create penetration limit at which comms port equipment would be required – this allows evolution of each utility individually
- No requirement for comms port equipment at DER when utility is below penetration limit (and no retroactive requirement to add one)
- Future use of comms port and control may need further customer agreements/protections – note difference between equipment availability and agreement to utilize in TIIR
- Develop agreements at future time – should have a few years for market and equipment to develop in response to 1547 req’s
- Requirement should be 1547-based
- Can require DER to accept comms/control in utility’s preferred language, as long as it is one of the three 1547 options (translators may be used, e.g 2030.5 to SunSpec)

Example to help design Cost Cap

- The below is not a proposal, but an example under consideration in CA
  - CA IOUs have noted that traditional telemetry/ communications could likely be provided for $20,000 or less per DER
  - Whether this could/should apply at 250 kW or 1 MW is contested
  - (many details apply)

@IRECUSA

Discuss: is it in the best interest of MN to allow all combinations allowed by 1547-2018?

- Do organizations have rough order of magnitude cost and schedule estimates for changing from one protocol to a different one from their software architects?
- What will serve MN the best?
  - What will the impact be with regards to test and verification?

What will it take to properly safeguard and utilize smart inverters?

- Training beyond electrical expertise throughout the supply chain including engineers, installers and inspectors
- Updates to 1547.1 and associated standards, including UL 1741
- Certification by NRTLs in accordance with updated standards

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Draft TIIR Section 9D: Cyber Security

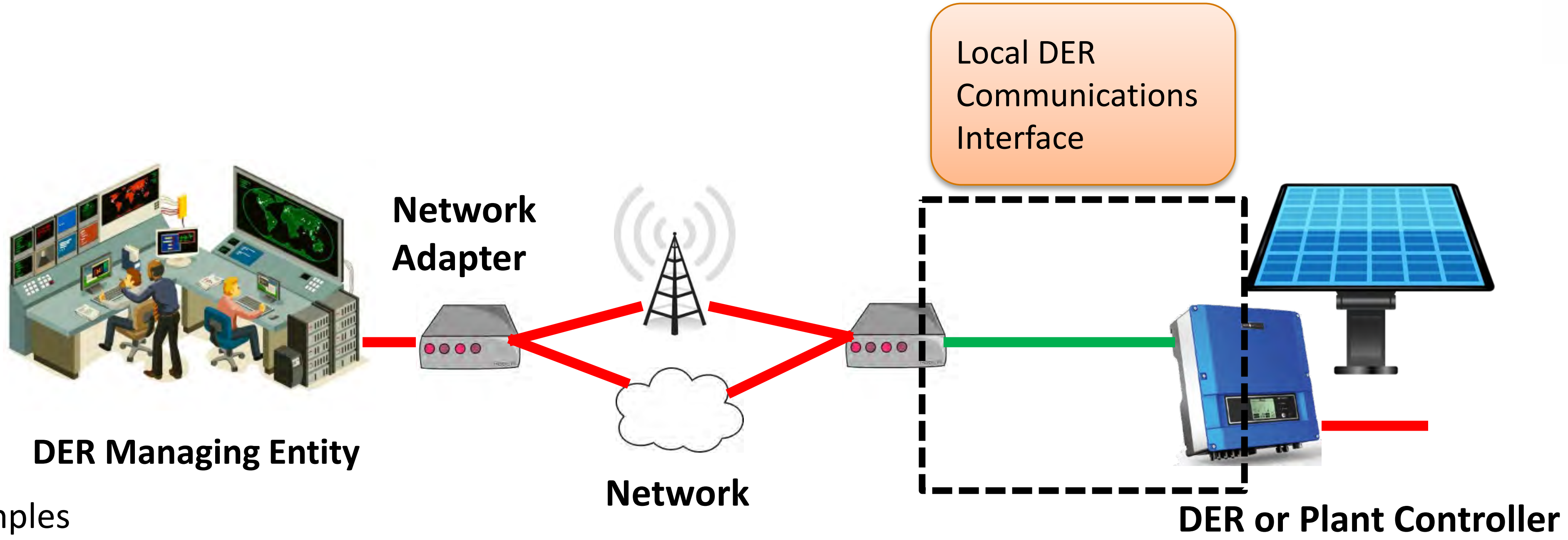
Other IEEE 1547-2018 statements for consideration (Annex D)

- Cyber security is a system-wide issue requiring a system-wide solution.
- This standard specifies the base functionality of a DER including the capability of exchanging specific information over a local DER communication interface.
- This standard cannot correctly address system level issues and should not constrain reasonable system solutions.
- The organization responsible for maintaining the reliability and security of the communications path to the DER must also be able to perform regular maintenance, upgrades, and changes to the network components, including the protocol and cyber security mechanisms.

Recent reporting rule-making will impact some stakeholders directly, others indirectly

- Under the current Critical Infrastructure Protection Reliability Standard CIP-008-5 (Cyber Security – Incident Reporting and Response Planning), incidents must be reported only if they have compromised or disrupted one or more reliability tasks.
- The final FERC rule dated July 19 directs NERC to modify the Standard within 6 months to expand the current reporting requirement, including
  - Reporting cyber security incidents that compromise, or attempt to compromise
  - Cyber Security Incident Reporting Reliability Standards; 164 FERC ¶ 61,033
    - Docket No. RM18-2-000; Order No. 848
- We include this for stakeholder awareness throughout the DER supply chain

Cyber Security in TIIR



Examples

- Network segmentation
- Intrusion detection systems
- Inline blocking devices
- Selective encryption
- Multi-Factor Authentication
- Patching
- Port security
- Strong user names and passwords
- Role based access

TIIR specifies that physical and network security requirments are in scope for Area EPS Operator TSM

Effective cyber security requires a system-wide solution.

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Cyber Security in TIIR

Xcel Energy

- TIIR leaves requirments to TSM for some of same reasons as 1547-2018: scope and complexity, system architecture flexibility, and testability
  - Standards should be used where available and applicable

- Recognizes a few areas of focus for Area EPS Operator's TSM based on Annex D of IEEE 1547-2018
  - DER Physical and front panel security
    - Ex) access to settings or controls
  - DER network security
    - Ex) if communication is required, a firewall or other network security device may be required
  - Local DER communication interface
    - Ex) includes considerations that are applicable to the end-to-end network, such as system architecture

- Implementation of TIIR Section 9D will be a progression that is anticipated to track with device and network security practices being implemented for other advanced field devices

Next Steps

Aug 23	Sept 14 TSG Mtg #7 Draft Agenda and Prep Work Assignment from Staff to TSG
Sept 5	Prep work due for Sept 14 TSG meeting #7
Sept 14	Test and Verification; Protocol to witness Testing (TSG Mtg #7)
Sept 21	In-Person TSG: Power Quality; Follow up items; TIIR edits discussion
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

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Thank You!

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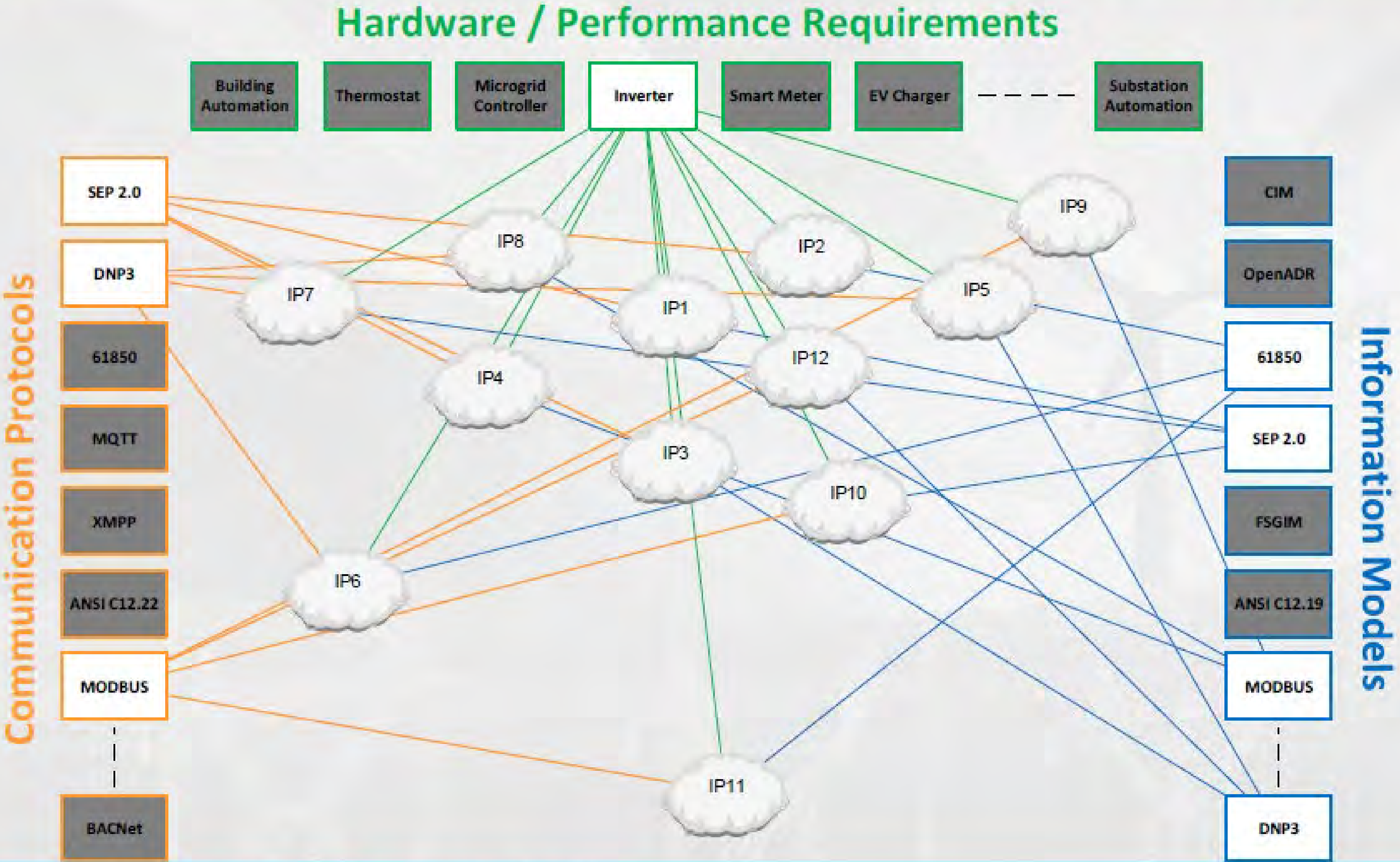
Back Up Slides

See next slide for graphical representation of what IEEE 1547 allows for interoperability in a given use case

Interoperability Profile: IEEE 1547 Case Study



This is not a comprehensive list; it is provided in the event you need a place to start looking at cyber security

- AEE report: Cybersecurity in a distributed energy future (Jan 2018): https://info.aee.net/hubfs/Cybersecurity_FINAL_WP_AEEInstitute_1.18.18.pdf
- NIST Cybersecurity Framework Home Page (generic, not grid specific) https://www.nist.gov/cyberframework
- Guidelines for Smart Grid Cybersecurity Volume 1 - Smart Grid Cybersecurity Strategy, Architecture, and High-Level Requirements http://dx.doi.org/10.6028/NIST.IR.7628r1
- Open Web Application Security Project (OWASP) Top 10 List (generic, not grid specific) https://www.owasp.org/images/7/72/OWASP_Top_10-2017_%28en%29.pdf.pdf

Discussion: Scope for Statewide Technical Requirements

These topics have been proposed as **in scope**.
Bold have been flagged for discussion.

1. Scope/Overview
2. References
3. Definitions
4. **Performance Category Assignments**
5. **Reactive Power Capability and Voltage/Power Control (volt-var & volt-watt) Performance**
6. **Response to Abnormal Conditions (Ride-through)**
7. **Protection Requirements**
8. **Metering**
9. **Interoperability (Monitoring, Control, Info Exchange, Cyber security)**
10. **Energy Storage**
11. Non-Export; Inadvertent Export
12. **Test and Verification Requirements**
13. **Agreements**
14. **Consumer Protection** (IREC)
15. **Reporting** (IREC)

(Source: “Regulated Utilities” TIIR Draft Proposal)

Discussion: Scope for Statewide Technical Requirements

1. Process requirements
2. Cost allocation
3. Interconnection to transmission system
4. **Protection system details of Area EPS or DER**
5. **Requirements or specification of system impact or facilities studies**
6. **Application of real and reactive power control functions**
7. **Details of communication networks; including architecture, technology and protocols, or other specifications related to interoperability**
8. **Details of metering requirements or specifications**
9. **Planning or operational considerations associated with Affected Systems, Regional Transmission Operator or Transmission Owners**
10. **Intentional Area EPS islanding**

These topics have been proposed as **out of scope** by some participants. Bold are flagged for additional discussion.

(Source: TIIR Draft Proposal, p. 9)

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PREP WORK for Sept. 14th TSG, #7
Test and Verification; Witness Test Protocol

Subgroup members review agenda and provide the following to staff by 9/5/18.

1) **Propose edits to the Regulated Utilities' TIIR Draft Proposal and/or flag topics for discussion. Send as red-lines and comments using track changes to the 7-26-18 Draft TIIR.**
   a. Definitions in Section 3B
   b. Test and Verification Requirements; Section 12
   c. Clarification on RPA, PCC, PoC and Supplemental DER Devices; Annex B
2) **Review and be prepared to reference IEEE 1547-2018 and one of its supporting documents**
   a. Definitions in Clause 3.1
   b. Test and Verification; Clause 11 (pages 76-94); unit vs. facility-level verification
   c. Annex F (informative) Discussion of testing and verification requirements at PCC or PoC
   d. UL 1741 CRD (attached and sent to TSG on 8/3 as Power Control Systems CRD Draft 20180731 and ECL-UC-v.2.4)
3) **Review and be prepared to reference the 2018 MN DIP leveraging the** August 13, 2018 Order (MN DIP) **and the proposed DGWG subgroup edits to MN DIP Attachment 5 (attached to email)**
   a. Inspection, Testing, Commissioning and Authorization; Section 5.7
   b. Certification Codes and Standards; MN DIP Attachment 4
   c. Certification of Distributed Energy Resource Equipment; MN DIP Attachment 5 (consider email attachment version)
4) **Please provide input to the below, slides are encouraged**
   a. How does 1547-2018 change the type of testing and verification required of an individual DER unit or multiple DER units in a DER facility, including option to witness? Does that apply to all DER or how should we consider different requirements for different DER? If you answer yes to either of the following, please include edits to the Draft TIIR:
      i. Are there any concerns due to the addition of testing for interoperability since 1547.1-2005?
      ii. Are there unique circumstances in MN that would indicate MN TIIR should take exception to any of the test and verification guidance in 1547 Clause 11? If yes, what and why?
   b. Examples of testing and verification being used today and how that has worked from different perspectives.
   c. Are additional definitions needed in the TIIR to provide clarity for parties implementing DER Interconnection in MN? If yes, please propose edits to TIIR

Section 3, 12, or both and be prepared to provide overview during TSG meeting. Consider the following phrases.

i. DER evaluation (explained in IEEE 1547 subclause 11.2.4 and also discussed in 11.2.1 and 11.3)
ii. Full conformance test (not defined, rather guidance given in IEEE 1547 subclause 11.3 and further discussed in Annex F)
iii. Partial conformance test (not defined, rather guidance given in IEEE 1547 subclause 11.3 and further discussed in Annex F)
iv. Compliance (used interchangeably with conformance in Clause 11?)
v. Witness test
vi. Periodic test and verifications (guidance given in IEEE 1547 subclause 11.2.6, including criteria for mandatory reverification)
vii. Equipment package (referenced in proposed DGWG edits to MN DIP Attachment 5)

----------------------------End Of Prep Work -------------------------------

Technical Subgroup Meeting 7 DRAFT AGENDA
Friday, September 14th
9:30am – 12:30pm Central Time

Join WebEx meeting

Meeting number (access code): 741 336 029

Meeting password: TBD

+1 206-596-0378 US Toll

844-302-0362 US Toll Free

Proposed Agenda

9:30 – 9:40 Welcome, Intros, Overview of Agenda, Recap

9:40 – 10:00 The Role of the Reference Point of Applicability (Draft TIIR Annex B)

10:00 – 11:30 Testing and Verification (Draft TIIR Sec. 12)

11:30- 12:00 Options to witness Testing

12:00 – 12:20 Check in on Sept 21 In Person Meeting

12:20 – 12:30 Next Steps

Phase II Technical Subgroup Roster

Craig Turner, Dakota Electric	Robert Jagusch, MMUA	Patrick Dalton/John Harlander/Alan Urban, Xcel Energy
Lise Trudeau, Dept of Commerce	Kevin McLean/Jenna Warmuth, MN Power	
	Kristi Robinson, MREA	John Dunlop/Chris Jarosch, MNSEIA
Brian Lydic/Sky Stanfield/Laura Hannah – Joint Movants	Dean Pawlowski, Otter Tail Power	Commissioner Matt Schuerger; Michelle Rosier; Cezar Panait
Professor Mahmoud Kabalan, St. Thomas Affiliation		Technical Assistance*: Michael Coddington and Michael Ingram, National Renewable Energy Laboratory Tom Key, Jens Boemer, Nadav Enbar; Electric Power Research Institute Pam Johnson, DOE Solar Energy Innovator Fellow

*****Technical assistance is not a participant or party to the docket and does not advocate for specific outcomes in the proceeding. The role of technical assistance is to support Commission staff in the process for these proceedings, and to provide an objective source of information or data, as requested, by Commission staff to understand areas of disagreement amongst participants.

Draft Meeting Topics Proposal

Date	Topic
3/23/18	Meeting 1 Scope/Overview** (Walk-through with explanations: Red-lined TIIR; List of topics in scope of TSMs; Definitions
4/13/18	Meeting 2 Performance Categories**; Response to abnormal conditions; MISO Bulk Power System
5/18/18	
6/1/18	Full DGWG Meeting Technical Subgroup update; Phase I Update/Next Steps
6/8/18	Meeting 3 Reactive Power and Voltage/Power Control Performance**; Protection Requirements
7/20/18	Meeting 4 Energy Storage**; Non-Export and Inadvertent Export**; Capacity**
8/3/18	Meeting 4 topics continued
8/24/18	Meeting 5 Interoperability** (Monitor and Control Criteria); Metering**; cyber security
9/14/18	Meeting 7; Test and Verification**; Witness Test Protocol
9/21/18	Full Day, In Person TSG Meeting – Power Quality; Follow up items; Review/Reconcile edits in the draft TIIR
10/19/18	References; Definitions*; 1-line diagram requirements; Agreements*, Frequency Ride-through
11/9/18	Full DGWG Meeting 7

Phase II Technical Subgroup Meeting #7
September 14, 2018
(Docket No. 16-521)

MINNESOTA
PUBLIC UTILITIES COMMISSION

https://mn.gov/puc

Agenda

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, Expectations, Recap
9:40 – 10:00	Definitions
10:00 – 11:30	TSG on Test and Verification MREA Commissioning Test Process and Experiences IREC Proposal for delineating TIIR content from TSM content Xcel Response to Prep Work Request
11:30 – 12:15	Discuss specific edits for Draft TIIR Section 12 and MN DIP Att. 4 & 5
12:15 – 12:25	Sept 21 In Person TSG Draft Agenda
12:25 – 12:30	Next Steps

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
June 8	Reactive Power and Voltage/Power Control Performance; Protection Requirements
July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 3	*July 20 topics continued*
Aug 24	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 14	Test and Verification; Protocol for witnessing Testing
Sept 21	In-Person TSG: Power Quality; Follow up items; TIIR edits discussion
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

Recap from August 24

- Discussion focused on specific details and cost considerations regarding metering or monitoring equipment with sufficient accuracy being captured in the Area EPS TSM and functional requirements in the MN DER TIIR
  - This is a change from existing MN requirements
- TSG does not recommend specifying one interoperability application layer communication protocol at this time
  - Test and verification standards (IEEE 1547.1 and UL 1741 updates) are evolving, not approved
  - The market has not yet responded to IEEE 1547-2018 specifications
  - This does not preclude use of interoperability communications between distribution system and DER
    - Lack of supply chain streamlining and facility verification in the interim was acknowledged
- Proposal was discussed to require the inclusion of the port to enable the interoperability physical layer for communication within the MN DER TIIR
  - Not discussed, but presentation included information that the transport layer and physical layer specification are 1:1 with each other

Goals for TSG Mtg #7: Testing, Verification and Witnessing

Discuss and address draft TIIR language and proposed edits related to Section 12 and consider interim MN DIP Attachments 4 & 5 consistent with Draft TIIR and timing of the final TIIR

Build a shared understanding of

- Test and Verification requirements and expectations at the time the TIIR becomes effective
- The protocol for witnessing a test
- Clarity of what test procedure a DER developer should be ready to execute at a given phase in a process. Including discussion clarifying
    - Basic terminology for DER and supplemental DER devices when those phrases are used in the testing and verification context
    - The concept of witnessing a test being unique from what test procedure is being utilized
        - This is clearly stated in Section 12, but “witness test” appears in slide decks, meeting notes, and MN DIP 2.3 and Exhibit C 2.3.1.

Interconnection Standards Adoption Roadmap Considerations

2016
- UL 1741 (SA) published
- Based on requirements specified in CA Rule 21 and Hawai'ian Rule 14H

2017
- UL 1741 (SA) certified equipment available

2018
- IEEE Std 1547-2018 published
- Requirements go beyond CA Rule 21 and HI Rule 14H

2019+
- IEEE Std 1547.1-2019 published
- UL 1741 updated

2021+
- IEEE Std 1547-2018.1 tested and UL 1741 certified equipment available

Adoption of CA Rule 21 and Hawai'ian Rule 14H by inverter certification per UL 1741 (SA).

Stopgap solution for **adoption of parts of IEEE Std 1547-2018** by inverter certification per UL 1741 (SA).

Full adoption of IEEE Std 1547-2018.

Question from **distribution** perspective:

Early need to increase hosting capacity?

Question from **transmission** perspective:

Early need to address bulk system reliability?

Consideration of Certification

- MN DIP goes into effect June 17, 2019.
  - Simplified Process and Fast Track Process have “certified” DER considerations.
- Current timeline for completing the Draft TIIR is February 2019.
  - Draft TIIR incorporates IEEE 1547 elements which are not included in UL 1741 certification. UL 1741 SA addresses some, but not all of IEEE 1547.
  - TSG discussed interim IEEE 1547 implementation requirements and suggested waiting for IEEE 1547.1 and UL 1741 updates. UL 1741 certified equipment for IEEE 1547 likely not available **<u>until 2021</u>**.
- Need to determine: Timing of TIIR implementation and MN DIP interim certification considerations (Att. 4 & 5).

Glossary germane to this presentation based on IEEE 1547-2018

- **Commissioning tests:** Commissioning tests are tests and verifications on one device or combination of devices forming a system to confirm that the system as designed, delivered, and installed meets the interconnection and interoperability requirements of this standard. [IEEE 1547-2018 p. 78]
  - Test procedures are provided by equipment manufacturers(s) or system designer(s) and approved by the equipment owner and Area EPS operator. Commissioning tests shall include visual inspections and may include, as applicable, operability and functional performance test.
- **DER evaluation:** DER evaluation comprises a design evaluation desk study during the interconnection review process and an as-built installation evaluation on site at the time of commissioning to verify that the composite of the individual partially compliant DER(s) and, if applicable, the supplemental DER device(s) forming a system meet the interconnection and interoperability requirements of this standard. [IEEE 1547-2018 p. 78]
- **Type tests:** A type test may be performed on one device or combination of devices. In case of a combination of devices forming a system, this test shows that the devices are able to operate together as a system. Type tests shall be performed, as applicable, to the specific DER unit or DER system. The tests shall be performed on a representative DER unit or DER system, either in the factory, at a testing laboratory, or on equipment in the field. Type test results from a DER within a product family of the same design, including hardware and software, shall be allowed as representative of other DERs within the same product family with power ratings between 50% to 200% of the tested DER. [IEEE 1547-2018 Clause 11.2.2]

Recommend caution with the following phrases as they may not be self-consistent within IEEE 1547

- **distributed energy resource (DER):** A source of electric power that is not directly connected to a bulk power system. DER includes both generators and energy storage technologies capable of exporting active power to an EPS. An interconnection system or a supplemental DER device that is necessary for compliance with this standard is part of a DER. [23] (IEEE 1547-2018, Clause 3.1, p. 22)
- **DER unit:** An individual DER device inside a group of DER that collectively form a system. (IEEE 1547-2018, Clause 3.1, p. 23)
- **DER equipment package:** not defined, Attachment 5 to MN DIP is labeled "Certification of DER Equipment Packages"
- **Interconnection system:** The collection of all interconnection and interoperability equipment and functions, taken as a group, used to interconnect a DER to an Area EPS. [24] (IEEE 1547-2018, Clause 3.1, p. 23)
  - Footnote 24: This term was frequently used in IEEE Std 1547-2003. Given the scope of the present standard, which may have implications to the design of the entirety of the DER, this standard uses the term "DER" in most places.

(emphasis added by staff)

MINNESOTA
PUBLIC UTILITIES COMMISSION

Draft TIIR Section 12: Test and Verification

Today's NEM Commissioning Tests

Vendor, electrician or member calls the Cooperative to schedule a commissioning test for the DER system. (Prior notice duration varies.)

Best Practice: electrician schedules commissioning test the same day the electrical inspector is out for inspection.

Electrical inspector often stays to watch commission test. Total commissioning test takes ~ 20 minutes.

Today's NEM Commissioning Tests

Cooperative send one or two personnel to perform commissioning. (Two personnel are sometimes required due to safety rules on disconnection of distribution systems.)

Best Practice: Request member, vendor or electrician also to be present.

Have discovered that electrician often will troubleshoot last minute issues discovered when utility personnel are on site. May often be able to repeat commissioning test immediately.

Today's NEM Commissioning Tests

Cooperative representative explains testing to others onsite. Disconnection of power to DER system will occur and possible temporary disconnection to residence.

Checks for electrical inspector stickering.

Confirms DER system installed matches one-line diagram provided with application.

Confirm AC Disconnect Switch is present and visual, accessible, and lockable.

Unexpected DER Additions

Minnesota Rural Electric Association

Today's NEM Commissioning Tests

First will operate AC disconnect switch:

- Will have multimeter monitoring amperage from DER system.
- Will have stopwatch going to ensure shutdown under 1 minute.

Once power production has stopped, it will restart stopwatch and restart DER system. Power production shall not start prior to 5 minutes.

Once power production is occurring again, it will create a temporary outage from the distribution system. Again, confirming power has ceased to generate.

Minnesota Rural Electric Association

Today's NEM Commissioning Tests

Example of Commission Documentation

PV/Turbine Final Commissioning Tests

Location ____________________
Member Name ____________________
Testing Date ____________________
Person Filling Out Form ____________________
DG System Type ____________________

Initial Observations

YES	NO	
		Testing procedures were explained to PV/turbine owner and/or representative
		Electrical Inspector sticker present on metering
		Visible, accessible, lockable disconnect switch present
		Control panel matches one-line diagram provided with DG application? (protective relaying present?)

Tests to Perform

Single-Phase and Three-Phase Units

Step 1. The DG system shall be started in parallel with the distribution system.
Step 2. Disconnect the PV/turbine from Utility's system via the lockable, accessible disconnect switch.

YES	NO	
		The PV/turbine stopped generating
		or
		Did the PV/turbine separate from the local load? (Turbine may still spin but no power is being produced to home/meter)

Step 3. Reconnect the turbine to utility's system by closing the disconnect switch.

YES	NO	
		Did the PV/turbine not re-parallel with utility's system or generate for at least 5 minutes once switch was closed?

Three-Phase Units Only

Step 4. Open cutouts or pull elbows one phase at a time.

YES	NO	
		The PV/turbine stopped generating after one phase was lost.
		The PV/turbine stopped generating after two phases were lost.
		The PV/turbine stopped generating after three phases were lost.

System Operation

YES	NO	
		Utility left the site with the DG system in operation (all breakers on, disconnect in the ON position)

Personnel Present for Testing ____________________

Other People Present for Testing ____________________

Please take a picture of metering setup, disconnect switch, transformer(s), turbine or PV system, and DG control panel.
A copy of this report will be provided to DG owner with a letter from utility allowing parallel operations of the DG system.

What has been found....

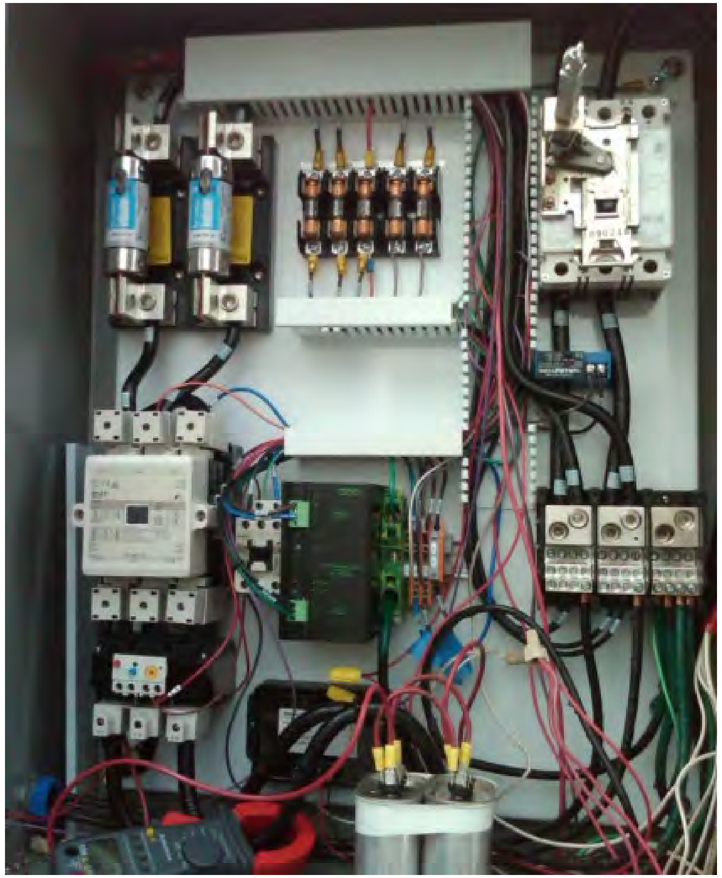
Solar system disconnect switch opened, solar system still generated. Opened second AC disconnect switch and solar system remained energized. Electrician had paralleled wired to solar system from two different main panels.

Relay equipment is present but not wired to trip anything. Or relaying was wired for lockout and no other functionality.

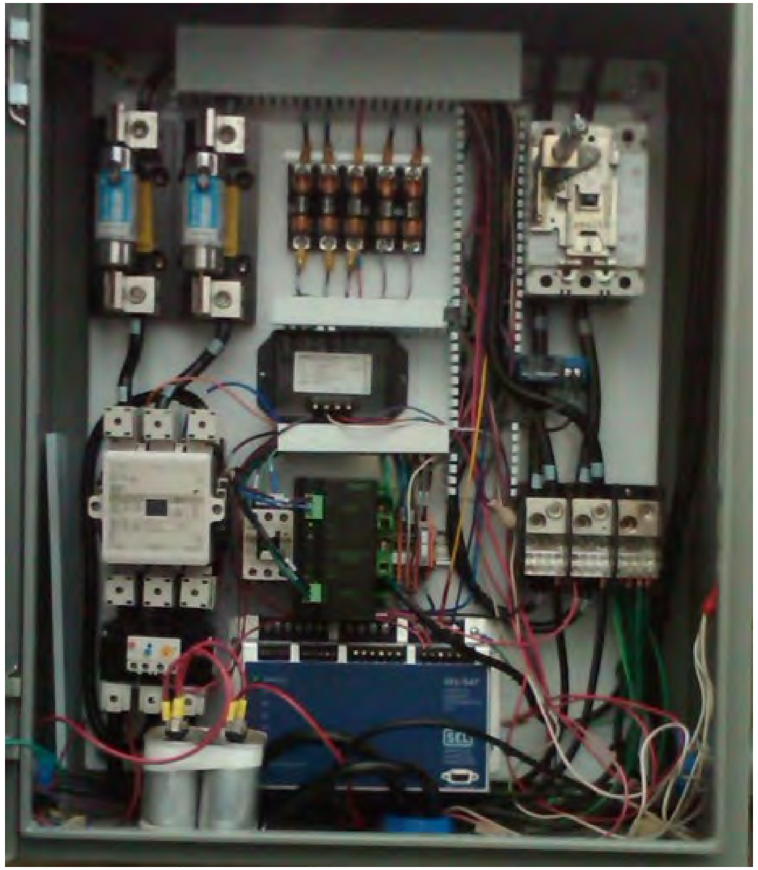
AC disconnect switch listed on one-line diagram was replaced with a rocker style breaker. Electrician claimed it was allowed in South Dakota and varied from vendor's plans.

What has been found....

Loss of phase protection was required on a three-phase wind system. Vendor had electrician install the SEL for the commission, and then moved it to a different unit that was scheduled for commission later in the week.



BAD



GOOD

Test and Verification

Brian Lydic

Regulatory Engineer

IREC

What goes in TIIR?

- Typical commissioning tests for common systems
- Explanation of test types (isolation, phase loss, enter service, etc.)
- Appendix of test details in absence of 1547.1
- Amend appendix as needed after 1547.1 completion

What goes in TSM?

- Logistics?
- Actual tests should not vary by utility and thus can be contained in TIIR

DRAFT -16-521 Phase 2 – TSG 7

Xcel Energy Prep Slides

9/14/18

Test and Verification General Comments

- Application of the Test and Verification requirements in IEEE 1547-2018 is dependent on completion of IEEE P1547.1 to define procedures and revised UL 1741 to implement type testing.

- IEEE 1547-2018 and IEEE P1547.1 apply to all DER, including units and composite systems

- The draft TIIR recognizes dependencies on ongoing standards development efforts and suggests that the section should be revised upon publication of the relevant standards.

- Potential areas for inclusion at this time:
  - Submission of applicable test and verification documentation
    - "The results of these test and verification methods shall be formally documented" (IEEE 1547-2018, Clause 11.1)
  - Fault current characterization is submittals (IEEE 1547-2018, Clause 11.4)
  - Reiterate that commissioning test procedures are submitted by the customer (IEEE 1547-2018, Clause 11.2.5.1)
  - Reiterate when reverification is required (IEEE 1547-2018, Clause 11.2.6)

Current Testing and Verification Practices

- Small inverter-based certified DER (i.e. rooftop solar)
  - Inspection that connections match the approved design
  - Inspection of UL 1741 certified equipment
  - Inspection of labeling
  - Operation of isolation device for anti-islanding test

- Large DER that is not type-tested as a system
  - Detailed DER evaluation (equipment, protection, grounding, etc.)
  - Inspection that connections and equipment match the approved design
  - Inspection of labeling
  - Verification of correct power factor if applicable
  - Anti-islanding testing
  - Open-phase testing
  - General site readiness (i.e. accessible roads, signage, etc.)
  - Signature from P.E. indicating the site is ready to operate.

What is the scope of IEEE 1547-2018 verification?

- Test and verification requirements for interconnection and interoperability functional requirments
  - Properties of the DER
  - Properties of operational interfaces that shall be maintained
  - Properties needed throughout the life of DER

- The interoperability aspects are new to IEEE P1547.1 when compared to IEEE 1547.1-2005

- Full vs Partial compliance
  - "Requirements and capabilities that are only partially verified through type testing shall be fully verified through DER evaluation and commissioning tests." - IEEE 1547-2018

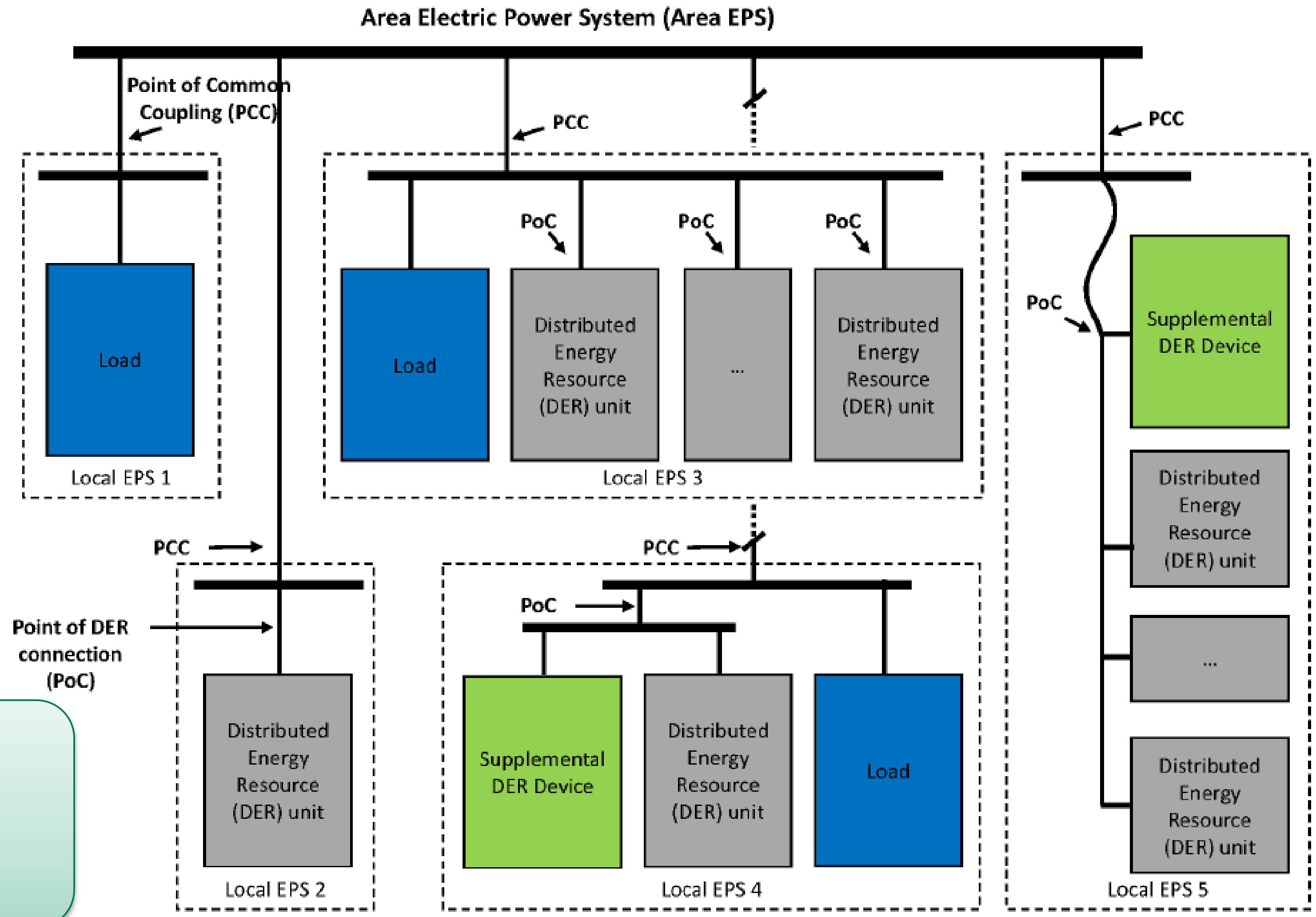
- Detailed vs Basic evaluation or testing

Where do Test and Verification Requirments Apply?

Test and Verification Applies at RPA, which may be the PCC or PoC or, under mutual agreement, a point in-between the PCC and PoC.

(IEEE 1547-2018, Clause 11.1 and Clause 4.2)

reference point of applicability (RPA): The location where the interconnection and interoperability performance requirements specified in this standard apply.



Operational View of RPA

RPA location impacted by:
- DER size
- Onsite load
- Zero-sequence continuity
- Mutual agreement

Examples of *Supplemental Devices:*
- Capacitor bank
- External relays
- Breakers or reclosers

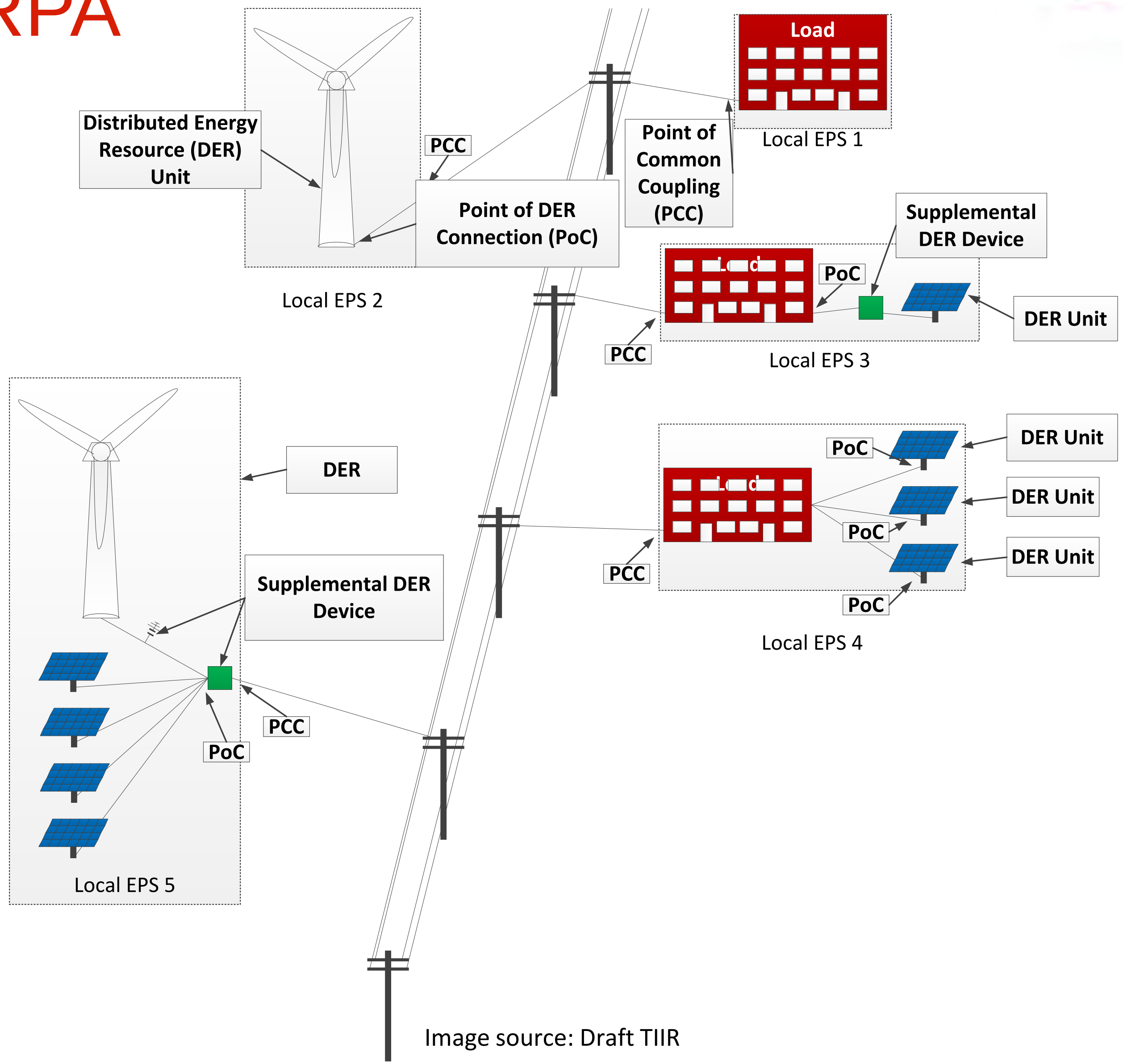


Image source: Draft TIIR

Test and Verification Requirement Framework

IEEE 1547-2018 Tests and Timing in Interconnection Process

1. **Type Tests**
2. **Production Tests**

Before Interconnection Process

3. **DER Evaluation**
   - DER design evaluation (desk study)
   - DER as-built installation evaluation (on-site)
   - Basic and detailed DER evaluation
4. **Commissioning Tests**
   - Full and Partial conformance testing and verification
     - » The need for supplemental devices differentiates full from partial
   - Requirements met at PCC or PoC

During Interconnection Process

5. **Periodic Tests**

After Interconnection Process

IEEE 1547-2018 Test and Verification Framework

Type Test → Production Test → DER Evaluation → Commissioning Test → Periodic Test

DER Evaluation:
- DER Design Evaluation (Desk study)
- DER As-Built Installation Evaluation (On-site)

Type Test: Performed at a NRTL on one device or combination of devices that is representative of product family.

Production Test: Performed on every DER unit and related equipment. May be performed at the factory.

DER Design Evaluation (Desk study): Largely applicable to *partially compliant* DER in order to verify composite of components meet requirments.

DER As-Built Installation Evaluation (On-site): Evaluation at the time of commissioning to verify the system meets requirments. This is a visual inspection rather than testing.

Commissioning Test: Onsite tests and verifications that installed system meets standard requirments. Tests are based on procedures provided by DER Customer.

Periodic Test: Based on scheduled time period or other criteria. Intended to reaffirm standards requirments are met.

IEEE 1547-2018 Test and Verification Framework

Xcel Energy

Type Test → Production Test → DER Evaluation → Commissioning Test → Periodic Test

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- DER Design Evaluation (Desk study)
- DER As-Built Installation Evaluation (On-site)

Type Test: Performed at a NRTL on one device or combination of devices that is representative of product family.

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Commissioning Test: Onsite tests and verifications that installed system meets standard requirments. Tests are based on procedures provided by DER Customer.

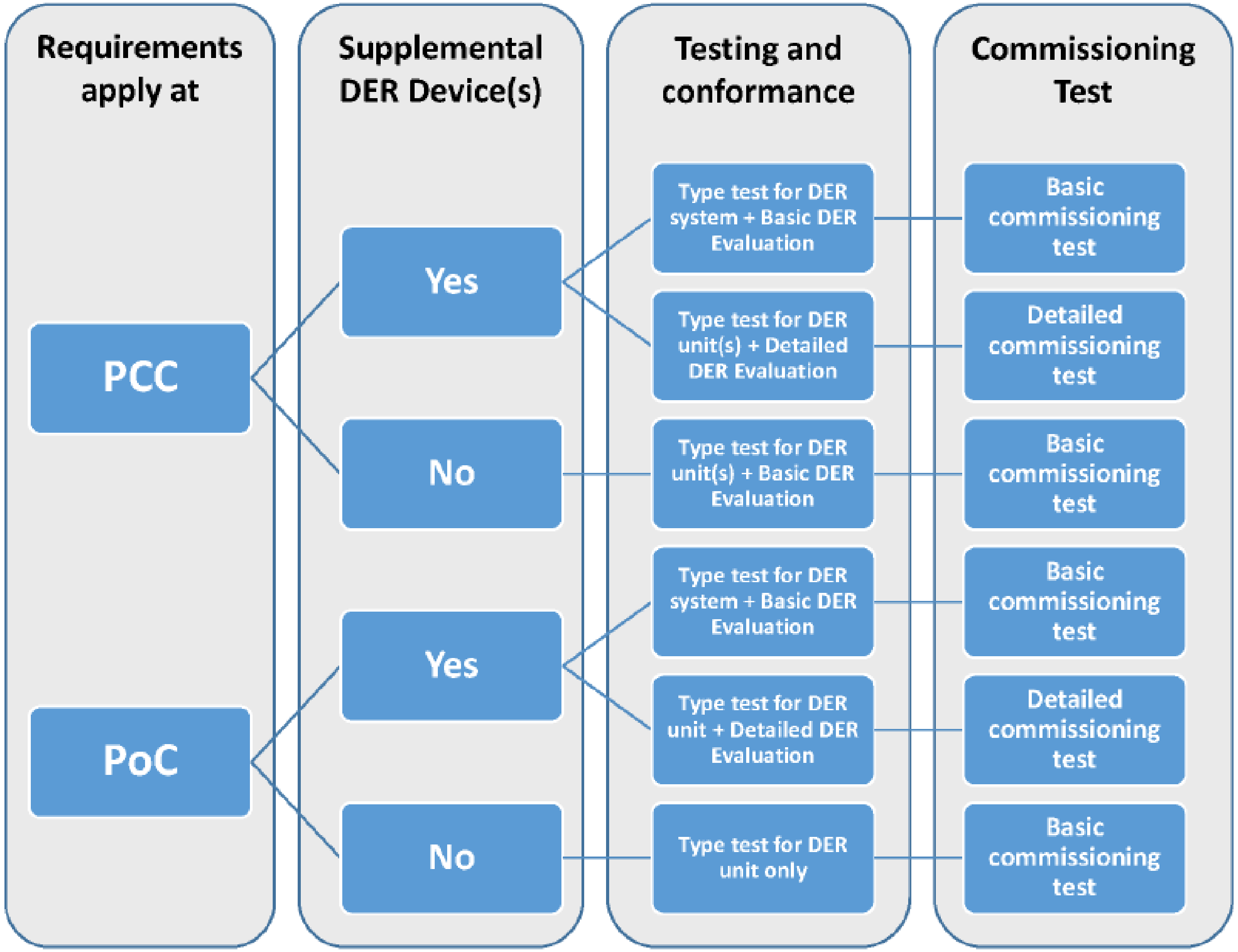
Periodic Test: Based on scheduled time period or other criteria. Intended to reaffirm standards requirments are met.

Basic or Detailed

DER Evaluation:
- Basic: Verification of installation meets design
- Detailed: Component verification; modeling and simulation

Commissioning Test:
- Basic: Inspection and isolation device
- Detailed: Basic + system functional tests

Applying the Test and Verification Framework



IEEE 1547-2018, Figure F.1 – Interconnection test specifications and requirments concept

Draft TIIR Proposal

In general, the process associated with design, approval and execution of test and verification procedures follows:

- The Area EPS Operator shall define the types of tests that are required by applying standards and best practices.
- The DER Operator shall provide written test procedure to the Area EPS Operator for review.
- The Area EPS Operator shall provide written feedback to the DER Operator as to if the test and verification meets applicable requirements.
- The DER Operator shall arrange qualified personnel to perform the test procedures
- The Area EPS Operator may arrange personnel to witness the test procedures being performed by the DER Operator. The Area EPS Operator may perform any applicable DER as-built installation evaluation during this site visit to verify that the installation meets interconnection and interoperability requirements.

Are additional defined terms needed in the TIIR?

- Additional definitions from IEEE 1547-2018 and IEEE P1547.1 may be needed, but much of this is unclear until the testing and verification framework is completed.
- The TIIR attempts not to duplicate requirements from IEEE 1547.
  - If no additional action is required in the TIIR, the terms may not be used in some cases.
- Propose determining content needed in TIIR for testing and verification, then including relevant defined terms.
  - This is dependent on completion of IEEE P1547.1

Full versus Partial Compliance

- DER is classified as partially or fully compliant depending
  - *DER Unit or System* is **fully complaint** if no supplemental devices needed to meet requirments.
  - *Composite* contains **partially compliant** DER or supplemental devices
- Both fully and partially compliant DER are type tested.
  - Partially compliant requires more DER evaluation and commissioning tests per IEEE 1547-2018, Table 43 and Table 44.
- Two traceability matrices based on location of the RPA
  - PCC
  - PoC
- "Test requirement matrices provide minimum testing requirements for traceability, but the Area EPS operator shall not be limited from requiring supplemental commissioning testing and verification." (IEEE 1547-2018, Clause 11.3.1)

Fault Current Characterization

- New IEEE 1547 requirements for documentation of DER fault response

(IEEE 1547-2018 Clause 11.4)

  - Oscillography voltage and current data for electronically coupled DER (i.e. inverters) sized at 500 kVA or larger

  - Common impedance parameters and kVA rating for synchronous and induction machines

When is reverification required?

The DER Operator shall notify the Area EPS if any of the following events occur:

- Functional software or firmware changes have been made on the DER.
- Any hardware component of the DER has been modified in the field or has been replaced or repaired with parts that are not substitutive components compliant with this standard.
- Protection settings have been changed after factory testing.
- Protection functions have been adjusted after the initial commissioning process.

Language is from IEEE 1547-2018, Clause 11.2.6, and repeated in Draft TIIR redlines submitted 9/5/18

Discussion: Proposed edits to Draft TIIR Section 12

- What is in TIIR vs. TSM?

> *The Area EPS Operator shall define the ~~types of~~ tests in Annex C that are required by applying standards and best practices.* (IREC edit)

- IREC edit seems accurate?

> *All inverter-based DER shall be UL 1741 certified in order to be considered fully compliant. Partially compliant DER will require further evaluation and possible testing.* (IREC edit)

- Agreement to eliminate?

> *~~If supplemental DER devices are included to meet IEEE 1547 requirements, the RPA is automatically at the PCC~~.* (IREC and Xcel edits)

- What is this stating?

> *The location of RPA is also a determination in partial or full compliance.* (IREC proposes deletion)

Discussion: Proposed Edits to Draft TIIR Sec. 12 cont'd and MN DIP Considerations

- Include in documentation?
  - *Fault current characterization information required in IEEE 1547-2018, subclause 11.4, shall be provided to the Area EPS Operator upon request or per the Area EPS Operator's TSM.* (Xcel edit)
- What should be included on periodic testing and reverification?
  - See new section E proposed by Xcel (also slide 37)

  ==

- Are changes needed to the protocol for witnessing testing from MN DIP?
  - Simplified Process (MN DIP 2.3 – *under DGWG subgroup revision* and MN DIP Att. 2, Ex. C 2.3) [Fresh Energy and MREA]
- Another MN DIP Att. 2: Simplified Application consideration?
  - If the Distributed Energy Resource(s) either: 1) does not use default IEEE 1547-2018 functions and settings; or 2) is not yet subject to a developed national standard or national certification, then at the option of the Area EPS Operator there needs to be in place an operating agreement to document and govern the operation of the Distributed Energy Resource(s). (MN DIP, Att. 2, Ex. C 2.6)

Discussion regarding edits to MN DER Draft TIIR Section 12

- Did today's conversation bring up any additional contributions for Section 12?
  - Is clarifying language needed regarding terminology?
  - Can "witness tests" be eliminated and replaced with "inspection" for DER that qualify for the Simplified Process? (Fresh Energy Proposal for MN DIP Sec. 2: Simplified Process)

Do we need to be more specific than the 2018 MN DIP Att. 4 & 5 regarding testing prior to 1547.1 updates?

- Attachment 4 of the MN DIP is an interim document while the Commission updates the MN DER TIIR… . For the transition period between Minnesota's existing statewide interconnection standards and the updated standards, both inverters certified to existing 1547.1 and 1547.1a-2015 (most current version); as well as, certified inverters per the expected revised 1547.1 standard should be acceptable. (MN DIP Attachment 4, Footnote 13.)

- Per draft MN DIP Att. 5, Item 1.0; DER equipment .. In an interconnection system (ALTERNATIVE: DER) shall be considered certified for interconnected operation if

  - Tested in accordance with … relevant codes and standards listed in MN DIP Att. 4
  - Labeled and publicly listed by such NRTL … and
  - Such NRTL makes readily available for verification (ALTERNATIVE: review) all test standards and procedures …..and, with consumer approval, the test data itself.

- National standards pertaining to test and verification are currently being revised

  - IEEE 1547.1 and UL 1741 are referenced in the MN DIP Att. 4 & 5
  - UL 1741 Supplement A (SA) is also being referenced in some other states

Which IEEE Std 1547-2018 type tests can be certified via UL 1741 (SA)?

Standards for DER		Listing/ Certification			Interconnection Standards			State/ PUC/Utility Rules	
								CA	HI/HECO
Function Set	Advanced Functions Capability	UL 1741	UL 1741(SA) 2016	IEEE 1547.1 -201?*	IEEE 1547-2003	IEEE 1547a-2014	IEEE 1547-2018	Rule 21 (Phases)	Rule 14H & UL SRDv1.1
All	Adjustability in Ranges of Allowable Settings			Δ		√	‡		
Monitoring & Control	Ramp Rate Control		Δ					‡ (P1)	‡
Monitoring & Control	Communication Interface			Δ			‡	‡ (P2)	‡
Monitoring & Control	Disable Permit Service (Remote Shut-Off, Remote Disconnect/Reconnect)			Δ			‡	‡ (P3)	‡
Monitoring & Control	Limit Active Power			Δ			‡	‡ (P3)	
Monitoring & Control	Monitor Key DER Data			Δ			‡	‡ (P3)	
Scheduling	Set Active Power							[‡ (P3)]	
Scheduling	Scheduling Power Values and Models							‡ (P3)	
Reactive Power & Voltage Support	Constant Power Factor	√	Δ	Δ	√	√	‡	‡ (P1)	X
Reactive Power & Voltage Support	Voltage-Reactive Power (Volt-Var)		Δ	Δ	X	√	‡	‡ (P1)	‡
Reactive Power & Voltage Support	Autonomously Adjustable Voltage Reference			Δ			‡	!!!	!!!
Reactive Power & Voltage Support	Active Power-Reactive Power (Watt-Var)			Δ	X		‡		‡
Reactive Power & Voltage Support	Constant Reactive Power	√		Δ	√	√	‡		
Reactive Power & Voltage Support	Voltage-Active Power (Volt-Watt)		Δ	Δ	X	√	‡	‡ (P3)	‡
Reactive Power & Voltage Support	Dynamic Voltage Support during VRT						√	[‡ (P3)]	
Bulk System Reliability & Frequency Support	Frequency Ride-Through (FRT)		Δ	Δ			‡	‡ (P1)	‡
Bulk System Reliability & Frequency Support	Rate-of-Change-of-Frequency Ride-Through			Δ			‡	!!!	!!!
Bulk System Reliability & Frequency Support	Voltage Ride-Through (VRT)		Δ	Δ			‡	‡ (P1)	‡
Bulk System Reliability & Frequency Support	VRT of Consecutive Voltage Disturbances			Δ			‡	!!!	!!!
Bulk System Reliability & Frequency Support	Voltage Phase Angle Jump Ride-Through			Δ			‡	!!!	!!!
Bulk System Reliability & Frequency Support	Frequency-Watt		Δ	Δ	X	√	‡	‡ (P3)	‡
Other Advanced DER Functions	Anti-Islanding Detection and Trip			Δ			‡	‡ (P1)	‡
Other Advanced DER Functions	Transient Overvoltage						‡		‡
Other Advanced DER Functions	Remote Configurability						‡	‡ (P2)	‡
Other Advanced DER Functions	Return to Service (Enter Service)						‡	‡ (P1)	‡

Legend: X Prohibited, √ Allowed by Mutual Agreement, ‡ Capability Required, Δ Test and Verification Defined
[...] Subject to clarification of the technical requirements and use cases, !!! Important Gap

Source: EPRI | *Please contact us for any suggested updates to this table.*

Draft 9/21 In-Person TSG Agenda

Time	Topic	Relevant Draft TIIR Sections
9:30 – 9:40	• Welcome, Introductions, Overview of Agenda, Expectations, Recap	
9:45 – 10:25	• Phase II Timing • TSG individual priorities	
10:25 – 10:55	• Highlight and confirm Draft TIIR edits accepted by TSG	All. Identify what remains in 4, 7, 9, 12, Ann. A & B

10:55 – 11:45	• Capacity of DER – A path forward
	  • Identify outstanding Energy Storage and Non-export issues
	  • Other considerations?
		10, 11 – likely won't resolve these sections.

11:45 – 12:30	• Enabling IEEE 1547 capabilities
	  • Voltage Regulation
	  • Reference Agreements and consumer protections
		5, 6

12:30 – 1:15	Lunch	

1:15 – 2:15	• Scope of the TIIR and Utility TSMs
	  • Metering functional requirements vs. metering specifics
	  • [Add Sub Topics]
		1,8

2:15 – 2:30	Evaluation and Next Steps	Note: 2, 3, 13 are scheduled for 10/19 TSG; & frequency ridethrough from 6.C

Next Steps

Sept 19	Initial Comments re: Review and revise or replace Att. 6: Rates?
Sept 21	In Person TSG; TIIR edits
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

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Thank You!

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Back Up Slides

Appendix

Table 43—Interconnection test specifications and requirements for DER that shall meet requirements at the PCC

LEGEND	
DER system	DER system is fully compliant at PCC*—no supplemental DER device needed *Individual DER units that are considered fully compliant at the PoC may only be considered fully compliant at the PCC if the impedance between the PoC and the PCC is less than 0.5% on the DER rated apparent power and voltage base.
Composite	Composite of partially compliant DER that is, as a whole, fully compliant at PCC*—may need one or more supplemental DER device(s). *Individual DER units that are considered fully compliant at the PoC shall not be considered fully compliant at the PCC if the impedance between the PoC and the PCC is equal to or greater than 0.5% on the DER rated apparent power and voltage base.
NR	Not Required
R	Required
L	Limited type testing is limited to partial compliance of the individual DER unit or DER system in order to evaluate the DER unit or DER system performance characteristics for later use in the DER evaluation that verifies full compliance of the composite DER at the PCC. The DER unit or DER system may not have any compliance at all with certain requirements, leaning on the supplemental equipment to comply.
D	Dependent on DER Design Evaluation
NA	Not Applicable

Table 44—Interconnection test specifications and requirements for DER that shall meet requirements at the PoC

LEGEND	
DER Unit	Individual DER unit is fully compliant at the PoC—no supplemental DER device needed
Composite	Composite of partially-compliant individual DER units that is, as a whole, fully compliant at PoC may need one or more supplemental DER device(s)
NR	Not Required
R	Required
L	Limited type testing is limited to partial compliance of the individual DER unit in order to evaluate the DER unit performance characteristics for later use in the DER evaluation that verifies full compliance of the composite DER at the PoC. The DER unit may not have any compliance at all with certain requirements, leaning on the supplemental equipment to comply.
D	Dependent on DER Design Evaluation
NA	Not Applicable

Requirement	Compliance at PCC achieved by:	Type tests	DER evaluation	Commissioning tests
4 General interconnection technical specifications and performance requirements				
4.2 Reference points of applicability	DER System	NR	R	NR
	Composite	NR	R	NR
4.3 Applicable voltages	DER System	NR	R	NR
	Composite	NR	R	NR
4.4 Measurement accuracy	DER System	R	R	NR
	Composite	L	R	NR
4.5 Cease to energize performance requirement	DER System	R	R	D
	Composite	L	R	D

Table F.1—High-level test and verification requirements when type tests are performed for DER unit(s) and not for DER system(s)

<table>
<tr><th colspan="2" rowspan="2">IEEE Std 1547
requirement XYZ</th><th colspan="2">Applicability of requirements</th></tr>
<tr><th>Point of DER connection (PoC)</th><th>Point of common coupling (PCC)</th></tr>
<tr><td rowspan="2">DER capability and conformance</td><td><u>F</u>ull
No Supplemental DER device needed</td><td>Type test
+
Basic commissioning test</td><td>Type test
+
Basic DER evaluation</td></tr>
<tr><td><u>P</u>artial
One or more Supplemental DER device(s) needed</td><td>Type test(s)
+
Detailed DER evaluation
+
Detailed commissioning test</td><td>Type test(s)
+
Detailed DER evaluation
+
Detailed commissioning test</td></tr>
</table>

Glossary/Phrases germane to this presentation from NIST and IEEE

- **Conformance Testing**: There are many types of testing including testing for performance, robustness, behavior, functions and interoperability. Conformance testing may include some of these kinds of tests but it has one fundamental difference. Conformance *testing* is testing to see if an implementation meets the requirements of a standard or specification. The requirements or criteria for conformance must be specified in the standard or specification, usually in a conformance clause or conformance statement. Some standards have subsequent standards for the test methodology and assertions to be tested. If the criteria or requirements for conformance are not specified there can be no conformance testing. [https://www.nist.gov/itl/ssd/information-systems-group/overview-conformance-testing]
  - Conformity assessment is regarded as the industry-accepted method of demonstrating a product adheres and conforms to a standard. Conformity assessment includes testing, inspection, certificate issuance and registration. https://standards.ieee.org/faqs/icap.html

Discussion: Scope for Statewide Technical Requirements

These topics have been proposed as **in scope**.
Bold have been flagged for discussion.

1. Scope/Overview
2. References
3. Definitions
4. **Performance Category Assignments**
5. **Reactive Power Capability and Voltage/Power Control (volt-var & volt-watt) Performance**
6. **Response to Abnormal Conditions (Ride-through)**
7. **Protection Requirements**
8. **Metering**
9. **Interoperability (Monitoring, Control, Info Exchange, Cyber security)**
10. **Energy Storage**
11. Non-Export; Inadvertent Export
12. **Test and Verification Requirements**
13. **Agreements**
14. **Consumer Protection** (IREC)
15. **Reporting** (IREC)

(Source: "Regulated Utilities" TIIR Draft Proposal)

Discussion: Scope for Statewide Technical Requirements

1. Process requirements
2. Cost allocation
3. Interconnection to transmission system
4. **Protection system details of Area EPS or DER**
5. **Requirements or specification of system impact or facilities studies**
6. **Application of real and reactive power control functions**
7. **Details of communication networks; including architecture, technology and protocols, or other specifications related to interoperability**
8. **Details of metering requirements or specifications**
9. **Planning or operational considerations associated with Affected Systems, Regional Transmission Operator or Transmission Owners**
10. **Intentional Area EPS islanding**

These topics have been proposed as **out of scope** by some participants. Bold are flagged for additional discussion.

(Source: TIIR Draft Proposal, p. 9)

Phase II Technical Subgroup In-Person Meeting
September 21, 2018
(Docket No. 16-521)

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Disclaimer

The following slides are not the position of the Commission. The slides attempt to capture the discussion the Technical Subgroup has had over the past seven meetings.

Staff will formally summarize today's meeting to focus and inform the Technical Subgroup's next stage; including an opportunity for TSG members to provide informal feedback on the summary (similar to Phase I meeting summaries.)

Agenda

Time	Topic
9:30 – 9:40	• Welcome, Introductions, Overview of Agenda, Expectations, Recap
9:45 – 10:25	• Phase II Timing • TSG individual priorities
10:25 – 10:55	• Highlight and confirm Draft TIIR edits accepted by TSG

10:55 – 11:45	• Capacity of DER – A path forward
	  • Identify outstanding Energy Storage and Non-export issues
	  • Other considerations?

11:45 – 12:30	• Enabling IEEE 1547 capabilities
	  • Voltage Regulation
	  • Reference Agreements and consumer protections

12:30 – 1:15	Lunch

1:15 – 2:15	• Scope of the TIIR and Utility TSMs
	  • Metering functional requirements vs. metering specifics
	  • [Add Sub Topics]

2:15 – 2:30	Evaluation and Next Steps

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
June 8	Reactive Power and Voltage/Power Control Performance; Protection Requirements
July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 3	*July 20 topics continued*
Aug 24	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 14	Test and Verification; Protocol for witnessing Testing
Sept 21	**In-Person TSG: Power Quality; Follow up items; TIIR edits discussion**
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

Phase II Timing

- Commission’s January 24, 2017 Order:

  It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission’s 2004 Interconnection Standards. (i.e. January 2019)

- MN DIP goes into effect June 17, 2019.

- TSG members agree Commission action on Draft TIIR should wait until IEEE 1547.1 and MISO ridethrough details are more developed (*Later in 2019?)* Further, TSG agrees “UL 1741” in MN DIP Att. 4 includes UL 1741SA certified inverters (*leaves option for earlier than 2021 certification of some advanced inverter functions?)*

- The TSG meetings only exist as the Draft TIIR edits, meeting slides, and participant submitted materials. The slides and participant submitted materials will be entered into the record. What else should be done to advance the Draft TIIR for Commission consideration (i.e. record and comments)? Over what timeframe?

Interconnection Standards Adoption Roadmap Considerations

2016
- UL 1741 (SA) published
- Based on requirements specified in CA Rule 21 and Hawai'ian Rule 14H

2017
- UL 1741 (SA) certified equipment available

2018
- IEEE Std 1547-2018 published
- Requirements go beyond CA Rule 21 and HI Rule 14H

2019+
- IEEE Std 1547.1-2019 published
- UL 1741 updated

2021+
- IEEE Std 1547-2018.1 tested and UL 1741 certified equipment available

Adoption of CA Rule 21 and Hawai'ian Rule 14H by inverter certification per UL 1741 (SA).

Stopgap solution for **adoption of parts of IEEE Std 1547-2018** by inverter certification per UL 1741 (SA).

Full adoption of IEEE Std 1547-2018.

Question from **distribution** perspective:

Early need to increase hosting capacity?

Question from **transmission** perspective:

Early need to address bulk system reliability?

Not the position of the Commission. Slides attempt to summarize TSG discussion to-date.

TSG Members' Individual Priorities

- What is your organization's priority and/or concerns with the Phase II update?
- If Commission adoption of statewide technical requirements slows down to match the anticipated IEEE 1547 implementation schedule, are there concerns about out-dated or unclear technical requirements with the new MN DIP going into effect in June 2019?
- Should TSG take time between 4Q 2018 and 2Q 2019 to informally work together (outside of MN PUC meetings) on Draft TIIR edits and track IEEE 1547.1 revision and MISO project? If so, is 4Q 2019 for Commission action a reasonable target?

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Highlight and Confirm DRAFT TIIR Further Work for TSG

Some Goals for Further Work

- Standardize in the TIIR what we can; especially for Simplified Projects (20 kW and under certified, inverter-based DER).
- Clearly defined, transparent additional details in the utility TSMs that are available online.

Topics for further TSG Discussion

Draft TIIR language	Concept to Incorporate	Section
Normal Performance Category Assignment	- Add footnote to chart re: inverter-based DER which may not qualify as Category B (e.g. fuel cells) - *Assignment of alternative performance categories* (IREC edit in Sec. 5.E)	4.B(1)

"48 hours…or protocol defined in TSM" for DER to update settings	Differentiate where possible:
	    - Urgent and non-urgent changes (e.g. Normal/non-urgent – 30 days)
	    - DER system size (or aggregated capacity/penetration?) and system voltage (e.g. 35kV – 3-5 MW; 4-12 kV – 500kW – 1 MW)
	- Recognize under abnormal conditions, if unable to respond disconnection
	- Consider the current voltage rule (Follow up needed)
		5

Voltage Ridethrough in Abnormal Conditions	Propose harmonizing the TIIR edits with IEEE 1547	5
Frequency trip settings	Statewide without TSM flexibility.	
Frequency droop settings	Statewide default settings for abnormal conditions without TSM flexibility?	
Protection Requirements in TSM	- *Mention, but don't detail customer protection re: more cost-effective alternatives or cost considerations*	7

Topics for further TSG Discussion

Draft TIIR Topic	Concept to Incorporate	Section
Metering	- Describe functional metering requirements (operational, planning, tariff compliance, REC accounting) - *Requirements for 20 kW and below DER*?	8
Intentional islanding	- Avoid microgrid terminology; focus on functionality – DER able to separate/island. - Clarify if focus is DER island or Area EPS island - Clarify how the RPA applies to DER capable of intentional islanding	
Local Communication Interface	- Clarify what is meant by provisions since not requiring all equipment. - Allow additional communication interface to exist and focus on what needs to be said about how it is used or maintained (response to EPRI suggested edits) - Cost considerations and transparency about when communication interface utilization is likely?	9
Cyber Security	- Include physical security in title?	9

Topics for further TSG Discussion

Draft TIIR Topic	Concept to Incorporate	Section
ESS Operational Control Modes	-More consideration of configuration setting (operational control modes?) and how customer may operate the ESS (application or use?) - Examples of how the two differ or do not re: grid impacts and utility/state treatment in interconnection process - Operating agreement which locks in operational control mode and application/use vs. worst case within an operational control mode has trade-offs for how DER is reviewed and what can be connected to grid without upgrades. - Note: Configuration settings do not appear to include rate of charge - What is process/expectations for customer over time if they wish to change how they use their storage? - If technical requirements address net energy metering integrity, are non-importing ESS exempt from those requirements? - What should be formalized vs. a road map without codification?	10

Topics for further TSG Discussion

Draft TIIR Topic	Concept to Incorporate	Section
Non-Exporting	- Focus this section on non-exporting systems. Leave limited export concept for future consideration (see handouts) - TSG is comfortable with limits described in 1-2 ; likely 4 with "verifiable minimum host load" and seasonal load consideration. Utilities do not support 3. Screens 5-6 question about capacity vs. export (See B. in IREC Sec 11 Edits..) - Is there a different bar for non-exporting that is for tariff compliance vs. grid impacts?	11

Testing	- Describe and standardize the type of tests (e.g. Commissioning tests) required for Simplified Projects (20 kW and under)
	  - How DER unit is being operated may change types of tests – for tariff compliance not 1547. (e.g. non-import for NEM)
	  - Discuss if multiple primary movers in small projects impacts the type of tests
	- MN DIP Att. 5 needs further consideration
		12

Not the position of the Commission. Slides attempt to summarize TSG discussion to-date.

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Capacity of DER – A Path Forward

Capacity of DER – Background

IEEE 1547 says:

- *This standard does not define the maximum DER capacity for a particular installation that may be interconnected to a single point of common coupling (PCC) or connected to a given feeder.* (Cl. 1.4, p. 16)
- ***nameplate ratings**: Nominal voltage (V), current (A), maximum active power (kW), apparent power (kVA), and reactive power (kvar) at which a DER is capable of sustained operation.*

  NOTE—For Local EPS with multiple DER units, the aggregate DER nameplate rating is equal to the sum of all DERs nameplate rating in the Local EPS, not including aggregate capacity limiting mechanisms such as coincidence factors, plant controller limits, etc., that may be applicable for specific cases. (Cl. 3.1 , p. 24)

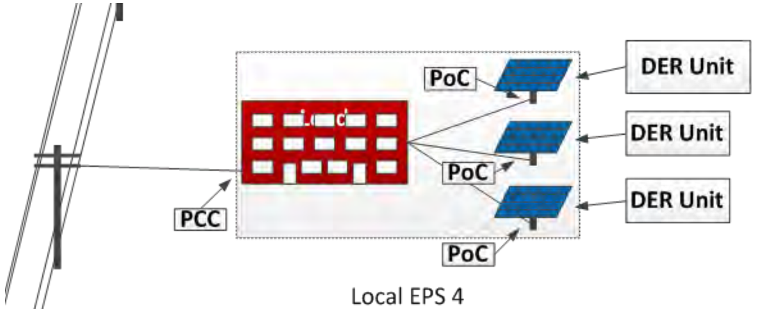
MN DIP:

- *All references to DER Nameplate Rating or maximum capacity as described in 5.14.3 herein are in alternating current (AC).* (MN DIP 1.1.2)
- Both interconnection applications ask for DER Nameplate rating, but simplified application (Att. 2) asks for DER capacity (as described in 5.14.3) and the interconnection application (Att. 3) asks for Maximum Export Capability.

Are installers and interconnection customers reporting nameplate rating in kWac today?

What needs to happen to ensure they do under MN DIP?

Nameplate Rating



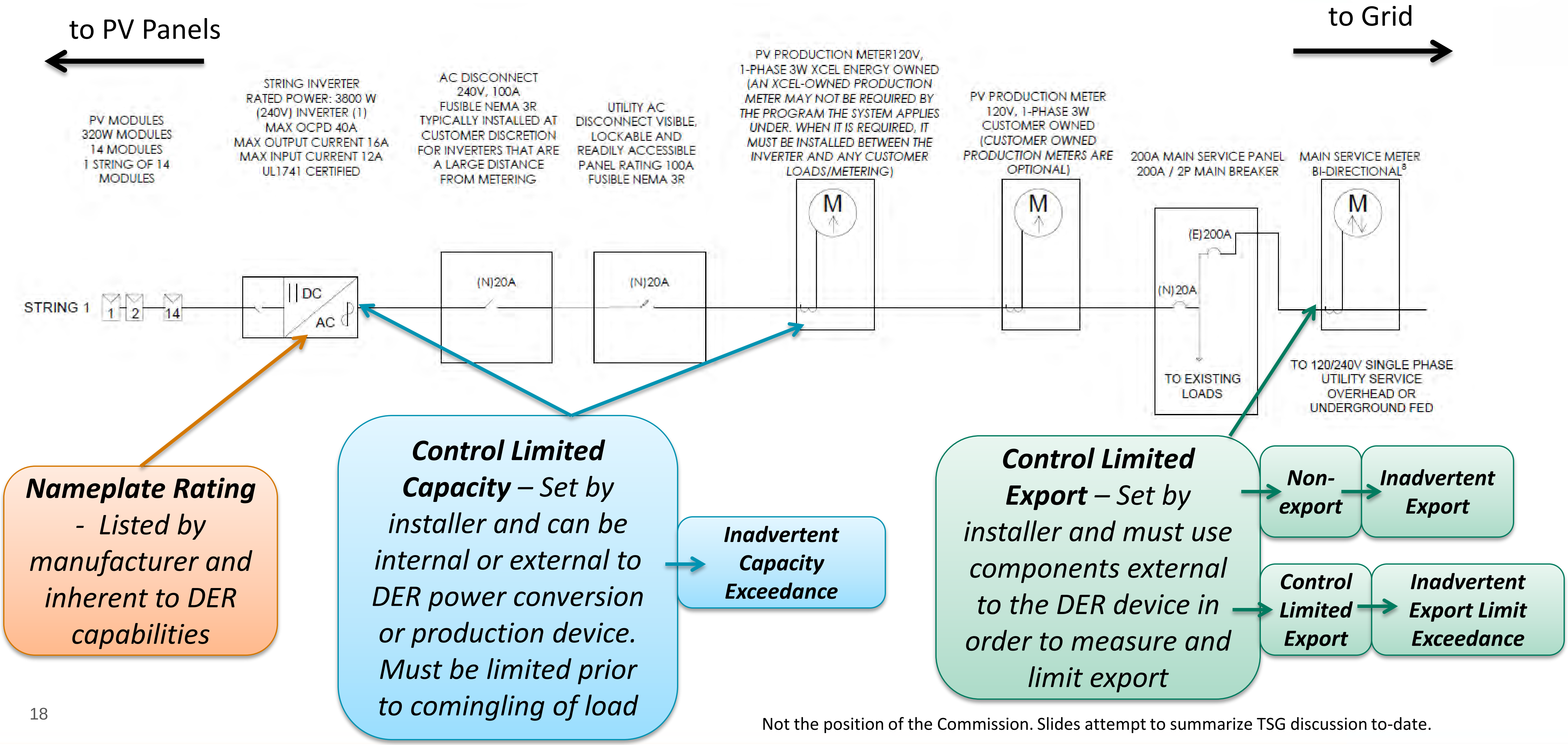
EXAMPLE:

If the solar arrays are 20 kWdc each and the inverters (at PoC) are 15 kWac each, what is the aggregate nameplate rating of this DER?

If the solar arrays are 20 kWdc each and the inverters (at PoC) are 25 kWac each, what is the aggregate nameplate rating of this DER?

2004 Minnesota Technical Standards (Att. 2)	IEEE 1547 and 2018-2019 MN DIP (underline is in MN DIP not 1547)
Nameplate Capacity is the total nameplate capacity rating of all the Generation included in the Generation System. For this definition the "standby" and/or maximum rated kW capacity on the nameplate shall be used."	**Nameplate Rating -** nominal voltage (V), current (A), maximum active power (kW<u>ac</u>), apparent power (kVA), and reactive power (kvar) at which a DER is capable of sustained operation. For a Local EPS with multiple DER units, the aggregate nameplate rating is equal to the sum of all DERs nameplate rating in the Local EPS, not including aggregate capacity limiting mechanisms such as coincidence factors, plant controller limits, etc. that may be applicable for specific cases <u>(Aggregate Nameplate Rating)</u>. <u>The nameplate ratings referenced in the MN DIP are alternating current nameplate DER ratings. See Section 5.14 on Capacity of the Distributed Energy Resource and Minnesota Technical Requirements.</u>
Generation is defined as any device producing electrical energy, i.e., rotating generators driving by wind, steam, turbines, internal combustion engines, hydraulic turbines, solar, fuel cells, etc.; or any other electric producing device, including energy storage technologies.	**Distributed Energy Resource (DER) Unit**: An individual DER device inside a group of DER that collectively form a system.
Generation System is the interconnected generator(s), controls, relays, switches, breakers, transformers, inverters and associated wiring and cables, up to the Point of Common Coupling.	**distributed energy resource (DER)**: A source of electric power that is not directly connected to a bulk power system. DER includes both generators and energy storage technologies capable of exporting active power to an EPS. An interconnection system or a supplemental DER device that is necessary for compliance with this standard is part of a DER.

Relationship and Use of Terms



Not the position of the Commission. Slides attempt to summarize TSG discussion to-date.

TSG 5 (Aug 3rd) Preparation and Discussions

- EPRI called attention to Clause 10.4 regarding configuration settings
  - "If a configuration setting value is different from the corresponding nameplate value, the configuration setting value shall be used as the rating within the DER."
  - Regarding nameplate, this can be referred to as a nameplate alternative
- Xcel had prepared slides considering a similar concept, and had named the concept "Control Limited Capacity"
  - Prior to and during the TSG, multiple sub-group members (including Xcel) noted the desire to avoid creating new definitions for a concept if a definition was already in use
  - Xcel noted that nameplate rating would continue to need to be used for process track eligibility and for some aspects of the technical review, including protection against short circuit current faults due to expected time for current limiting devices to detect and respond to said fault
  - Xcel noted that "control limited capacity" (or it's otherwise agreed to name) could be used in some aspects of the technical review, such as regarding whether mitigation would be needed for thermal purposes
- Concern regarding the implications in a situation with the RPA between PoC and PCC with regards to 1547.1 were raised for further consideration.

TIIR Option

- Add additional note to TIIR definition (which is currently a 1:1 with 1547-2018)
- **nameplate ratings[X]:** nominal voltage (V), current (A), maximum active power (kW), apparent power (kVA), and reactive power (kvar) at which a DER is capable of sustained operation.
    - NOTE—For Local EPS with multiple DER units, the aggregate DER nameplate rating is equal to the sum of all DERs nameplate rating in the Local EPS, not including aggregate capacity limiting mechanisms such as coincidence factors, plant controller limits, etc., that may be applicable for specific cases.
    - NOTE – A configuration setting captured in an interconnection agreement that is a nameplate alternative is used for steady state aspects of technical review. Aggregate nameplate is used for short circuit current analysis and MN DIP process track eligibility.

MN DIP Option

Add MN DIP Option 5.14.4?

5.14.4 The limit referenced in 5.14.1 and 5.14.3 shall be the nameplate alternative *per IEEE 1547-2018 Clause 10.4* as provided in the Interconnection Agreement.

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

TSG FOLLOW UP: Address when limit and/or RPA is b/w PoC and PCC? Review Initial Review Screens, Supplemental Review Screens, Study Process to confirm when nameplate rating and the nameplate alternative would be used. Need to update MN DIP applications for consistency with whatever outcome.

DRAFT -16-521 Phase 2 – TSG 8

Xcel Energy Prep Slides

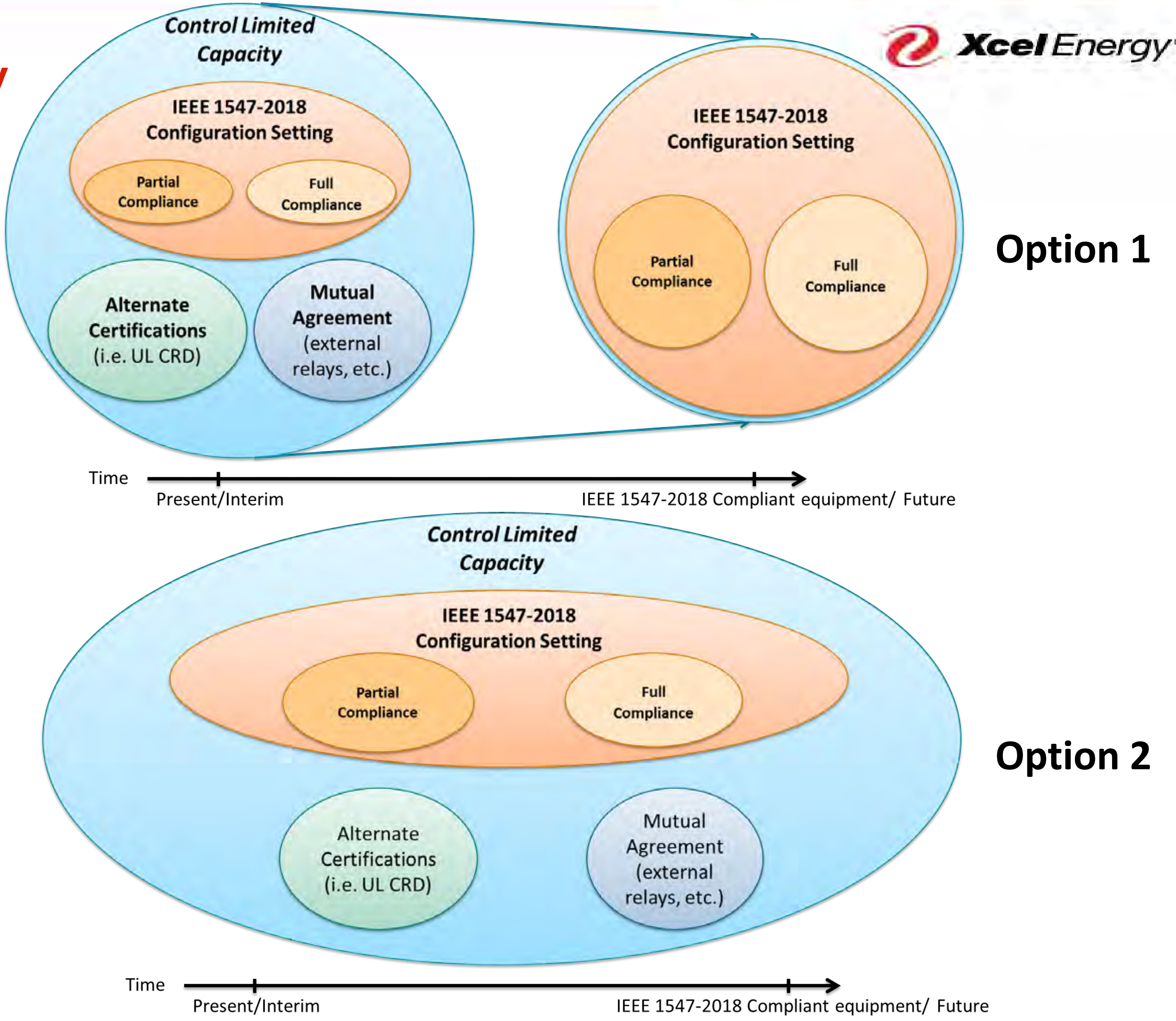
9/21/18

Control Limited Capacity

Two Possible Futures

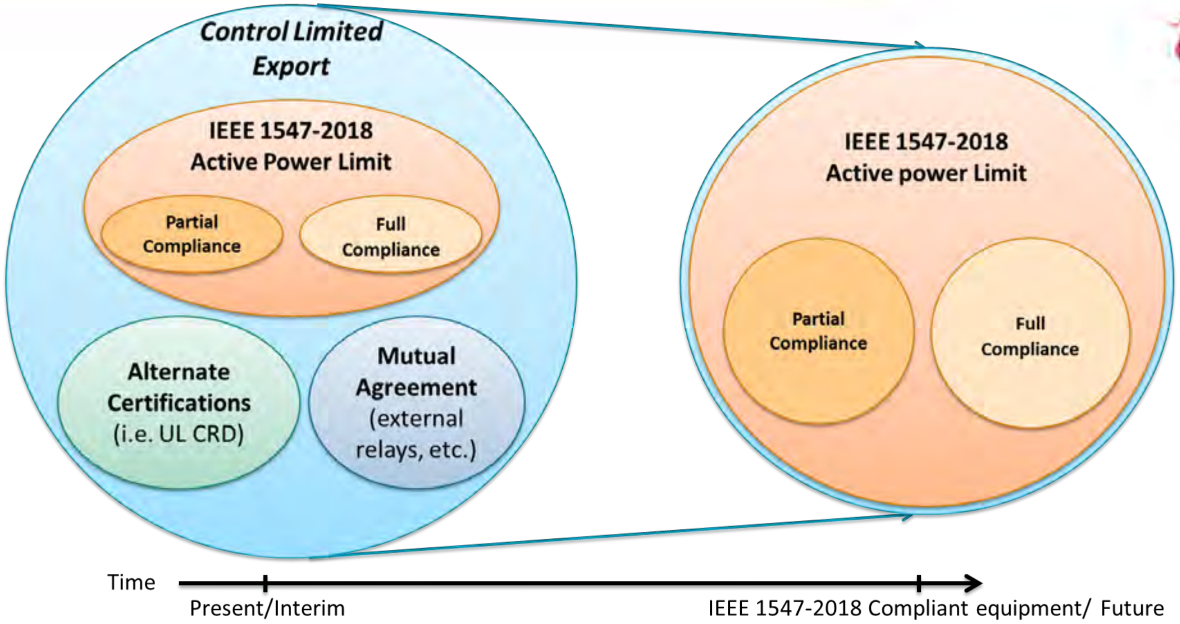
Fundamental question:
Should the TIIR set a course towards the IEEE 1547 *configuration setting* being the only means of "Maximum AC Capacity"/ "Control Limited Capacity" ?

Working hypothesis:
The *configuration setting* is expected to be a key means of implementing capacity limits, but at this time we need to allow for a future with multiple options.

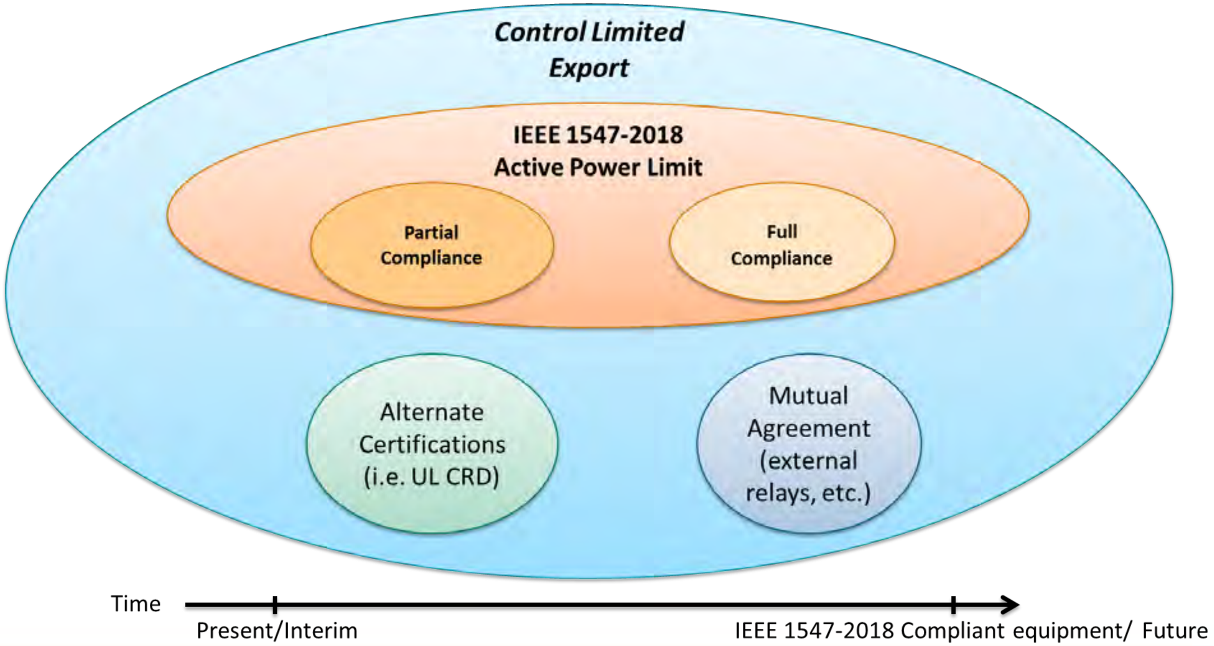


Control Limited Export

Control Limited Export could be viewed as analogous to Control Limited Capacity regarding possible paths for definition and IEEE 1547 standard application.



Option 1



Option 2

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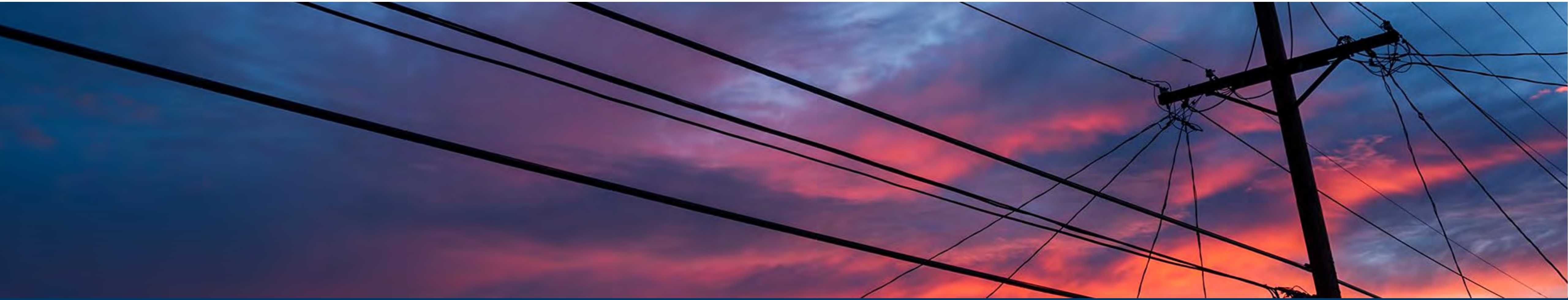

Enabling 1547 Voltage Regulation Capabilities

Enabling Voltage-Reactive Power Mode (Volt-Var)

- If default voltage regulation is to use a constant power factor of .98 in TIIR, what should be said about enabling the alternative of voltage-reactive power mode (a.k.a. volt-var) to utilize advanced inverter functions?
  - Larger systems with detailed study (not Fast Track)?
  - Utility discretion or consideration?
  - Require communication enabled?
  - Mutual agreement?
  - Future TIIR consideration based on studies, pilots, national learnings, revisit on a future date?
- If enabling the volt-var mode instead of constant power factor in some instances, IEEE 1547 Table 8 (p. 39) on Voltage-Reactive Power Settings includes a range of allowable settings. Should those be included or referenced in Draft TIIR Sec. 5?

Table - voltage-reactive power settings

Voltage-reactive power parameters	**Default settings**	
	Category A	**Category B**
V_{Ref}	V_N	V_N
V2	V_N	V_{Ref} – 0.02 V_N
Q2	0	0
V3	V_N	V_{Ref} + 0.02 V_N
Q3	0	0
V1	0.9 V_N	V_{Ref} – 0.08 V_N
Q1a	25% of nameplate apparent power rating, injection	44% of nameplate apparent power rating, injection
V4	1.1 V_N	V_{Ref} + 0.08 V_N
Q4	25% of nameplate apparent power rating, absorption	44% of nameplate apparent power rating, absorption
Open loop response time	10 s	5 s

Note: V_{ref} may change based on installation location.

Figure: Example Voltage-Reactive Power Characteristic (Volt-Var)

Enabling Voltage-Active Power Mode (Volt-Watt)

- Voltage-Active Power mode is able to remain active with any of the voltage-reactive power modes (e.g. Constant Power Factor and Voltage-Reactive Power)
- Voltage-Active Power mode default is disabled in IEEE 1547 (IEEE 1547 5.4.1.)
- TSG agrees to enable for future proofing, not anticipated use today.
- Draft TIIR Footnote 28: The default IEEE 1547 volt-watt default setting will not begin curtailing real power until the voltage is beyond 1.06 per unit voltage, which is the upper end of the range of normal voltages allowed under ANSI C84.1.

Table – voltage-active power settings

Voltage-active power parameters	Default Settings	Range of allowable settings	
		Minimum	Maximum
V_1	1.06 V_N	1.05 V_N	1.09 V_N
P_1	P_{rated}	N/A	N/A
V_2	1.1 V_N	V_1 + 0.01 V_N	1.10 V_N
P_2	The lesser of 0.2 P_{rated} or P_{min}[a]	P_{min}	P_{rated}
P'_2	0[b]	0	P'_{rated}
Open Loop Response Time	10 s[c]	0.5 s	60 s

[a] P_{min} is the minimum active power output in p.u. of the DER rating (i.e., 1.0 p.u.)
[b] P'_{rated} is the maximum amount of active power that can be absorbed by the DER. ESS operating in the negative real power half plane, through charging, shall follow this curve as long as available energy storage capacity permits this operation.
[c] Any settings for the open loop response time of less than 3 s shall be approved by the Area EPS operator with due consideration of system dynamic oscillatory behavior.

- What consumer protection language needs to be added? (ex. not used in study as mitigation, installer design issues, complaint process, ability to change settings by location, and if used in place of upgrades needs to be informed?)
- IEEE 1547 Table 10 (p. 41) on Voltage-Reactive Power Settings includes range of allowable settings. Should those be included or referenced in Draft TIIR Sec. 5?

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Scope of TIIR and TSMs

Discussion: Scope for Statewide Technical Requirements

1. Scope/Overview
2. References
3. Definitions
4. Performance Category Assignments
5. Reactive Power Capability and Enabling the Utilization of Voltage/Power Control (volt-var & volt-watt) ~~*Performance*~~
6. Response to Abnormal Conditions (Ride-through)
7. Protection Requirements
8. Metering Functional Requirements and need to consider costs
9. Interoperability (Monitoring, Control, Info Exchange, Cyber security)
10. Energy Storage
11. Non-Export; Inadvertent Export
    A. Limited capacity is included in TIIR. Limited Export for later consideration
12. Test and Verification Requirements
    A. Types of Tests for Simplified Projects
13. **Agreements**
14. **Consumer Protection** (IREC)
15. **Reporting** (IREC)
16. **Requirements related to tariff restrictions?**
17. **As much detail for 20 kW and smaller systems re: metering, testing, etc. as possible?**

Discussion: Out of Scope for the TIIR?

These topics have been proposed as **out of scope** by some participants. Bold are flagged for additional discussion.

1. Process requirements
2. Cost allocation
3. Interconnection to transmission system
4. **Protection system details of Area EPS or DER**
5. **Requirements or specification of system impact or facilities studies**
6. **Application of real and reactive power control functions beyond default settings/range of allowable settings and requirements to enable the utilization?**
7. **Details of communication networks; including architecture, technology and protocols, or other specifications related to interoperability**
8. **Details of metering requirements or specifications beyond functional requirements and need for cost consideration?**
9. **Planning or operational considerations associated with Affected Systems, Regional Transmission Operator or Transmission Owners**
10. **Intentional Area EPS islanding**

(Source: TIIR Draft Proposal, p. 9; Staff edits based on TSG discussion)

Discussion: Scope of TSMs?

- What is in scope for a utility specific TSM? How can the TIIR address the scope or outline of what is covered in a TSM? Examples from TSG discussion:
  - Protection requirements outside IEEE 1547 (e.g. line extension fusing or reclosing, relays, protection coordination)
  - If required, utility accessible, external disconnect switch requirements
  - DER specific settings within range of allowable (e.g. voltage trip and ridethrough setting flexibility)
  - Metering requirement details (including timing and format of information collected) for > 20 kW systems
  - Commissioning and testing from current practice until 1547.1 is updated for > 20 kW systems
  - 1-line diagram details?
  - Best practices for new technology not adopted into statewide or national standards yet
  - Cyber and physical security details
  - Non-parallel systems requirements
- If TSM is an annual informational filing with the Commission, what is the process if the DER customer(s) disputes the TSM requirements? Does the type of dispute matter?

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

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Thank You!

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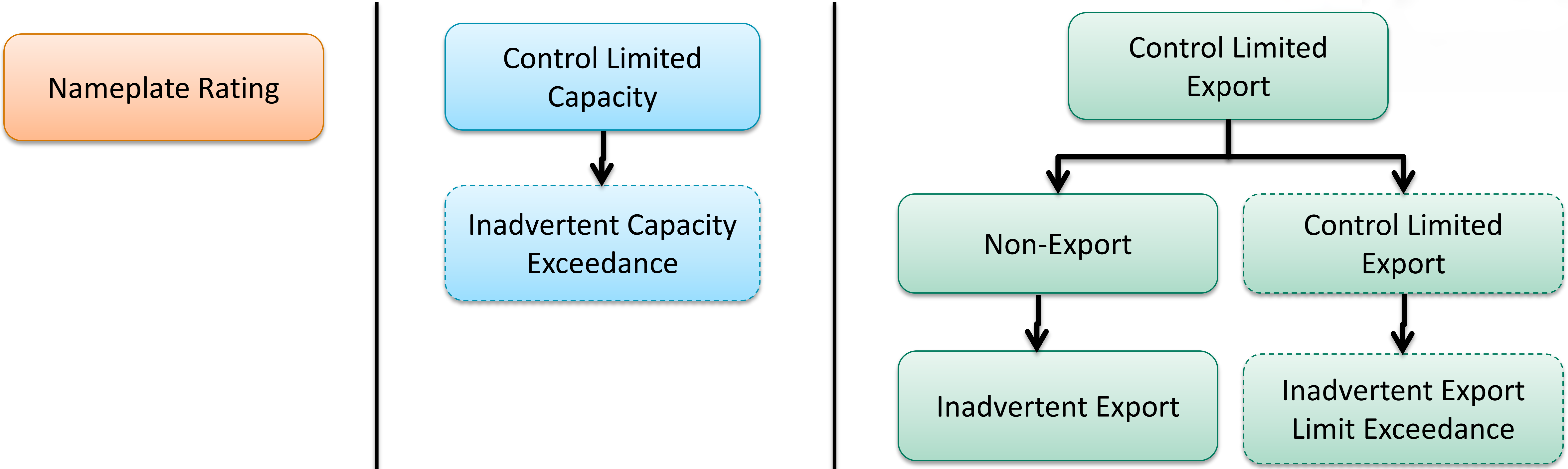
Additional Slides

Framework of Defined Terms

Terms



Purpose / Use

- Determines process track eligibility
- Captures DER maximum capability for system records
- Used in some aspects of technical review

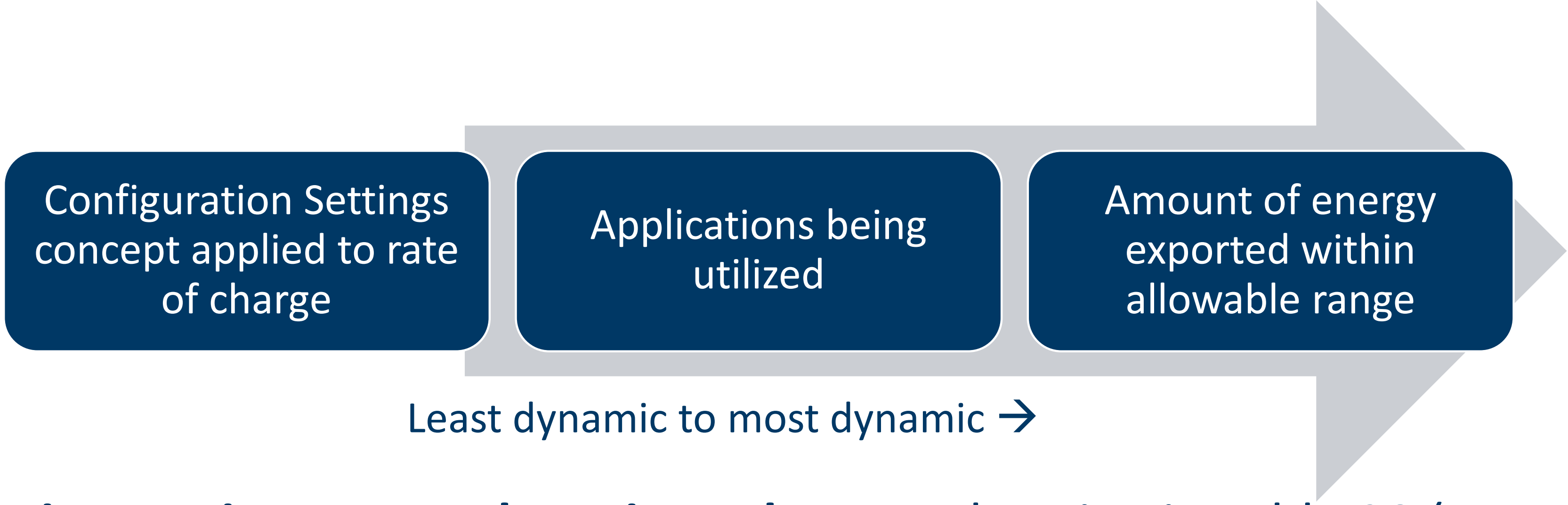
- Captures steady state operation for Interconnection Agreements
- Used in some aspects of technical review

- Non-export is currently useful for contractual considerations (i.e “NEM integrity”) in MN
- Export limited is related and likely needed in the future (i.e. Hawaii example)
- Need terms

Not the position of the Commission. Slides attempt to summarize TSG discussion to-date.

Note: dashed lines around a box indicate the term has not yet been contemplated by MN interconnection standards update process

Configuration Settings



- **Configuration setting; currently active values:** Each rating in Table 28 (Nameplate information), may have an associated configuration setting that represents the as-configured value. If a configuration setting value is different from the corresponding nameplate value, the configuration setting value shall be used as the rating within the DER. Changes to the configuration setting shall be made with mutual agreement between the DER system operator and Area EPS operator. Configuration settings are not intended for continuous dynamic adjustment. (IEEE 1547-2018, Table 28 and Clause 10.4, p. 70)

Understanding ESS Control Modes and Use Cases/Applications?

Applications in use by Customer (C) or Area EPS/Utility (U)	Reflected in Interconnection Agreement (Y or N)	Change in Control Mode or Setting required in order to switch applications (Y or N)	Notification Required between DER Operator and Area EPS when change in application or setting occurs (Y or N)	Non-Exporting Service only (X = Yes)
TOU Bill Management (C)				
Demand Charge Reduction (C)				
Increased PV Self Consumption (C)				
Backup Power (C)				
Transmission Deferral (U)				
Transmission Congestion Relief (U)				
Distribution Deferral (U)				
Resource Adequacy (U)				

Phase II Technical Subgroup In-Person Meeting
September 21, 2018
(Docket No. 16-521)

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Disclaimer

The following slides are not the position of the Commission. The slides attempt to capture the discussion the Technical Subgroup has had over the past seven meetings.

Staff will formally summarize today's meeting to focus and inform the Technical Subgroup's next stage; including an opportunity for TSG members to provide informal feedback on the summary (similar to Phase I meeting summaries.)

NOTE: Red, under-lined or strikethrough content has been added to this "Updated" version of the slides. Red without underline was used in the original slide deck to track changes staff identified from the TSG meetings leading up to the 9/21 meeting.

Agenda

Time	Topic
9:30 – 9:40	• Welcome, Introductions, Overview of Agenda, Expectations, Recap
9:45 – 10:25	• Phase II Timing • TSG individual priorities
10:25 – 10:55	• Highlight and confirm Draft TIIR edits accepted by TSG

10:55 – 11:45	• Capacity of DER – A path forward
	  • Identify outstanding Energy Storage and Non-export issues
	  • Other considerations?

11:45 – 12:30	• Enabling IEEE 1547 capabilities
	  • Voltage Regulation
	  • Reference Agreements and consumer protections

12:30 – 1:15	Lunch

1:15 – 2:15	• Scope of the TIIR and Utility TSMs
	  • Metering functional requirements vs. metering specifics
	  • [Add Sub Topics]

2:15 – 2:30	Evaluation and Next Steps

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
June 8	Reactive Power and Voltage/Power Control Performance; Protection Requirements
July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 3	*July 20 topics continued*
Aug 24	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 14	Test and Verification; Protocol for witnessing Testing
Sept 21	**In-Person TSG: Power Quality; Follow up items; TIIR edits discussion**
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

Phase II Timing

- Commission's January 24, 2017 Order:

  It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. (i.e. January 2019)

- MN DIP goes into effect June 17, 2019.

- TSG members agree Commission action on Draft TIIR should wait until IEEE 1547.1 and MISO ridethrough details are more developed (*Later in 2019?)* Further, TSG agrees "UL 1741" in MN DIP Att. 4 includes UL 1741SA certified inverters (*leaves option for earlier than 2021 certification of some advanced inverter functions?)*

- The TSG meetings only exist as the Draft TIIR edits, meeting slides, and participant submitted materials. The slides and participant submitted materials will be entered into the record. What else should be done to advance the Draft TIIR for Commission consideration (i.e. record and comments)? Over what timeframe?

Interconnection Standards Adoption Roadmap Considerations

2016

- UL 1741 (SA) published
- Based on requirements specified in CA Rule 21 and Hawai'ian Rule 14H

2017

- UL 1741 (SA) certified equipment available

2018

- IEEE Std 1547-2018 published
- Requirements go beyond CA Rule 21 and HI Rule 14H

2019+

- IEEE Std 1547.1-2019 published
- UL 1741 updated

2021+

- IEEE Std 1547-2018.1 tested and UL 1741 certified equipment available

Adoption of CA Rule 21 and Hawai'ian Rule 14H by inverter certification per UL 1741 (SA).

Stopgap solution for **adoption of parts of IEEE Std 1547-2018** by inverter certification per UL 1741 (SA).

Full adoption of IEEE Std 1547-2018.

Question from **distribution** perspective:

Early need to increase hosting capacity?

Question from **transmission** perspective:

Early need to address bulk system reliability?

Not the position of the Commission. Slides attempt to summarize TSG discussion to-date.

TSG Members' Individual Priorities

- What is your organization's priority and/or concerns with the Phase II update?
- If Commission adoption of statewide technical requirements slows down to match the anticipated IEEE 1547 implementation schedule, are there concerns about out-dated or unclear technical requirements with the new MN DIP going into effect in June 2019?
- Should TSG take time between 4Q 2018 and 2Q 2019 to informally work together (outside of MN PUC meetings) on Draft TIIR edits and track IEEE 1547.1 revision and MISO project? If so, is 4Q 2019 for Commission action a reasonable target?

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Highlight and Confirm DRAFT TIIR Further Work for TSG

Some Goals for Further Work

- Standardize in the TIIR what we can; especially for Simplified Projects (20 kW and under certified, inverter-based DER).
- Clearly defined, transparent additional details in the utility TSMs that are available online.

Topics for further TSG Discussion

Draft TIIR language	Concept to Incorporate	Section
Normal Performance Category Assignment	- Add footnote to chart re: inverter-based DER which may not qualify as Category B (e.g. fuel cells) – May not be necessary (see 9/21 mtg summary) - *Assignment of alternative performance categories* (IREC edit in Sec. 5.E)	4.B(1)
"48 hours…or protocol defined in TSM" for DER to update settings	Differentiate where possible: - Urgent and non-urgent changes (e.g. Normal/non-urgent – 30 days) - DER system size (or aggregated capacity/penetration?) and system voltage (e.g. 35kV – 3-5 MW; 4-12 kV – 500kW – 1 MW) - Recognize under abnormal conditions, if unable to respond disconnection - Consider the current voltage rule (Follow up needed) – What is current requirement for DER to update settings?	5
Voltage Ridethrough in Abnormal Conditions	Propose harmonizing the TIIR edits with IEEE 1547	5
Frequency trip settings	Statewide without TSM flexibility.	
Frequency droop settings	Statewide default settings for abnormal conditions without TSM flexibility?	
Protection Requirements in TSM	*- Mention, but don't detail customer protection re: more cost-effective alternatives or cost considerations*	7

Topics for further TSG Discussion

Draft TIIR Topic	Concept to Incorporate	Section
Metering	- Describe optimization of functional metering requirements (operational, planning, tariff compliance, REC accounting) ~~- *Requirements for 20 kW and below DER?*~~	8
Intentional Local EPS islanding	- Avoid microgrid terminology; focus on functionality – DER able to separate/island. ~~- Clarify if focus is DER island or Area EPS island~~ - Clarify how the RPA applies to DER capable of intentional islanding	
~~Local Communication Interface~~	~~- Clarify what is meant by provisions since not requiring all equipment.~~ ~~- Allow additional communication interface to exist and focus on what needs to be said about how it is used or maintained (response to EPRI suggested edits)~~ ~~- Cost considerations and transparency about when communication interface utilization is likely?~~	9
Cyber Security	- Include physical security in title?	9

Topics for further TSG Discussion

Draft TIIR Topic	Concept to Incorporate	Section
ESS Operational Control Modes	-More consideration of configuration setting (operational control modes?) and how customer may operate the ESS (application or use?) - Clarify 1547 applies only to discharge state (and transition to charge state), not to charging because DER definition doesn't include load. - Examples of how the two differ or do not re: grid impacts and utility/state treatment in interconnection process - Operating agreement which locks in operational control mode and application/use vs. worst case within an operational control mode has trade-offs for how DER is reviewed and what can be connected to grid without upgrades. - Note: Configuration settings do not appear to include rate of charge - What is process/expectations for customer over time if they wish to change how they use their storage? - If technical requirements address net energy metering integrity, are non-importing ESS exempt from those requirements? - What should be formalized vs. a road map without codification?	10

Topics for further TSG Discussion

Draft TIIR Topic	Concept to Incorporate	Section
Non-Exporting	- Focus this section on non-exporting systems. Leave limited export concept for future consideration (see handouts) - TSG is comfortable with limits described in 1-2 ; likely 4 with "verifiable minimum host load" and seasonal load consideration. Utilities do not support 3. Screens 5-6 question about capacity vs. export (See B. in IREC Sec 11 Edits..) - Is there a different bar for non-exporting that is for tariff compliance vs. grid impacts?	11

Testing	- Describe and standardize the type of tests (e.g. Commissioning tests) required for Simplified Projects (20 kW and under)
	    - How DER unit is being operated may change types of tests – for tariff compliance not 1547. (e.g. non-import for NEM)
	    - Discuss if multiple primary movers in small projects impacts the type of tests
	- MN DIP Att. 5 needs further consideration
		12

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Capacity of DER – A Path Forward

Capacity of DER – Background

IEEE 1547 says:

- *This standard does not define the maximum DER capacity for a particular installation that may be interconnected to a single point of common coupling (PCC) or connected to a given feeder.* (Cl. 1.4, p. 16)

- ***nameplate ratings****: Nominal voltage (V), current (A), maximum active power (kW), apparent power (kVA), and reactive power (kvar) at which a DER is capable of sustained operation.*

  NOTE—For Local EPS with multiple DER units, the aggregate DER nameplate rating is equal to the sum of all DERs nameplate rating in the Local EPS, not including aggregate capacity limiting mechanisms such as coincidence factors, plant controller limits, etc., that may be applicable for specific cases. (Cl. 3.1 , p. 24)

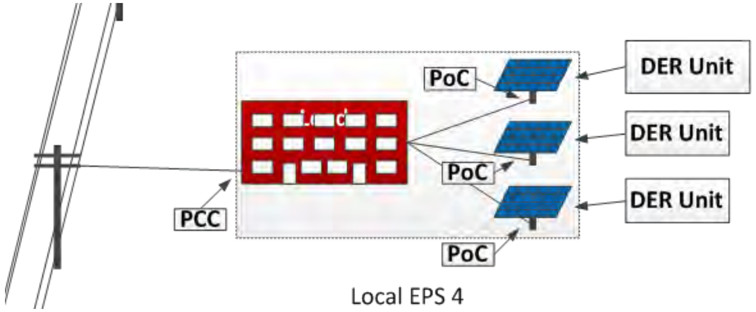
MN DIP:

- *All references to DER Nameplate Rating or maximum capacity as described in 5.14.3 herein are in alternating current (AC).* (MN DIP 1.1.2)

- Both interconnection applications ask for DER Nameplate rating, but simplified application (Att. 2) asks for DER capacity (as described in 5.14.3) and the interconnection application (Att. 3) asks for Maximum Export Capability.

- TSG was in agreement that the inverter(s) is/are the kWac nameplate rating(s) of the DER, and that more kWdc behind the inverter is not uncommon in design (~20%). However, if the inverter is current limited (instead of real power limited) you could exceed nameplate kWac rating by up to 10% in ideal conditions.

Nameplate Rating



EXAMPLE:
If the solar arrays are 20 kWdc each and the inverters (at PoC) are 15 kWac each, what is the aggregate nameplate rating of this DER?

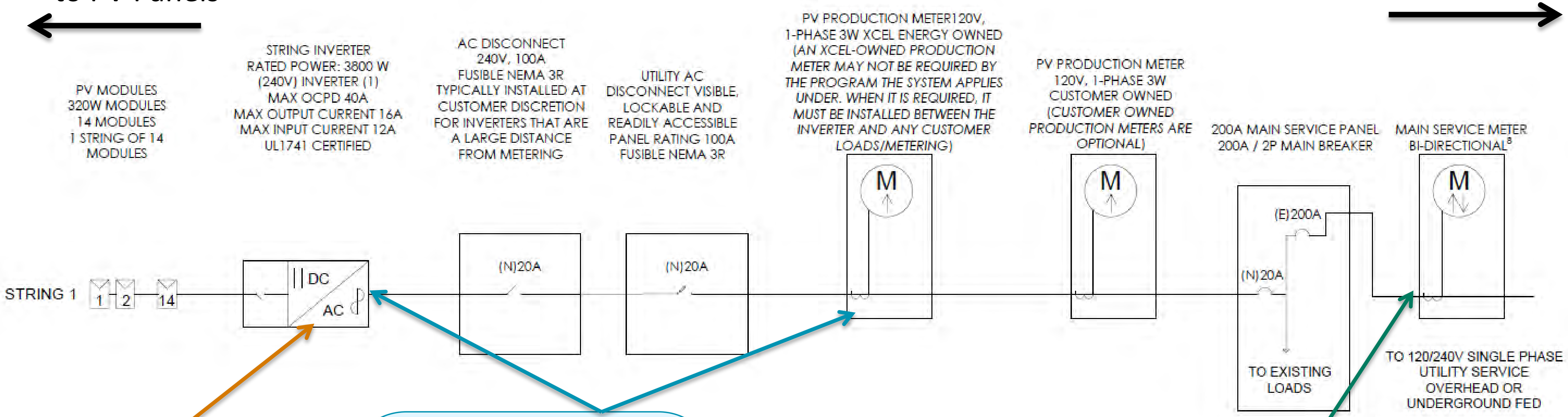
If the solar arrays are 20 kWdc each and the inverters (at PoC) are 25 kWac each, what is the aggregate nameplate rating of this DER?

2004 Minnesota Technical Standards (Att. 2)	IEEE 1547 and 2018-2019 MN DIP (underline is in MN DIP not 1547)
Nameplate Capacity is the total nameplate capacity rating of all the Generation included in the Generation System. For this definition the "standby" and/or maximum rated kW capacity on the nameplate shall be used."	**Nameplate Rating -** nominal voltage (V), current (A), maximum active power (kWac), apparent power (kVA), and reactive power (kvar) at which a DER is capable of sustained operation. For a Local EPS with multiple DER units, the aggregate nameplate rating is equal to the sum of all DERs nameplate rating in the Local EPS, not including aggregate capacity limiting mechanisms such as coincidence factors, plant controller limits, etc. that may be applicable for specific cases (Aggregate Nameplate Rating). The nameplate ratings referenced in the MN DIP are alternating current nameplate DER ratings. See Section 5.14 on Capacity of the Distributed Energy Resource and Minnesota Technical Requirements.
Generation is defined as any device producing electrical energy, i.e., rotating generators driving by wind, steam, turbines, internal combustion engines, hydraulic turbines, solar, fuel cells, etc.; or any other electric producing device, including energy storage technologies.	**Distributed Energy Resource (DER) Unit**: An individual DER device inside a group of DER that collectively form a system.
Generation System is the interconnected generator(s), controls, relays, switches, breakers, transformers, inverters and associated wiring and cables, up to the Point of Common Coupling.	**distributed energy resource (DER)**: A source of electric power that is not directly connected to a bulk power system. DER includes both generators and energy storage technologies capable of exporting active power to an EPS. An interconnection system or a supplemental DER device that is necessary for compliance with this standard is part of a DER.

Relationship and Use of Terms

to PV Panels

to Grid



***Nameplate Rating** - Listed by manufacturer and inherent to DER capabilities*

***Control Limited Capacity** – Set by installer and can be internal or external to DER power conversion or production device. Must be limited prior to comingling of load*

Inadvertent Capacity Exceedance

***Control Limited Export** – Set by installer and must use components external to the DER device in order to measure and limit export*

Non-export

Inadvertent Export

Control Limited Export

Inadvertent Export Limit Exceedance

Not the position of the Commission. Slides attempt to summarize TSG discussion to-date.

TSG 5 (Aug 3rd) Preparation and Discussions

- EPRI called attention to Clause 10.4 regarding configuration settings
  - "If a configuration setting value is different from the corresponding nameplate value, the configuration setting value shall be used as the rating within the DER."
  - Regarding nameplate, this can be referred to as a nameplate alternative
- Xcel had prepared slides considering a similar concept, and had named the concept "Control Limited Capacity"
  - Prior to and during the TSG, multiple sub-group members (including Xcel) noted the desire to avoid creating new definitions for a concept if a definition was already in use
  - Xcel noted that nameplate rating would continue to need to be used for process track eligibility and for some aspects of the technical review, including protection against short circuit current faults due to expected time for current limiting devices to detect and respond to said fault
  - Xcel noted that "control limited capacity" (or it's otherwise agreed to name) could be used in some aspects of the technical review, such as regarding whether mitigation would be needed for thermal purposes
- Concern regarding the implications in a situation with the RPA between PoC and PCC with regards to 1547.1 were raised for further consideration.

TIIR Option

- Add additional note to TIIR definition (which is currently a 1:1 with 1547-2018)
- **nameplate ratings[x]:** nominal voltage (V), current (A), maximum active power (kW), apparent power (kVA), and reactive power (kvar) at which a DER is capable of sustained operation.
  - NOTE—For Local EPS with multiple DER units, the aggregate DER nameplate rating is equal to the sum of all DERs nameplate rating in the Local EPS, not including aggregate capacity limiting mechanisms such as coincidence factors, plant controller limits, etc., that may be applicable for specific cases.
  - NOTE –A limit as described in MN DIP 5.14 may be established by nameplate alternative configuration setting, alternate certification or mutual agreement and is used for steady state aspects of technical review. Aggregate nameplate is used for short circuit current analysis and MN DIP process track eligibility.

MN DIP Option

Add MN DIP Option 5.14.4?

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

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

TSG FOLLOW UP: Address when limit and/or RPA is b/w PoC and PCC? Review Initial Review Screens, Supplemental Review Screens, Study Process to confirm when nameplate rating and the nameplate alternative would be used. Need to update MN DIP applications for consistency with whatever outcome.

DRAFT -16-521 Phase 2 – TSG 8

Xcel Energy Prep Slides

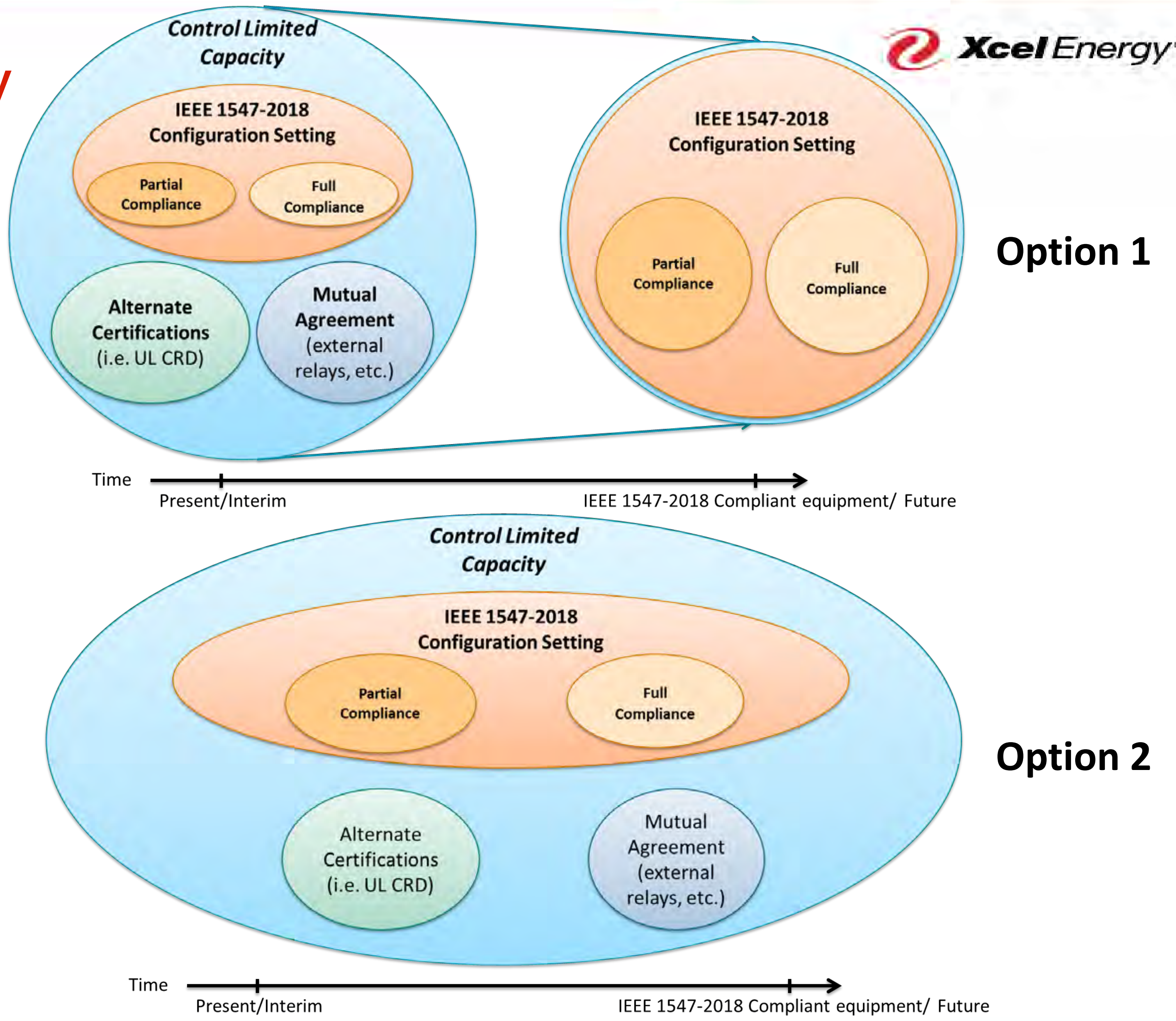
9/21/18

Control Limited Capacity

Two Possible Futures

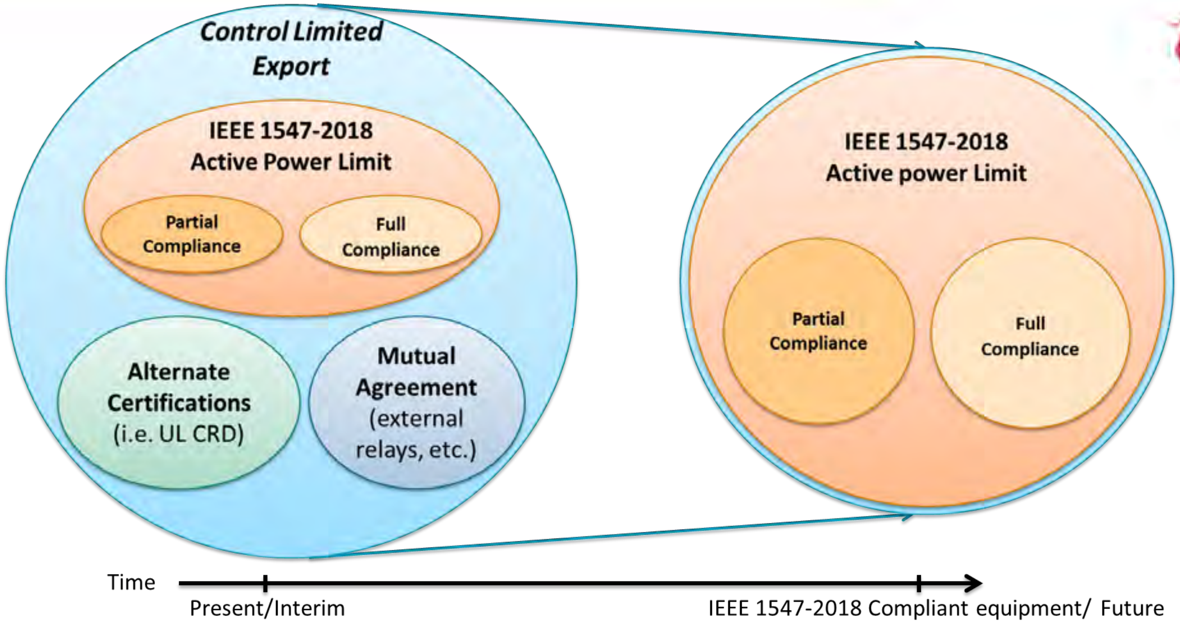
Fundamental question:
Should the TIIR set a course towards the IEEE 1547 *configuration setting* being the only means of "Maximum AC Capacity"/ "Control Limited Capacity" ?

Working hypothesis:
The *configuration setting* is expected to be a key means of implementing capacity limits, but at this time we need to allow for a future with multiple options.

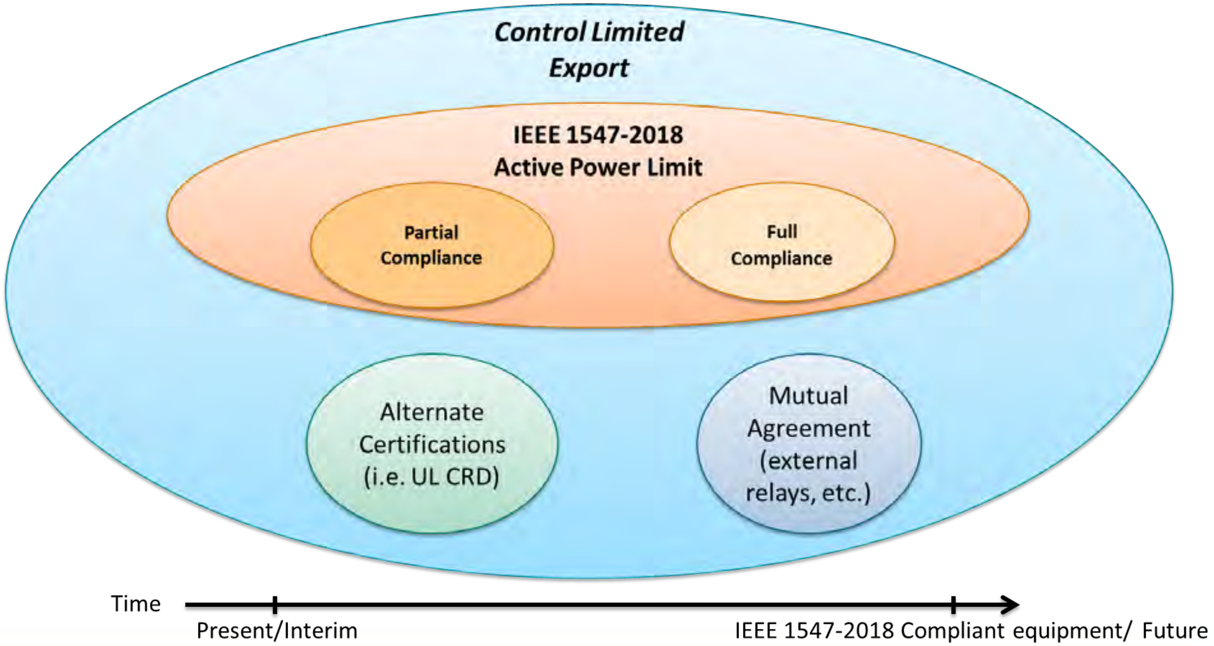


Control Limited Export

Control Limited Export could be viewed as analogous to Control Limited Capacity regarding possible paths for definition and IEEE 1547 standard application.



Option 1



Option 2

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Enabling 1547 Voltage Regulation Capabilities

Enabling Voltage-Reactive Power Mode (Volt-Var)

- If default voltage regulation is to use a constant power factor of .98 in TIIR, what should be said about enabling the alternative of voltage-reactive power mode (a.k.a. volt-var) to utilize advanced inverter functions?
  - Larger systems with detailed study (not Fast Track)?
  - Utility discretion or consideration?
  - Require communication enabled?
  - Mutual agreement?
  - Future TIIR consideration based on studies, pilots, national learnings, revisit on a future date?

- If enabling the volt-var mode instead of constant power factor in some instances, IEEE 1547 Table 8 (p. 39) on Voltage-Reactive Power Settings includes a range of allowable settings. Should those be included or referenced in Draft TIIR Sec. 5?

Table - voltage-reactive power settings

Voltage-reactive power parameters	Default settings	
	Category A	Category B
V_{Ref}	V_N	V_N
V2	V_N	$V_{Ref} - 0.02\ V_N$
Q2	0	0
V3	V_N	$V_{Ref} + 0.02\ V_N$
Q3	0	0
V1	$0.9\ V_N$	$V_{Ref} - 0.08\ V_N$
Q1a	25% of nameplate apparent power rating, injection	44% of nameplate apparent power rating, injection
V4	$1.1\ V_N$	$V_{Ref} + 0.08\ V_N$
Q4	25% of nameplate apparent power rating, absorption	44% of nameplate apparent power rating, absorption
Open loop response time	10 s	5 s

Note: V_{ref} may change based on installation location.

Figure: Example Voltage-Reactive Power Characteristic (Volt-Var)

Enabling Voltage-Active Power Mode (Volt-Watt)

- Voltage-Active Power mode is able to remain active with any of the voltage-reactive power modes (e.g. Constant Power Factor and Voltage-Reactive Power)
- Voltage-Active Power mode default is disabled in IEEE 1547 (IEEE 1547 5.4.1.)
- TSG agrees to enable for future proofing, not anticipated use today.
- Draft TIIR Footnote 28: The default IEEE 1547 volt-watt default setting will not begin curtailing real power until the voltage is beyond 1.06 per unit voltage, which is the upper end of the range of normal voltages allowed under ANSI C84.1.

Table – voltage-active power settings

Voltage-active power parameters	Default Settings	Range of allowable settings	
		Minimum	Maximum
V_1	1.06 V_N	1.05 V_N	1.09 V_N
P_1	P_{rated}	N/A	N/A
V_2	1.1 V_N	V_1 + 0.01 V_N	1.10 V_N
P_2	The lesser of 0.2 P_{rated} or P_{min}[a]	P_{min}	P_{rated}
P'_2	0[b]	0	P'_{rated}
Open Loop Response Time	10 s[c]	0.5 s	60 s

[a] P_{min} is the minimum active power output in p.u. of the DER rating (i.e., 1.0 p.u.)
[b] P'_{rated} is the maximum amount of active power that can be absorbed by the DER. ESS operating in the negative real power half plane, through charging, shall follow this curve as long as available energy storage capacity permits this operation.
[c] Any settings for the open loop response time of less than 3 s shall be approved by the Area EPS operator with due consideration of system dynamic oscillatory behavior.

- What consumer protection language needs to be added? (ex. not used in study as mitigation, installer design issues, complaint process, ability to change settings by location, and if used in place of upgrades needs to be informed?)
- IEEE 1547 Table 10 (p. 41) on Voltage-Reactive Power Settings includes range of allowable settings. Should those be included or referenced in Draft TIIR Sec. 5?

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Scope of TIIR and TSMs

Discussion: Scope for Statewide Technical Requirements

1. Scope/Overview
2. References
3. Definitions
4. Performance Category Assignments
5. Reactive Power Capability and Enabling the Utilization of Voltage/Power Control (volt-var & volt-watt) ~~*Performance*~~
6. Response to Abnormal Conditions (Ride-through)
7. Protection Requirements
8. Metering Functional Requirements and need to consider costs
9. Interoperability (Monitoring, Control, Info Exchange, Cyber security)
10. Energy Storage
11. Non-Export; Inadvertent Export
    - A. Limited capacity is included in TIIR. Limited Export for later consideration
    - B. Intentional Local EPS islanding
12. Test and Verification Requirements
    - A. Types of Tests for Simplified Projects
13. **Agreements**
14. **Consumer Protection** (IREC)
15. **Reporting** (IREC)
16. **Requirements related to tariff restrictions?**
17. **As much detail for 20 kW and smaller systems re: metering, testing, etc. as possible?**

Discussion: Out of Scope for the TIIR?

1. Process requirements
2. Cost allocation
3. Interconnection to transmission system
4. **Protection system details of Area EPS or DER**
5. **Requirements or specification of system impact or facilities studies**
6. **Application of real and reactive power control functions beyond default settings/range of allowable settings and requirements to enable the utilization?**
7. **Details of communication networks; including architecture, technology and protocols, or other specifications related to interoperability**
8. **Details of metering requirements or specifications beyond functional requirements and need for cost consideration?**
9. **Planning or operational considerations associated with Affected Systems, Regional Transmission Operator or Transmission Owners**
10. **Intentional Area EPS islanding**

These topics have been proposed as **out of scope** by some participants. Bold are flagged for additional discussion.

(Source: TIIR Draft Proposal, p. 9; Staff edits based on TSG discussion)

Discussion: Scope of TSMs?

- What is in scope for a utility specific TSM? How can the TIIR address the scope or outline of what is covered in a TSM? Examples from TSG discussion:
  - Protection requirements outside IEEE 1547 (e.g. line extension fusing or reclosing, relays, protection coordination)
  - If required, utility accessible, external disconnect switch requirements
  - DER specific settings within range of allowable (e.g. voltage trip and ridethrough setting flexibility)
  - Metering requirement details (including timing and format of information collected) for > 20 kW systems
  - Commissioning and testing from current practice until 1547.1 is updated for > 20 kW systems
  - 1-line diagram details?
  - Best practices for new technology not adopted into statewide or national standards yet
  - Cyber and physical security details
  - Non-parallel systems requirements
- If TSM is an annual informational filing with the Commission, what is the process if the DER customer(s) disputes the TSM requirements? Does the type of dispute matter?

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

Thank You!

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Additional Slides

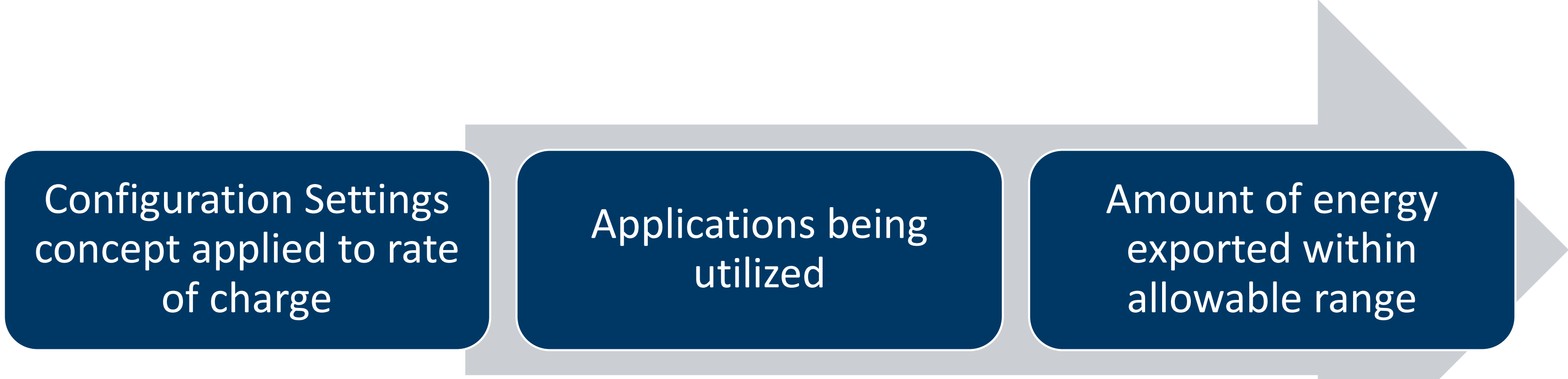
Framework of Defined Terms

Terms	Nameplate Rating	Control Limited Capacity Inadvertent Capacity Exceedance	Control Limited Export Non-Export Control Limited Export Inadvertent Export Inadvertent Export Limit Exceedance
Purpose / Use	• Determines process track eligibility • Captures DER maximum capability for system records • Used in some aspects of technical review	• Captures steady state operation for Interconnection Agreements • Used in some aspects of technical review	• Non-export is currently useful for contractual considerations (i.e “NEM integrity”) in MN • Export limited is related and likely needed in the future (i.e. Hawaii example) • Need terms

Not the position of the Commission. Slides attempt to summarize TSG discussion to-date.

Note: dashed lines around a box indicate the term has not yet been contemplated by MN interconnection standards update process

Configuration Settings



Least dynamic to most dynamic →

- **Configuration setting; currently active values:** Each rating in Table 28 (Nameplate information), may have an associated configuration setting that represents the as-configured value. If a configuration setting value is different from the corresponding nameplate value, the configuration setting value shall be used as the rating within the DER. Changes to the configuration setting shall be made with mutual agreement between the DER system operator and Area EPS operator. Configuration settings are not intended for continuous dynamic adjustment**.** (IEEE 1547-2018, Table 28 and Clause 10.4, p. 70)

Understanding ESS Control Modes and Use Cases/Applications?

Applications in use by Customer (C) or Area EPS/Utility (U)	Reflected in Interconnection Agreement (Y or N)	Change in Control Mode or Setting required in order to switch applications (Y or N)	Notification Required between DER Operator and Area EPS when change in application or setting occurs (Y or N)	Non-Exporting Service only (X = Yes)
TOU Bill Management (C)				
Demand Charge Reduction (C)				
Increased PV Self Consumption (C)				
Backup Power (C)				
Transmission Deferral (U)				
Transmission Congestion Relief (U)				
Distribution Deferral (U)				
Resource Adequacy (U)				

Not the position of the Commission. Slides attempt to summarize TSG discussion to-date.

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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.

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PREP WORK for Oct. 19th TSG, #8
References; Definitions; 1-line diagram requirements; Agreements

Subgroup members review agenda and provide the following to staff by 10/9/18.

1) **Propose edits to the Regulated Utilities' TIIR Draft Proposal and/or flag topics for discussion. Send as red-lines and comments using track changes to the 9-14-18 Draft TIIR. Slides calling out proposed edits to the draft TIIR are encouraged.**
   a. References in Section 2
   b. Definitions in Section 3B
   c. Agreements in Section 13
2) **Review and be prepared to reference IEEE 1547-2018**
   a. References in Clause 2
   b. Definitions in Clause 3.1
   c. Power Quality in Clause 7 and Informative Power Quality clause concepts and guidelines in Annex G
3) **Review and be prepared to cross-reference the TIIR Draft proposal definitions with the** MN DIP **and the proposed DGWG subgroup edits to MN DIP Attachment 5 (attached to email). Also review past TSG meeting slides (specifically TSG In-person 9-21). Although not the only definitions up for discussion, definitions known to need work include phrases for referring to a limited value of capacity, the application of storage capabilities, and inadvertent export. Slides with summary of proposed changes are encouraged.**
   a. Simplified Application Form, Attachment 2
   b. Certification Codes and Standards; MN DIP Attachment 4
   c. Certification of Distributed Energy Resource Equipment; MN DIP Attachment 5 (consider email attachment version)
4) **Utilities: Please provide an example of the Operating Agreements and/or Maintenance Agreements required and explain the rationale. Non-Utilities: What, if any, concerns do you have with the items included in the agreements as described in the Draft TIIR Sec 13?**
5) **What elements of the 1-line diagram are most frequently contested or missing? Are there ways to improve 1-line diagram details being required from utility and DER's perspectives? Slides are encouraged, including a potential example one-line diagram.**

----------------------------End Of Prep Work --------------------------------

Technical Subgroup Meeting 8 DRAFT AGENDA
Friday, October 19th
9:30am – 12:30pm Central Time

Join Webex meeting

844-302-0362 US Toll Free

+1 206-596-0378 US Toll

Proposed Agenda

9:30 – 9:40 Welcome, Intros, Overview of Agenda, Recap

9:40 – 10:50 Operating Agreements and Maintenance Agreements

10:50 - 11:40 Reference and Definition Reconciliation

- UL 1741 (2010) – how cited in MN DIP Att. 4
- DER unit, DER System, DER equipment package – see MN DIP Att. 5
- Inadvertent export
- Control Limited Capacity consistent with MN DIP 15.4
- Clarify or replace "ESS Operational Control Modes" to address differences between application of storage capabilities and charge/discharge settings

11:40 – 12:10 Aligning on expectations for One-line Diagram Submittal and Review

12:10 – 12:30 Next Steps; including writing group update

Phase II Technical Subgroup Roster

Craig Turner, Dakota Electric	Robert Jagusch, MMUA	Patrick Dalton/John Harlander/Alan Urban, Xcel Energy
Lise Trudeau, Dept of Commerce	Kevin McLean/Jenna Warmuth, MN Power	
	Kristi Robinson, MREA	John Dunlop/Chris Jarosch, MNSEIA
Brian Lydic/Sky Stanfield/Laura Hannah – Joint Movants	Dean Pawlowski, Otter Tail Power	Commissioner Matt Schuerger; Michelle Rosier; Cezar Panait
Professor Mahmoud Kabalan, St. Thomas Affiliation		Technical Assistance*: Michael Coddington and Michael Ingram, National Renewable Energy Laboratory Tom Key, Jens Boemer, Nadav Enbar; Electric Power Research Institute Pam Johnson, DOE Solar Energy Innovator Fellow

*****Technical assistance is not a participant or party to the docket and does not advocate for specific outcomes in the proceeding. The role of technical assistance is to support Commission staff in the process for these proceedings, and to provide an objective source of information or data, as requested, by Commission staff to understand areas of disagreement amongst participants.

Draft Meeting Topics Proposal

Date	Topic
3/23/18	Meeting 1 Scope/Overview** (Walk-through with explanations: Red-lined TIIR; List of topics in scope of TSMs; Definitions
4/13/18	Meeting 2 Performance Categories**; Response to abnormal conditions; MISO Bulk Power System
5/18/18	
6/1/18	Full DGWG Meeting Technical Subgroup update; Phase I Update/Next Steps
6/8/18	Meeting 3 Reactive Power and Voltage/Power Control Performance**; Protection Requirements
7/20/18	Meeting 4 Energy Storage**; Non-Export and Inadvertent Export**; Capacity**
8/3/18	Meeting 4 topics continued
8/24/18	Meeting 5 Interoperability** (Monitor and Control Criteria); Metering**; cyber security
9/14/18	Meeting 7; Test and Verification**; Witness Test Protocol
9/21/18	Full Day, In Person TSG Meeting – Power Quality; Follow up items; Review/Reconcile edits in the draft TIIR
10/19/18	References; Definitions*; 1-line diagram requirements; Agreements*, Frequency Ride-through
11/9/18	Full DGWG Meeting 7

Phase II Technical Subgroup Meeting #8

October 19, 2018

(Docket No. 16-521)

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https://mn.gov/puc

Agenda

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, Expectations, Recap
9:40 – 10:50	Operating Agreements and Maintenance Agreements
10:50 – 11:40	Reference and Definition Reconciliation • UL 1741 (2010) – how cited in MN DIP Att. 4 • DER unit, DER System, DER equipment package – see MN DIP Att. 5 • Control Limited Capacity consistent with MN DIP 5.14 • Inadvertent export • Clarify or replace “ESS Operational Control Modes” to address differences between application of storage capabilities and charge/discharge settings
11:40 – 12:10	Aligning on expectations for One-line Diagram Submittal and Review
12:10 – 12:30	Next Steps; including writing group update

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
June 8	Reactive Power and Voltage/Power Control Performance; Protection Requirements
July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 3	*July 20 topics continued*
Aug 24	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 14	Test and Verification; Protocol for witnessing Testing
Sept 21	In-Person TSG: Power Quality; Follow up items; TIIR edits discussion
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7

Recap from September 21

- Commission staff suggested TSG continue Draft TIIR development with the following understanding of how Aggregate Nameplate Rating and MN DIP 5.14.3 limit on capacity applies
    - Limited value (less than aggregate nameplate rating) is appropriate for some of the steady state analysis during the engineering screens if it is controlled by a means articulated in an interconnection agreement
    - Aggregate nameplate rating is appropriate for DER capacity for application track. Aggregate Nameplate Rating is expected to be used for fault current analysis, possibly other analysis of dynamic system behavior.
- Not all participants had the same expectations as to which version of UL1741 was applicable with regards to certifying a DER, or DER units
- PUC Agenda meeting on TIIR proposal anticipated in ~Q4 2019 (was Feb. 2019)
    - A sub-set of TSG stakeholders will participate in a writing group that will report back to the balance of the TSG at interim milestones
- September 21 Meeting Summary will have more details. Goal to finalize feedback by 11/9.

Goals for TSG Mtg #8: References; Definitions; One-line diagram requirements; Agreements

- Discuss and address draft TIIR language and proposed edits related to Sections 2, 3 and 13 and consider interim MN DIP Attachments 4 & 5, consistent with Draft TIIR

Build a shared understanding of

- Path forward to an aligned set of expectations regarding Operating Agreements
- What work remains with regards to TIIR references and definitions
- Opportunities for improvement in the application process regarding one-line diagrams

Sample term usage germane to this presentation from IEEE 1547-2018

- **distributed energy resource (DER):** A source of electric power that is not directly connected to a bulk power system. DER includes both generators and energy storage technologies capable of exporting active power to an EPS. <u>An interconnection system or a supplemental DER device that is necessary for compliance with this standard is part of a DER.</u> [23] (IEEE 1547-2018, Clause 3.1, p. 22)

- **DER unit:** An individual DER device inside a group of DER that collectively form a system. (IEEE 1547-2018, Clause 3.1, p. 23)

- **DER equipment package:** not defined, Attachment 5 to MN DIP is labeled "Certification of DER Equipment Packages"

- **Interconnection system:** The collection of all interconnection and interoperability equipment and functions, taken as a group, used to interconnect a DER to an Area EPS. [24] (IEEE 1547-2018, Clause 3.1, p. 23)
  - Footnote 24: This term was frequently used in IEEE Std 1547-2003. Given the scope of the present standard, which may have implications to the design of the entirety of the DER, <u>this standard uses the term "DER" in most places</u>.

(<u>emphasis</u> added by staff)

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Draft TIIR Section 13: Agreements

Operating Agreements

-content received from Fresh Energy

- Are the process steps and timelines associated with the exchange and execution of the DIA the same for the Operating Agreement? In other words, is it realistic to think they are paired through the entire process?

- Might there be a “minor modification” scenario where the operating parameters could change slightly without requiring a new interconnection application?

Xcel Energy®

DRAFT -16-521 Phase 2 – TSG 8

Xcel Energy Prep Slides

10/9/18

Operating Agreement

- Specify Power Factor
- Contingency Operations
- Distribution System Outages and Modifications
- Local and Remote Control
- Contact Information and Actions
- Right of Access
- Energy Storage Operating Mode (when Declaration option selected)

Note: non-exhaustive list of typical Operating Agreement topics

Maintenance Agreement

- Routine Maintenance
- Metering and Telemetry
- Modification to Generation System
- Special Facilities

Note: non-exhaustive list of typical Maintenance Agreement topics

Operating and Maintenance Agreements

Brian Lydic

Regulatory Engineer

Interstate Renewable Energy Council

O&M agreement

- TIIR notes a broad non-exclusive list of items that could be included.
- It is unclear what the process would be to alter the agreement over time if needed/requested by the utility.
- If a customer does not agree with changes to the agreement in the future, how would/could it be resolved?
- If a customer requests changes and the utility does not agree, how would/could it be resolved?

Some Suggestions

- Make clear when these agreements will be necessary (all IA's, or only those with X considerations?)
- Include Annex in TIIR with typical agreements for PV, storage (or PV+storage) and engine generators, based on default TIIR req's.
- Elaborate on process to initiate updates and resolve disagreements (MIP dispute resolution?)
- Define agreement limitations (term, excluded items)?

Discussion regarding edits to MN DER Draft TIIR Section 13

- What needs to be specified with “ESS permitted and disallowed operating control modes”? (IREC question)
- Did today’s conversation or reviewing the participant materials submitted for this meeting bring up any additional contributions for Section 13 on Agreements?
  - Is clarifying language needed regarding what shall or shall not be in an Agreement?

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Draft TIIR Section 2: References

How do we reconcile the reference in 2018 MN DIP regarding certification prior to 1547.1 updates?

- Attachment 4 of the MN DIP is an interim document while the Commission updates the MN DER TIIR… . For the transition period between Minnesota's existing statewide interconnection standards and the updated standards, both inverters certified to existing 1547.1 and 1547.1a-2015 (most current version); as well as, certified inverters per the expected revised 1547.1 standard should be acceptable. (MN DIP Attachment 4, Footnote 13.)
- However, the MN DIP reference section points to UL1741 (2010), which does NOT include Supplement A to UL1741,
  - IEEE 1547.1-2018 is expected to contain similar technical concepts to UL1741 SA
- Do these combined pieces lead to potential confusion in 2019 among users of the MN DIP?

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Draft TIIR Section 3: Definitions and Related MN DIP Terms

Thoughts on Attachment 5 – Certification of DER

- Propose using terms ***DER unit*** and ***DER system*** to be consistent with IEEE 1547-2018 usage
  - Table 43 and Table 44 use these terms for systems that are fully compliant (i.e. certified)
  - Suggest avoiding *composite* due to implication of *supplemental devices*
  - See example below for Clause 1 of Attachment 5

A Distributed Energy Resource (DER) ~~equipment~~ unit, or a DER ~~composite~~ system, proposed for use ~~use separately or packaged with other equipment~~ in an interconnection ~~system~~ shall be considered certified for interconnected operation if: 1) it has been tested

Is this consistent with all other usages of DER, DER unit and DER system?

- What is the implication if it isn't?

Capacity Definition Proposal

<u>Xcel Energy draft proposal (replaces MN DIP "Maximum Capacity")</u>

- **Control Limited Capacity :** The resulting power capability when a DER or total of DER source(s) behind the point of interconnection are limited in active power production below the aggregate DER nameplate rating through the use of power control systems, power relays, or other similar device settings or adjustments. Mechanisms for control limited capacity are protective to the utility system and shall be secured or hardware limited. Technical evaluations shall address DER characteristics and capabilities that are not impacted by source limiting.

Note: this is same definition as proposed in the TSG 5 meeting materials.

Is there a general trend in the path forward for inadvertent export?

- We discussed this in Meetings #4 and #5.
- Does this need to be covered in this version of the TIIR?
- Is there a definition onto which we are converging?

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Draft TIIR Section 3: Definitions and Related MN DIP Terms specific to charging and discharging energy storage

There are multiple phrases used to refer to what appears to be the manner and rate of storage charge and discharge

- MN DER TIIR specific to storage
    - ESS operating control modes (Sec. 13B)
    - ESS operational control mode (Sec. 3)
- MN DER TIIR referring to all DER
    - DER operating state control modes (Sec. 9B) Mode (Sec. 9B) in statement "*execution of mode and parameter changes*."
    - Operational control modes (Sec. 13B)
    - Operational modes (Sec. 13B)
- MN DIP Attachment 2 Exhibit B – For Energy Storage
    - Available control operating modes
    - Control modes being enabled
    - Changing operational modes of the energy storage
- Can the following tool showcase where there is agreement with the concept? Can that agreement help drive clarity and consistency among the phrases?

(This is not intended to be a comprehensive list.)

Potential Alignment in Consideration of Energy Storage Applications and Settings Changes

Applications in use by Customer (C) or Area EPS/Utility (U)	Reflected in Interconnection Agreement (Y or N)	Change in Control Mode or Setting required in order to switch applications (Y or N)	Notification Required between DER Operator and Area EPS when change in application or setting occurs (Y or N)	Non-Exporting Service only (X = Yes)
TOU Bill Management (C)				
Demand Charge Reduction (C)				
Increased PV Self Consumption (C)				
Backup Power (C)				
Transmission Deferral (U)				
Transmission Congestion Relief (U)				
Distribution Deferral (U)				
Resource Adequacy (U)				

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TSM Opportunity: One-line Diagram Submittal and Review

Oneline and Site Plans General Information

- Guideline documents for oneline diagrams, site plans, labeling details, and test plans are for Solar*Rewards and Solar*Rewards Community (Gardens) on website
  - Numerous primary and secondary garden configurations

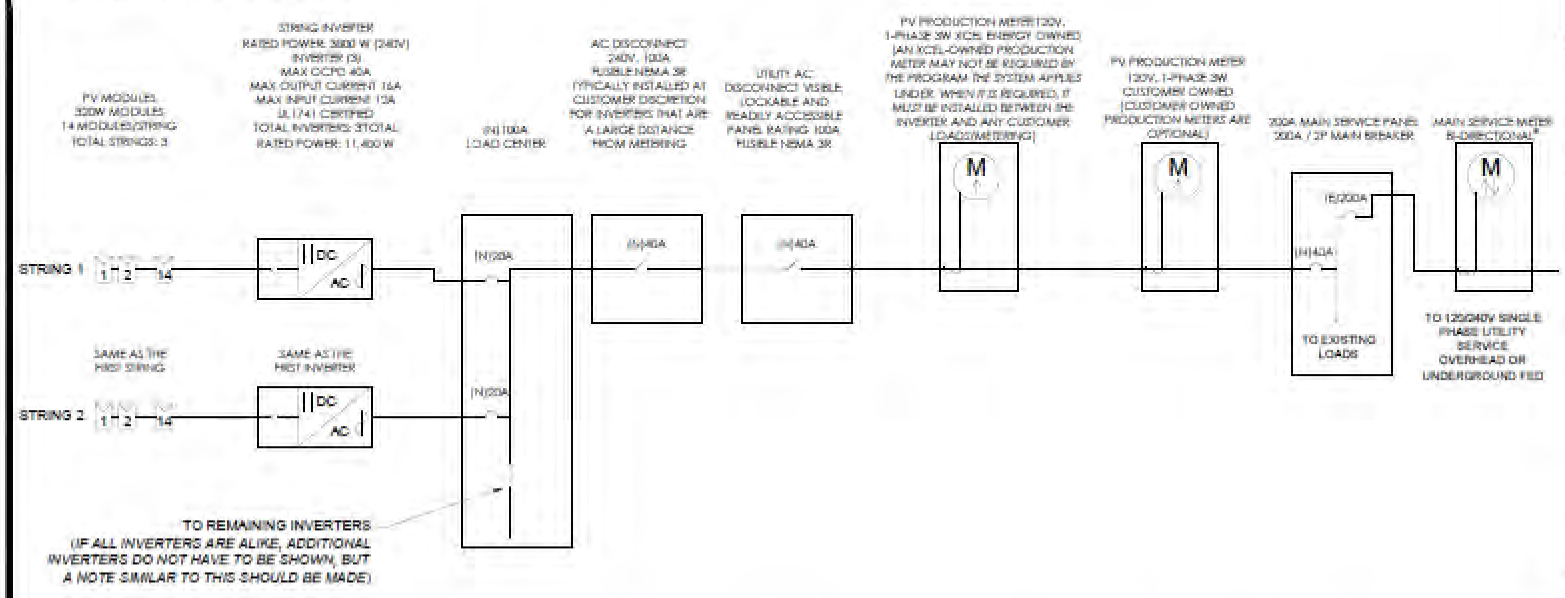
- Clear and accurate drawings contribute to expeditious application approval

- Protection and control diagrams are typically required for non-certified equipment

Oneline Example

Xcel Energy®

ONE-LINE EXAMPLE B:
FOR MULTIPLE INVERTER SYSTEMS



	PV MODULE	INVERTER	UTILITY DISCONNECT	PV METER	MAIN SERVICE PANEL	INTERCONNECTION METHOD
Make:						
Model:						
Rating:						
Total:						

NOTES:

PV SYSTEM:

RACK CONFIGURATION:

INVERTER INFORMATION:

ABBREVIATIONS:

SYSTEM SIZE
11.4 KW AC / 13.44 W DC

[redacted]

CUSTOMER NAME
JOHN DOE

SCALE

PROJECT
EXAMPLE DRAWINGS FOR SMALL SOLAR INTERCONNECTIONS
INSTALLATION ADDRESS

INSTALLER NAME & CONTACT

SHEET
ONE LINE DIAGRAM
SUBMITTAL
EXAMPLE

#	DATE	REVISION
01	09/12/17	XcelFx Comments
02	10/04/17	XcelFx Comments

APPLICATION OID OR SRC NUMBER

PROFESSIONAL CERTIFICATION

DRAWN BY
R PAWAR

CHECKED BY
S DAS

DATE
08.10.17

PROJECT #
2017-106.1

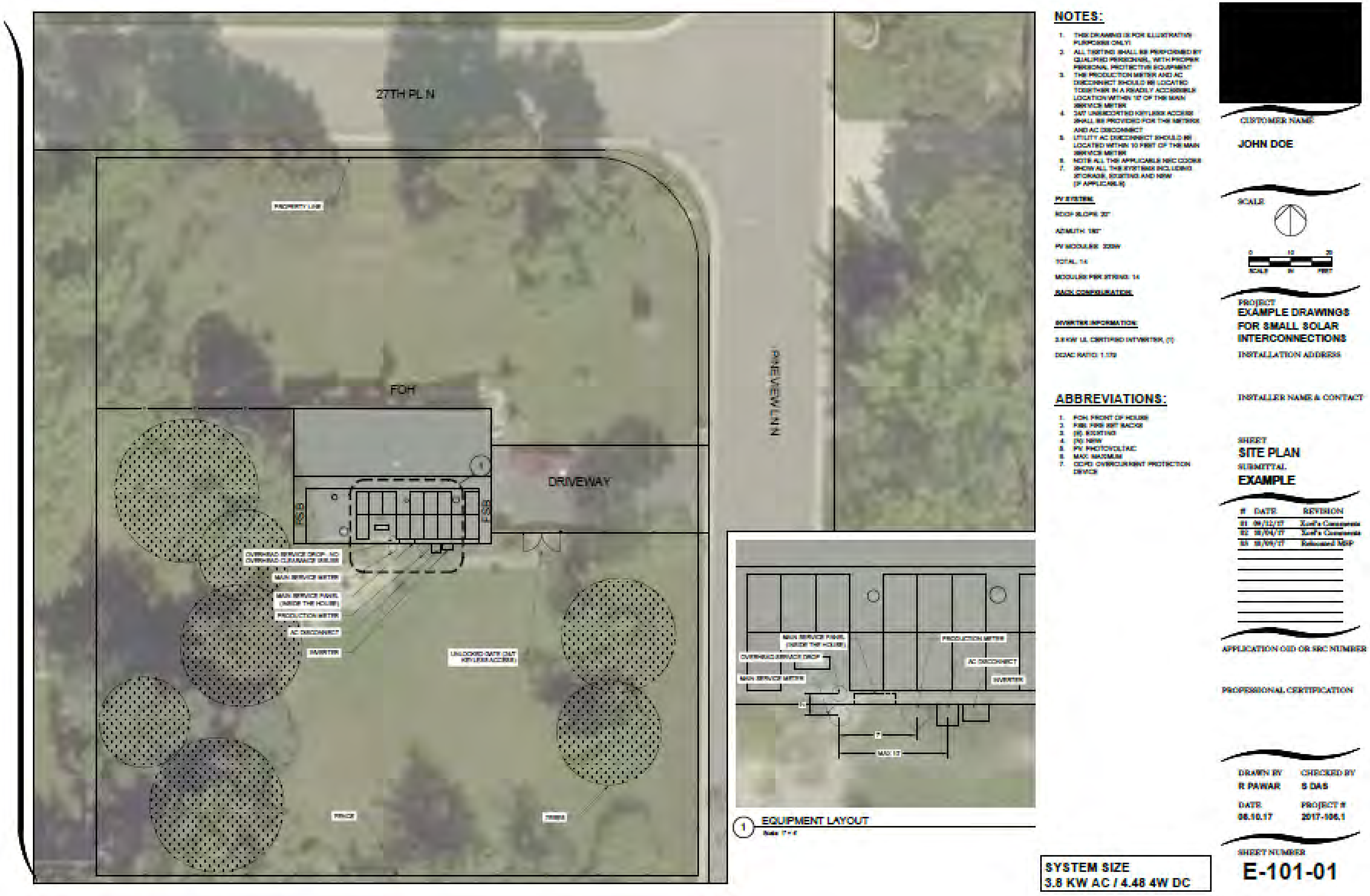
SHEET NUMBER
E-101-02B

Oneline Requirements

- Customer Name, Address, and Application ID
- Installer contact
- Labeling details
- Metering and Instrumentation
- Protective devices
- AC disconnect
- DER – new and existing
- Equipment ratings
- Grounding, if applicable
- Remote monitoring, if applicable
- UL 1741 Certification, if applicable

Note: See guidelines posted on Xcel Energy website for full details

Site Plan Example



Site Plan Requirements

- Customer name, Address, and Application ID
- Buildings and Street names
- Compass direction indicating North
- Main service entrance
- Meters
- AC Disconnects
- Transformers
- Other electrical devices, if applicable (i.e. switchgear, breakers, reclosers, etc.)

Note: See guidelines posted on Xcel Energy website for full details

Labeling Example and Requirements

Xcel Energy

1. PRODUCTION METER
2. Photovoltaic Power Source
3. WARNING
ELECTRIC SHOCK HAZARD
THE DC CONDUCTORS OF THIS PHOTOVOLTAIC SYSTEM ARE UNGROUNDED AND MAY BE ENERGIZED
4. WARNING
ELECTRIC SHOCK HAZARD
DO NOT TOUCH THESE TERMINALS, TERMINALS ON BOTH LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION
5. WARNING
ELECTRIC SHOCK HAZARD
WHEN A GROUND FAULT IS ACTIVE CONDUCTORS THAT ARE NORMALLY GROUNDED MAY BE UNGROUNDED AND ENERGIZED
6. CAUTION
PHOTOVOLTAIC SYSTEM IS BACKFED
7. WARNING
Turn off AC disconnect prior to working inside panel
8. DO NOT DISCONNECT UNDER LOAD
9. PV SYSTEM
DC DISCONNECT
10. MAIN PV SYSTEM
AC DISCONNECT
11. CAUTION
PHOTOVOLTAIC ENERGY IS BEING FED INTO THIS SYTEM
12. CAUTION
DUAL POWER SOURCE
SECOND SOURCE IS A PV SYSTEM
13. CAUTION
MAXIMUM OPERATING CURRENT 16 A
MAXIMUM OPERATING AC VOLTS 240 V
14. CAUTION
NOMINAL OPERATING AC VOLTAGE 240 V
NOMINAL OPERATING AC FREQUENCY 60 Hz
MAXIMUM AC POWER 3.8 kW
MAXIMUM AC CURRENT 16 A
OVERCURRENT PROTECTION RATING 20 A

NOTES:

[redacted]

CUSTOMER NAME
JOHN DOE

SCALE

APPR

PROFESSIONAL CERTIFICATION

DRAWN BY
N PAWAR

CHECKED BY
S DAS

DATE
06.10.17

PROJECT #
2017-106.1

SHEET NUMBER
E-101-03

Label Locations/Details

1	Production Meter
2	PV System Utility AC Disconnect, Main Service Disconnect
3	DC BUS, DC Disconnect, Inverter(s)
4	PV System Utility AC Disconnect, Main Service Disconnect
5	DC BUS, DC Disconnect, Inverter(s)
6	PV System Utility AC Disconnect, PV-AC Disconnect load side and line side
7	PV-AC Disconnect
8	PV System Utility AC Disconnect
9	PV System DC Disconnect
10	PV System Utility AC Disconnect
11	Main Service Panel(House/Area Panel), Production meter
12	Main Service Panel(House/Area Panel), Production meter
13	PV-AC Disconnect, AC Panel combiner, Production meter
14	PV-AC Disconnect, AC Panel combiner, Production meter

SYSTEM SIZE
3.8 KW AC / 4.48 4W DC

- **Compliance with NEC 690**
- **AC Disconnect**
- **Caution at Main Service Meter**

Note: See guidelines posted on Xcel Energy website for full details

Single Line
-content received from Fresh Energy

- Let’s create a Single Line template form for Simplified applications!
  - Advantages: uniform requirements across the state, easier for utility to review, clear to the customer what information is required, streamlined and efficient for all parties, etc.

- PG&E does not require a single line drawing for standard configurations, instead they collect the relevant information on the application form – (see next slide)

APPLICATION
Net Energy Metering (NEM2) Interconnection For Solar And/Or Wind Electric Generating Facilities Of 30 Kilowatts Or Less

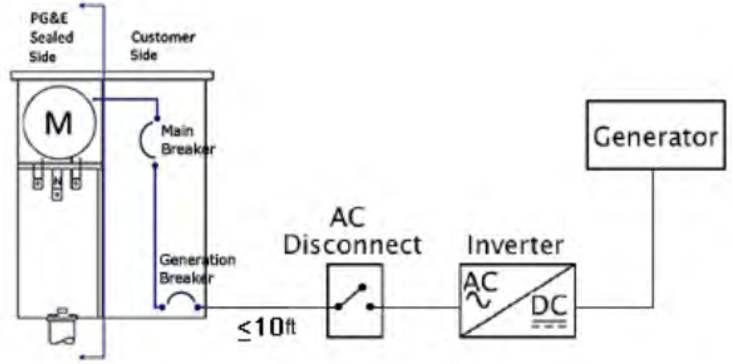
E. Basic Single-Line Diagram (SLD) for Solar Projects (check one):

☐ I certify the following:

1) SLD below and the PV equipment information in Part II accurately represent the Customer's service, 2) the Generating Facility (there are no other Generator Facility(ies) connected to the service, and 3) the project does not require a Variance Request.

Utility Service: (if using the SLD to the right)

Panel Voltage (volts)	**Main Breaker** (amps)	**PV Breaker Size** (amps)



☐ I will submit a custom SLD for one or more of the following reasons: there is/are existing Generating Facility(ies) connected to the service, I am modifying an existing Generating Facility, the Basic SLD does not accurately reflect the project, or I am submitting a Variance Request.
(See Part III Section D for Custom SLD details.)

-content received from Fresh Energy

Discussion: how do we make this process easier for all involved?

- Agreements to define acronyms prior to first use within a given document?
- Specification of control diagrams and protection diagrams for equipment that isn’t certified?
- Site plan and/or commissioning test plan examples included?

Next Steps

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

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Thank You!

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Back Up Slides

Glossary germane to this presentation based on IEEE 1547-2018

- **Commissioning tests:** Commissioning tests are tests and verifications on one device or combination of devices forming a system to confirm that the system as designed, delivered, and installed meets the interconnection and interoperability requirements of this standard. [IEEE 1547-2018 p. 78]
  - Test procedures are provided by equipment manufacturers(s) or system designer(s) and approved by the equipment owner and Area EPS operator. Commissioning tests shall include visual inspections and may include, as applicable, operability and functional performance test.

- **DER evaluation:** DER evaluation comprises a design evaluation desk study during the interconnection review process and an as-built installation evaluation on site at the time of commissioning to verify that the composite of the individual partially compliant DER(s) and, if applicable, the supplemental DER device(s) forming a system meet the interconnection and interoperability requirements of this standard. [IEEE 1547-2018 p. 78]

- **Type tests:** A type test may be performed on one device or combination of devices. In case of a combination of devices forming a system, this test shows that the devices are able to operate together as a system. Type tests shall be performed, as applicable, to the specific DER unit or DER system. The tests shall be performed on a representative DER unit or DER system, either in the factory, at a testing laboratory, or on equipment in the field. Type test results from a DER within a product family of the same design, including hardware and software, shall be allowed as representative of other DERs within the same product family with power ratings between 50% to 200% of the tested DER. [IEEE 1547-2018 Clause 11.2.2]

(emphasis added by staff)

Which IEEE Std 1547-2018 type tests can be certified via UL 1741 (SA)?

Standards for DER		Listing/ Certification			Interconnection Standards			State/ PUC/Utility Rules	
								CA	HI/HECO
Function Set	Advanced Functions Capability	UL 1741	UL 1741(SA) 2016	IEEE 1547.1 -201?*	IEEE 1547-2003	IEEE 1547a-2014	IEEE 1547-2018	Rule 21 (Phases)	Rule 14H & UL SRDv1.1
All	Adjustability in Ranges of Allowable Settings			Δ		√	‡		
Monitoring & Control	Ramp Rate Control		Δ					‡ (P1)	‡
	Communication Interface			Δ			‡	‡ (P2)	‡
	Disable Permit Service (Remote Shut-Off, Remote Disconnect/Reconnect)			Δ			‡	‡ (P3)	‡
	Limit Active Power			Δ			‡	‡ (P3)	
	Monitor Key DER Data			Δ			‡	‡ (P3)	
Scheduling	Set Active Power							[‡ (P3)]	
	Scheduling Power Values and Models							‡ (P3)	
Reactive Power & Voltage Support	Constant Power Factor	√	Δ	Δ	√	√	‡	‡ (P1)	X
	Voltage-Reactive Power (Volt-Var)		Δ	Δ	X	√	‡	‡ (P1)	‡
	Autonomously Adjustable Voltage Reference			Δ			‡	!!!	!!!
	Active Power-Reactive Power (Watt-Var)			Δ	X		‡		‡
	Constant Reactive Power	√		Δ	√	√	‡		
	Voltage-Active Power (Volt-Watt)		Δ	Δ	X	√	‡	‡ (P3)	‡
	Dynamic Voltage Support during VRT						√	[‡ (P3)]	
Bulk System Reliability & Frequency Support	Frequency Ride-Through (FRT)		Δ	Δ			‡	‡ (P1)	‡
	Rate-of-Change-of-Frequency Ride-Through			Δ			‡	!!!	!!!
	Voltage Ride-Through (VRT)		Δ	Δ			‡	‡ (P1)	‡
	VRT of Consecutive Voltage Disturbances			Δ			‡	!!!	!!!
	Voltage Phase Angle Jump Ride-Through			Δ			‡	!!!	!!!
	Frequency-Watt		Δ	Δ	X	√	‡	‡ (P3)	‡
Other Advanced DER Functions	Anti-Islanding Detection and Trip			Δ			‡	‡ (P1)	‡
	Transient Overvoltage						‡		‡
	Remote Configurability						‡	‡ (P2)	‡
	Return to Service (Enter Service)						‡	‡ (P1)	‡

Legend: X Prohibited, √ Allowed by Mutual Agreement, ‡ Capability Required, Δ Test and Verification Defined
[…] Subject to clarification of the technical requirements and use cases, !!! Important Gap

Source: EPRI | *Please contact us for any suggested updates to this table.*

Interconnection Standards Adoption Roadmap Considerations

2016
- UL 1741 (SA) published
- Based on requirements specified in CA Rule 21 and Hawai'ian Rule 14H

2017
- UL 1741 (SA) certified equipment available

2018
- IEEE Std 1547-2018 published
- Requirements go beyond CA Rule 21 and HI Rule 14H

2019+
- IEEE Std 1547.1-2019 published
- UL 1741 updated

2021+
- IEEE Std 1547-2018.1 tested and UL 1741 certified equipment available

Adoption of CA Rule 21 and Hawai'ian Rule 14H by inverter certification per UL 1741 (SA).

Stopgap solution for **adoption of parts of IEEE Std 1547-2018** by inverter certification per UL 1741 (SA).

Full adoption of IEEE Std 1547-2018.

Question from **distribution** perspective:

Early need to increase hosting capacity?

Question from **transmission** perspective:

Early need to address bulk system reliability?

Discussion: Scope for Statewide Technical Requirements

These topics have been proposed as **in scope**.
Bold have been flagged for discussion.

1. Scope/Overview
2. References
3. Definitions
4. **Performance Category Assignments**
5. **Reactive Power Capability and Voltage/Power Control (volt-var & volt-watt) Performance**
6. **Response to Abnormal Conditions (Ride-through)**
7. **Protection Requirements**
8. **Metering**
9. **Interoperability (Monitoring, Control, Info Exchange, Cyber security)**
10. **Energy Storage**
11. Non-Export; Inadvertent Export
12. **Test and Verification Requirements**
13. **Agreements**
14. **Consumer Protection** (IREC)
15. **Reporting** (IREC)

(Source: "Regulated Utilities" TIIR Draft Proposal)

Discussion: Scope for Statewide Technical Requirements

1. Process requirements
2. Cost allocation
3. Interconnection to transmission system
4. **Protection system details of Area EPS or DER**
5. **Requirements or specification of system impact or facilities studies**
6. **Application of real and reactive power control functions**
7. **Details of communication networks; including architecture, technology and protocols, or other specifications related to interoperability**
8. **Details of metering requirements or specifications**
9. **Planning or operational considerations associated with Affected Systems, Regional Transmission Operator or Transmission Owners**
10. **Intentional Area EPS islanding**

These topics have been proposed as **out of scope** by some participants. Bold are flagged for additional discussion.

(Source: TIIR Draft Proposal, p. 9)

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Technical Subgroup Meeting 9 DRAFT AGENDA
Friday, May 31st
9:30am – 12:30pm Central Time

Join Webex meeting
Meeting number (access code): 747 667 198
Meeting password: ymRQy2P5

Proposed Agenda

9:30 – 9:40 Welcome, Intros, Overview of Agenda, Recap (10 min)

9:40 – 9:55 MISO Straw Proposal and Process (15 min)

9:55 – 10:35 Writing Subgroup Presentation on Draft TIIR and Clarifying Questions (30 min presentation/10 min questions)

10:35 - 11:50 TSG Discussion of Flagged Topics – Resolve, Meet, or Written Comments? (1 hr 15 min)

11:50 – 12:10 Open Phase (Anti-Islanding) Testing and Grounding Bank Requirements (5 min for MNSEIA and Xcel summaries; 10 min discussion)

12:10 – 12:20 Process for MN DIP/DIA and TIIR as "living documents" (10 min)

12:20 – 12:30 Next Steps; Phase II Timing (10 min)

Objectives for May 31st:

1) Ensure TSG is aware of MISO straw proposal and process for finalizing regional guidance;
2) Review Writing Subgroup's Draft TIIR and determine next steps on Flagged Topics;
3) Summarize concerns related to open phase (anti-islanding) and grounding bank requirements and determine next steps, if any, required by TSG;
4) Share perspectives/concerns re: process for MN DIP/DIA and TIIR as "living documents"
5) Flesh out the Phase II Timing (i.e. next steps toward a Commission-approved TIIR)

Phase II Technical Subgroup Roster

Craig Turner, Dakota Electric	Robert Jagusch, MMUA	Patrick Dalton/John Harlander/Alan Urban, Xcel Energy
Lise Trudeau, Dept of Commerce	Kevin McLean/Jenna Warmuth, MN Power	
	Kristi Robinson, MREA	John Dunlop/Chris Jarosch, MNSEIA
Brian Lydic/Sky Stanfield/Laura Hannah – Joint Movants	Dean Pawlowski, Otter Tail Power	Commissioner Matt Schuerger; Michelle Rosier; Cezar Panait
Professor Mahmoud Kabalan, St. Thomas Affiliation		Technical Assistance*: Michael Coddington and Michael Ingram, National Renewable Energy Laboratory Tom Key, Jens Boemer, Nadav Enbar; Electric Power Research Institute Pam Johnson, DOE Solar Energy Innovator Fellow

*Technical assistance is not a participant or party to the docket and does not advocate for specific outcomes in the proceeding. The role of technical assistance is to support Commission staff in the process for these proceedings, and to provide an objective source of information or data, as requested, by Commission staff to understand areas of disagreement amongst participants.

Draft Meeting Topics Proposal

Date	Topic
3/23/18	Meeting 1 Scope/Overview** (Walk-through with explanations: Red-lined TIIR; List of topics in scope of TSMs; Definitions
4/13/18	Meeting 2 Performance Categories**; Response to abnormal conditions; MISO Bulk Power System
5/18/18	
6/1/18	Full DGWG Meeting Technical Subgroup update; Phase I Update/Next Steps
6/8/18	Meeting 3 Reactive Power and Voltage/Power Control Performance**; Protection Requirements
7/20/18	Meeting 4 Energy Storage**; Non-Export and Inadvertent Export**; Capacity**
8/3/18	Meeting 4 topics continued
8/24/18	Meeting 5 Interoperability** (Monitor and Control Criteria); Metering**; cyber security
9/14/18	Meeting 7; Test and Verification**; Witness Test Protocol
9/21/18	Full Day, In Person TSG Meeting – Power Quality; Follow up items; Review/Reconcile edits in the draft TIIR
10/19/18	Meeting 8; References; Definitions*; 1-line diagram requirements; Agreements*, Frequency Ride-through
11/9/18	Full DGWG Meeting 7
5/31/19	Meeting 9; Writing Subgroup Updated Draft TIIR; MISO Straw Proposal; Open Phase “Anti-Islanding” and Grounding Bank Requirements; Phase II Timing

Phase II Technical Subgroup Meeting #9
May 31, 2019
(Docket No. 16-521)

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https://mn.gov/puc

Agenda

Time	Topic
9:30 – 9:40	Welcome, Introductions, Overview of Agenda, Expectations, Recap
9:40 – 9:55	Update on MISO Straw Proposal and Process
9:55 – 10:35	Writing Subgroup Presentation on Draft TIIR and Clarifying Questions
10:35 – 11:50	TSG Discussion on Flagged Topics – Resolve, Meet or Written Comments? - Utility Technical Specification Manuals - Reactive Power and Voltage/Power Control - Communication Requirements - Other?
11:50 – 12:10	Open Phase (Anti-Islanding) Testing and Ground Bank Requirements
12:10 – 12:20	Process for MN DIP/DIA and TIIR as “Living Documents”
12:20 – 12:30	Next Steps; Phase II Timing

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System
June 8	Reactive Power and Voltage/Power Control Performance; Protection Requirements
July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 3	*July 20 topics continued*
Aug 24	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 14	Test and Verification; Protocol for witnessing Testing
Sept 21	In-Person TSG: Power Quality; Follow up items; TIIR edits discussion
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7
May 31	Review Writing Subgroup Updated Draft TIIR, MN DIP/DIA as "living documents", Phase II Timing, MISO Regional Guidance Update, Flag Open Phase(anti-islanding) testing and Grounding Bank Reqs.

Update on MISO Regional Guidance on IEEE 1547

- August 2019 is goal for publishing MISO regional guidance
- Evolution of the MISO straw proposal is available here: https://cdn.misoenergy.org//11_EPRI_MISO-WS-April23_Report%20Out342089.pdf
- MISO will schedule a follow up conference call to discuss feedback and finalize the guidance.
- Feedback requests and responses are managed through MISO's Feedback Tool at:

https://www.misoenergy.org/stakeholder-engagement/stakeholder-feedback/

- MISO IEEE 1547 Website:

https://www.misoenergy.org/planning/generator-interconnection/ieee-1547/

MISO's 6th Straw Proposal – Overview (based on WS outcomes)

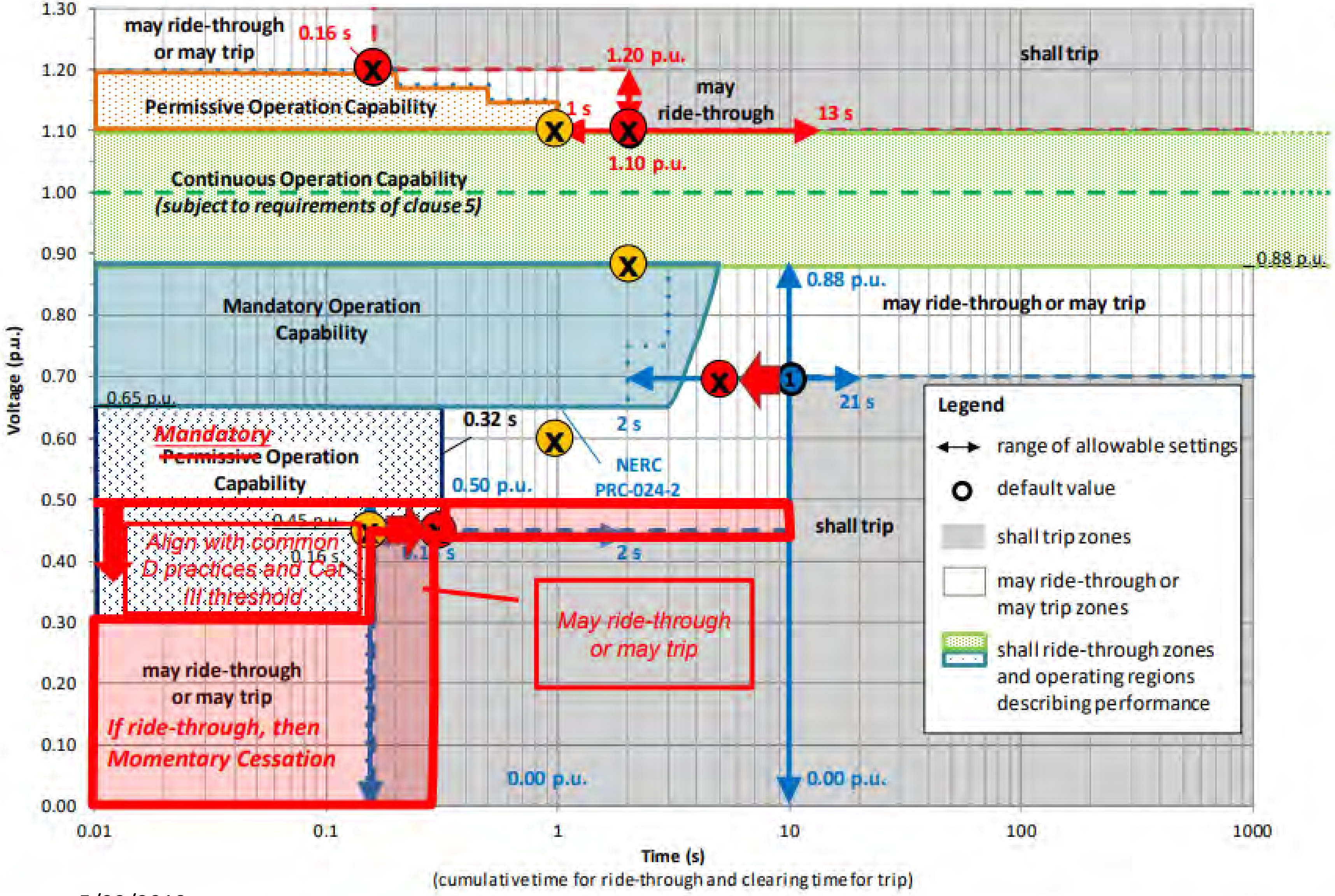
red = modification relative to 2nd proposal from 4th Pre-WS call

- Ride-through performance category assignment
  - Synchronous generation: Category I
  - Inverters-based generation & storage: Category II
  - Allow for exceptions with notification of MISO
- Clause 4.10 (Enter Service)
  - Clause 4.10.2 (Enter Service Criteria)
    - Default settings
  - Clause 4.10.3 (Performance during entering service)
    - Default settings – *MISO would welcome a longer ramp time but gives distribution utilities latitude to select shorter ramp time in which case they should notifiy MISO.*
- Clause 6.4.1 (Mandatory Voltage Tripping Requirements)
  - OV1, and OV2 default settings
  - UV1 = 5 sec – *bulk needs, AID, reclosing*
  - UV2 = default plus 160 ms margin = 320 ms
  - Allow for exceptions with notification of MISO
- Clause 6.5.1 (Mandatory Frequency Tripping Requirements)
  - Default settings – *UFLS is out of scope here but may have to be appropriately coordinated*
  - Do NOT allow for exceptions

(Guide, exceptions at company policy level should be notified to MISO)

- Clause 6.4.2.7.3 (Transition between performance operating regions for Category III DER)
  - Momentary Cessation mandatory for Inverters (Category II) in part of the Permissive Operation Capability Region
  - Momentary Cessation threshold of 0.5 pu *= default value for Cat III to align with common distribution practices and keep certification simple*
- Clause 6.5.2.7.2 (Frequency-DrXp (Frequency/Power) Operation)
  - Enabled per 1547, standard does not allow to disable
  - Default settings
  - Do NOT allow for exceptions
- Clause 6.4.2.6 (Dynamic Voltage Support)
  - Refer to guidance in IEEE P1547.2 (Guide - 2020)

MISO's 6th Straw Proposal – VRT for Inverters (Category II) (based on WS outcomes)



- Ranges of allowable settings (↔) defined such that IEEE Std 1547a-2014 default settings (X) can be accommodated.
- Permissive Operation Capability region may include requirements for Momentary Cessation, similar to Category III. !
- Trip settings (X) proposed in MISO's 1st Straw Proposal
  - OV1, and OV2 default settings
  - UV1 = 5 sec.
  - UV2 = default plus 160 ms margin = 320 ms
  - Momentary Cessation threshold of 0.5 pu
  - For Dynamic Voltage Support, refer to guidance in IEEE P1547.2 (Guide - 2020)

Status of Standards

- In addition to MISO's work on IEEE 1547…
- A stakeholder working group titled System Planning Impacts from DERs (SPIDERWG) has been assembled to address bulk system impacts of DER adoption
- Based on EPRI's review of NERC Reliability Standards, an active distribution system & significant DER *may* give rise to:
  - New methods to comply
  - Need for new data exchanges
  - *Potential* need to reexamine NERC provisions
- Aiming for Q1 2020 publication of "Reliability Guideline: BPS Planning under Increasing DER"
- IEEE 1547.1 is out for balloting.

Writing Subgroup Members

- Patrick Dalton, Xcel Energy
- Laura Hannah, Fresh Energy
- Brian Lydic, IREC
- Kristi Robinson, STAR Energy Services LLC
- Craig Turner, Dakota Electric Association

TIIR Highlights

Writing sub-subgroup presentation to the DGWG technical subgroup

TIIR Highlights

- Status of Standards
- Tone of Document
- References
- Definitions
- Performance Categories
- Reactive Power and Voltage/Power Control
- Energy Storage
- Power Limiting
- Testing and Verification
- TSM
- Future Revisions of the TIIR
- Transition to the TIIR

Balance of Document Tone

- Expectation the reader of the TIIR has a level of technical understanding
- Removal of “editorial” and “teaching” aspects in the TIIR
  - Kept TIIR technical rather than clouding issues with policy
- Avoidance of specific examples in the TIIR
  - Some footnotes may have examples as insight for the reader
- Purposely vague in specific areas of the TIIR – as standards are still in development at national level
  - Attempting to avoid this version of the TIIR conflicting with an evolving national/ISO standard

References

- The TIIR has additional references not found in the MN DIP
  - Different lists of references does not pose an issue
  - Not all references apply in all situations
- Included standards, codes, certifications, guides and recommended practices in TIIR Reference section.
- The TIIR references may become the more complete and up-to-date source over time

Definitions

- IEEE 1547-2018 definitions are used when a conflict with MN DIP exists
- Subgroup determined that conflicts between TIIR and IEEE 1547 were most serious for application of technical document
- Definition origins are noted with symbols
  - New MN DIP definitions: ^

Performance Categories

- Normal performance category the same
- Abnormal performance has temporary settings profile based on MISO straw proposal
- Section added for allowing alterative assignment by mutual agreement

Energy Storage

- Evolving standards at the national level lead to the Energy Storage section being less definitive
  - Expectation that future revisions of the TIIR will provide more details in accordance with new standards
- Currently requiring notification to the Area EPS Operator if ESS control modes are changed to evaluate the impact on safety, reliability and power quality
- ESS can be both a generation and a load. The ESS having dual abilities can significantly effect the distribution system
- The “password protection” concept is currently in the UL CRD
  - Only qualified personnel (i.e. manufacturer approved technicians) can change control modes

Energy Storage

- In the initial Interconnection Application the Interconnection Customer is to identify all available control modes and which control modes will be utilized
- It is assumed the Area EPS Operator will only study the control modes being used as indicated in the Interconnection Application
- A change to a control mode that wasn't indicated as being used in the initial Interconnection Application will required notification to the Area EPS Operator.
- The TIIR leaves is flexible how the notification in change of control mode is communicated to the Area EPS Operator

"This information may be collected through an Area EPS Operator specific document or the Area EPS Operator's online application portal."

Power Control Limiting

- Looked to create a process where the DER Operator may have more operational options
- TIIR provides guidance, but does not constrain future options
- Workgroup did not want to place limits on how Power Control is utilized
- Crafting rules specific to one technology could negatively impact another technology
- Additional industry development in Power Control limiting concepts is needed

Reactive Power and Voltage / Power Control

- Settings can affect Transmission Operation & Studies
  - Need to coordinate with Transmission Providers / MISO
- Voltage-Reactive Power (Volt-Var)
  - Default is fixed power factor of 0.98 PF
- Voltage-Active Power (Volt-Watt)
  - Default is Enabled with default IEEE 1547-2018 parameters
- May require setting changes in the inverter from what is programmed from the manufacturer

Power Control Limiting

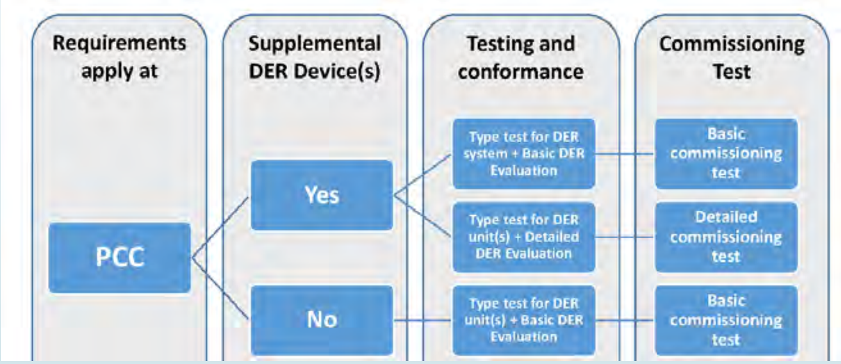
- Three Sections
  - Limiting Capacity
    - Could lower cost of distribution upgrades
  - Limiting Export / Import
    - Could help with integration issues and operational issues
  - Other Methods
    - Keep the options open as this is a quickly changing area, don't want to hinder future applications

- Ability to protect configuration settings is critical for safety
  - Example: maintenance personnel changed a transfer switch from open to closed transfer with a simple jumper change. Trying to eliminate blinks during testing.

Test and Verification

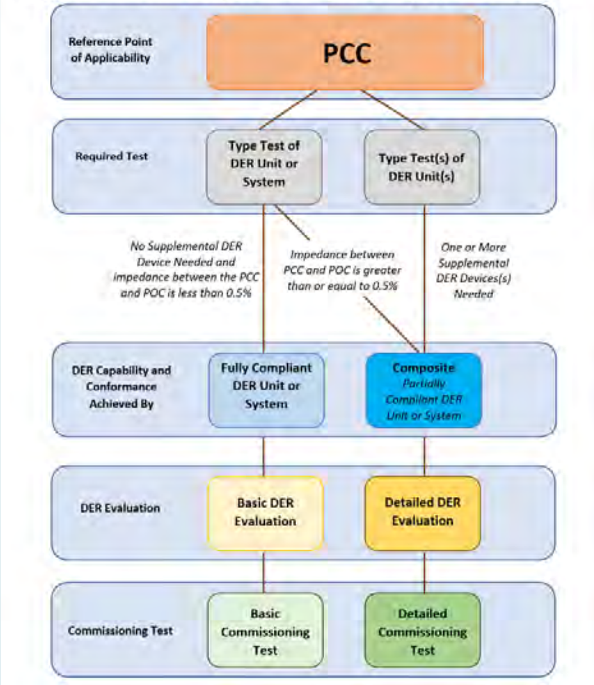
- RPA determines evaluation/testing
  - "RPA shall be specified in one-line"
    - Ensures agreement b/w developer and utility

IEEE 1547



TIIR

Figure 4 Test and Verification Required Steps for RPA at PCC



- Simplified Process Testing Procedure
  - Basic field evaluation and tests for fully compliant inverters

TSM

- Proposed plan for utilities to all have a similar organization of topics addressed in TSM
- Currently are planning for example documents for the Simplified Process
  - Example: one-line diagram, site diagram, testing procedure
- If found that utilities are all having a common requirement(s) on a specific area – suggestion to consider including common requirement(s) in future version of the TIIR
- TSM will be somewhat lengthy documents to include the entirety of the Area EPS Operator’s specific technical requirements

Future revisions of TIIR

- Keeping pace with technology and field experience will be important
- Subgroup recommends that the TIIR be a "living document" – linked to the MNDIP revision process in a way that is considerate of stakeholder time and resources
- Intentionally high-level at this stage, but details will likely be added as:
  - The TSMs are written and compared, with an aim to standardize across the state where possible
  - More experience is gained

Timeline for Transition

Issues

- UL 1741will not be available to IEEE 1547-2018 standards for 18-24 months (or more)

- There is a need for technical requirements for DER systems that exists today but was not addressed in the 2005 MN Technical Requirements

- Much of the information in the TIIR *most likely* can be implemented now; further review needed to identify areas of TIIR that could not be fully implemented immediately

Timeline for Transition

Possible Solutions

- Allow DER Operator to voluntarily adopt the full TIIR stating at the publication of IEEE 1547.1 and equipment being available that meets updated standard.

- Fall back to existing Technical Requirements (2005) until the timeframe expires in the UL Certification process.

- Identify sections in the TIIR that do not need to be followed until equipment readily available that meets IEEE 1547.1. (Transition TIIR document)

TSG Discussion on Updated TIIIR

- Utility-Specific Technical Specification Manuals
- Reactive Power and Voltage/Power Control
- Communication Requirements
- Other?

Open Phase (Anti-Islanding Testing) and Ground Bank Requirements

- From Xcel's May 25 2018 Letter: Single-phase testing isolates the DER during unforeseen system outages. When DERs are not completely isolated, induced voltage can be pushed back to Xcel Energy causing notable power quality issues, customer equipment damages and potential safety concerns. Section 4.4 of IEEE 1547-2003 (in effect when the CSG were installed) requires that facilities prevent energizing a portion of the Area Electric Power System.

- MNSEIA is hearing from developers concerns about the cost and safety associated with Single phase (anti-islanding) testing requirements Xcel is now requiring from CSG.

- IEEE C62.92.6 – Guide for Application of Neutral Grounding in Electrical Utility Systems - Systems supplied by current-regulated sources

  "…provides definitions and considerations related to system grounding where the dominant sources of system energization are current-regulated or power-regulated power conversion devices."

- EPRI Technical Brief provides additional information on Xcel Energy's findings.

“Living Document”

As these standards go into effect and more distributed energy resources interconnect with utility systems, the Commission expects this to be a living document. (MN DIP, pg. 1)

21. The Commission delegates to its Executive Secretary the authority to establish and maintain an ongoing Distributed Generation Workgroup to meet annually, or more frequently as needed, to review implementation and technical issues that arise with implementation of the MN DIP, MN DIA, or emerging DER technology. Updates to the MN DIP and/or MN DIA may be accomplished by Commission order in response to a petition. (Aug 13, 2018 Commission Order)

Phase II Timing

- If there are outstanding contested issues, staff anticipates a minimum of 4 months from start of written comments to final order.
- IEEE 1547.1 is out for balloting; however, still do not expect certified equipment until 2021.
- Should we host additional TSG meetings to work through any outstanding issues? On what timeframe?
- How should we address timing of TIIR implementation with IEEE 1547.1 and Certification implementation? (See slide 25 for Writing Subgroup Potential Solutions)

Next Steps

May 20, 2019	Xcel Energy Compliance Filing on Phase I tariff updates
May 30, 2019	MISO Follow Up Meeting on Draft Regional Guidance on IEEE 1547
May 31, 2019	TSG Meeting #9: Updated Draft TIIR, Phase II Timing, MISO Regional Guidance, etc.
Jun 17, 2019	Effective Date of the MN DIP and MN DIA
~3Q/4Q 2019	Commission Action on Phase II

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Back Up Slides

Glossary germane to this presentation based on IEEE 1547-2018

- **Commissioning tests:** Commissioning tests are tests and verifications <u>on one device or combination of devices forming a system to confirm that the system</u> as designed, delivered, and installed meets the interconnection and interoperability requirements of this standard. [IEEE 1547-2018 p. 78]
  - Test procedures are provided by equipment manufacturers(s) or system designer(s) and approved by the equipment owner and Area EPS operator. Commissioning tests shall include visual inspections and may include, as applicable, operability and functional performance test.
- **DER evaluation:** DER evaluation comprises a design evaluation desk study during the interconnection review process and an as-built installation evaluation on site at the time of commissioning to verify that the <u>composite of the individual partially compliant DER(s) and, if applicable, the supplemental DER device(s) forming a system</u> meet the interconnection and interoperability requirements of this standard. [IEEE 1547-2018 p. 78]
- **Type tests:** A type test may be performed on one device or combination of devices. In case of a combination of devices forming a system, this test shows that the devices are able to operate together as a system. Type tests shall be performed, as applicable, to the specific DER unit or DER system. The tests shall be performed on a representative DER unit or DER system, either in the factory, at a testing laboratory, or on equipment in the field. Type test results from a DER within a product family of the same design, including hardware and software, shall be allowed as representative of other DERs within the same product family with power ratings between 50% to 200% of the tested DER. [IEEE 1547-2018 Clause 11.2.2]

(<u>emphasis</u> added by staff)

Which IEEE Std 1547-2018 type tests can be certified via UL 1741 (SA)?

Standards for DER		Listing/ Certification			Interconnection Standards			State/ PUC/Utility Rules	
								CA	HI/HECO
Function Set	Advanced Functions Capability	UL 1741	UL 1741(SA) 2016	IEEE 1547.1 -201?*	IEEE 1547-2003	IEEE 1547a-2014	IEEE 1547-2018	Rule 21 (Phases)	Rule 14H & UL SRDv1.1
All	Adjustability in Ranges of Allowable Settings			Δ		√	‡		
Monitoring & Control	Ramp Rate Control		Δ					‡ (P1)	‡
	Communication Interface			Δ			‡	‡ (P2)	‡
	Disable Permit Service (Remote Shut-Off, Remote Disconnect/Reconnect)			Δ			‡	‡ (P3)	‡
	Limit Active Power			Δ			‡	‡ (P3)	
	Monitor Key DER Data			Δ			‡	‡ (P3)	
Scheduling	Set Active Power							[‡ (P3)]	
	Scheduling Power Values and Models							‡ (P3)	
Reactive Power & Voltage Support	Constant Power Factor	√	Δ	Δ	√	√	‡	‡ (P1)	X
	Voltage-Reactive Power (Volt-Var)		Δ	Δ	X	√	‡	‡ (P1)	‡
	Autonomously Adjustable Voltage Reference			Δ			‡	!!!	!!!
	Active Power-Reactive Power (Watt-Var)			Δ	X		‡		‡
	Constant Reactive Power	√		Δ	√	√	‡		
	Voltage-Active Power (Volt-Watt)		Δ	Δ	X	√	‡	‡ (P3)	‡
	Dynamic Voltage Support during VRT						√	[‡ (P3)]	
Bulk System Reliability & Frequency Support	Frequency Ride-Through (FRT)		Δ	Δ			‡	‡ (P1)	‡
	Rate-of-Change-of-Frequency Ride-Through			Δ			‡	!!!	!!!
	Voltage Ride-Through (VRT)		Δ	Δ			‡	‡ (P1)	‡
	VRT of Consecutive Voltage Disturbances			Δ			‡	!!!	!!!
	Voltage Phase Angle Jump Ride-Through			Δ			‡	!!!	!!!
	Frequency-Watt		Δ	Δ	X	√	‡	‡ (P3)	‡
Other Advanced DER Functions	Anti-Islanding Detection and Trip			Δ			‡	‡ (P1)	‡
	Transient Overvoltage						‡		‡
	Remote Configurability						‡	‡ (P2)	‡
	Return to Service (Enter Service)						‡	‡ (P1)	‡

Legend: X Prohibited, √ Allowed by Mutual Agreement, ‡ Capability Required, Δ Test and Verification Defined
[...] Subject to clarification of the technical requirements and use cases, !!! Important Gap

Source: EPRI | *Please contact us for any suggested updates to this table.*

Interconnection Standards Adoption Roadmap Considerations

2016
- UL 1741 (SA) published
- Based on requirements specified in CA Rule 21 and Hawai'ian Rule 14H

2017
- UL 1741 (SA) certified equipment available

2018
- IEEE Std 1547-2018 published
- Requirements go beyond CA Rule 21 and HI Rule 14H

2019+
- IEEE Std 1547.1-2019 published
- UL 1741 updated

2021+
- IEEE Std 1547-2018.1 tested and UL 1741 certified equipment available

Adoption of CA Rule 21 and Hawai'ian Rule 14H by inverter certification per UL 1741 (SA).

Stopgap solution for **adoption of parts of IEEE Std 1547-2018** by inverter certification per UL 1741 (SA).

Full adoption of IEEE Std 1547-2018.

Question from **distribution** perspective:

Early need to increase hosting capacity?

Question from **transmission** perspective:

Early need to address bulk system reliability?

Discussion: Scope for Statewide Technical Requirements

These topics have been proposed as **in scope**.
Bold have been flagged for discussion.

1. Scope/Overview
2. References
3. Definitions
4. **Performance Category Assignments**
5. **Reactive Power Capability and Voltage/Power Control (volt-var & volt-watt) Performance**
6. **Response to Abnormal Conditions (Ride-through)**
7. **Protection Requirements**
8. **Metering**
9. **Interoperability (Monitoring, Control, Info Exchange, Cyber security)**
10. **Energy Storage**
11. Non-Export; Inadvertent Export
12. **Test and Verification Requirements**
13. **Agreements**
14. **Consumer Protection** (IREC)
15. **Reporting** (IREC)

(Source: “Regulated Utilities” TIIR Draft Proposal)

Discussion: Scope for Statewide Technical Requirements

1. Process requirements
2. Cost allocation
3. Interconnection to transmission system
4. **Protection system details of Area EPS or DER**
5. **Requirements or specification of system impact or facilities studies**
6. **Application of real and reactive power control functions**
7. **Details of communication networks; including architecture, technology and protocols, or other specifications related to interoperability**
8. **Details of metering requirements or specifications**
9. **Planning or operational considerations associated with Affected Systems, Regional Transmission Operator or Transmission Owners**
10. **Intentional Area EPS islanding**

These topics have been proposed as **out of scope** by some participants. Bold are flagged for additional discussion.

(Source: TIIR Draft Proposal, p. 9)

Phase II Technical Subgroup Meeting #10

August 9, 2019

(Docket No. 16-521)

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https://mn.gov/puc

Agenda

Time	Topic
2:00-2:10	Welcome, Introductions, Overview of Agenda, Expectations, Recap
2:10 – 2:20	MISO Regional Guidance Update
2:20 – 2:50	Final Update on the DRAFT TIIR
2:50 – 3:20	Utility Technical Specification Manuals/Table of Contents
3:20 – 3:25	Upcoming Schedule/Next Steps in Phase II
3:25 – 4:00	Questions/Feedback – We may end early.

Commission Order

January 24, 2017

- The Commission hereby delegates authority to the Executive Secretary to issue Notice(s), set schedules, and designate comment periods for the scope outlined in paragraphs 2 – 3 below. The Executive Secretary will, in cooperation with the Department of Commerce, convene a work group of appropriate size and composition, and may select a facilitator, to develop the record more fully.
- The Commission will transition the Minnesota Interconnection Process to one based on the FERC SGIP and SGIA. The Executive Secretary will set schedules and take comments. It is anticipated that the Commission will consider the record and comments within 18 months of this order, to replace Attachments 1, 3, 4, and 5 to its 2004 Interconnection Standards in this Docket. The Executive Secretary will use the Joint Movants' May 12, 2016 filing, generally, as the starting point for comments.
- **In the longer-term (nine to twenty-two months), the Executive Secretary will set schedules and take comments on updating the Minnesota interconnection technical standards. It is anticipated that the Commission will consider the record and comments within 24 months of this Order, to replace Attachment 2 to the Commission's 2004 Interconnection Standards. This stage of work would incorporate newly revised national technical standards, and other issues identified as areas in need of updating.**
- The Commission hereby designates Commissioner Matthew Schuerger as lead commissioner pursuant to Minn. Stat. § 216A.03, Subd. 9, with authority to help develop the record necessary for resolution of the issues, and to develop recommendations to the Commission in this docket.

Phase II Meetings: Topics and Timeline

March 23	Scope/Overview; Inventory of Definitions to Discuss
April 13	Performance Categories in Normal & Abnormal Conditions; MISO Bulk Power System
June 8	Reactive Power and Voltage/Power Control Performance; Protection Requirements
July 20	Energy Storage; Non-export; Inadvertent export; Limited export, Capacity
Aug 3	*July 20 topics continued*
Aug 24	Interoperability (Monitor and Control Criteria); Metering; Cyber security
Sept 14	Test and Verification; Protocol to witness Testing
Sept 21	In-Person TSG: Power Quality; Follow up items; TIIR edits discussion
Oct 19	References; Definitions; 1-line diagram requirements; Agreements, Frequency Ride-Through
Nov 9	Full DGWG Meeting # 7
May 31 ’19	MISO Regional Guidance, 2nd Draft TIIR from Writing Subgroup, Open Phase (Anti-Islanding) Testing and Grounding Bank Requirements; MN DIP/DIA & TIIR as “living documents”
Aug. 9 ’19	MISO Regional Guidance, Utility TSMs, Final Draft TIIR from Writing Subgroup

TSG Recap

- TSG has met 11 times over the past 10 months to discuss Minnesota statewide technical interconnection and interoperability requirements for DERs.
- In Sept. 2018, TSG met in person to reconcile and prioritize feedback from first 7 TSG meetings. Writing Subgroup provided 3 draft TIIRs based on TSG feedback. TSG has responded with 3 rounds of feedback.
- Last meeting identified two primary outstanding issues: Utility Technical Specification Manuals and Implementation of TIIR in interim of IEEE 1547-2018 roll out. Writing Subgroup added language to TIIR and sought TSG feedback in June.

Goals for TSG #10

- Final check in on Draft TIIR as TSG prior to Commission issuing a notice of comment on the draft.
- Build shared understanding of
  - MISO Regional Guidance on IEEE 1547-2018 Implementation
  - Utility Technical Specification Manual Scope and Content
  - Phase II Timing and Next Steps

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MISO Regional Guidance on IEEE 1547-2018

MISO July 1 Update

- The draft guideline can be found on: https://www.misoenergy.org/planning/generator-interconnection/ieee-1547/ (look for 6th Straw Proposal in the presentation)
- MISO is currently working with the broader industry to request an amendment to IEEE Std 1547-2018. IEEE 1547 drafting team is discussing with IEEE Standards Association (IEEE SA) and its committees the possibility of an amendment to the voltage ride through requirement to enable easier implementation in MISO, PJM, and ISO NE (maybe others in the future)*. MISO expects the IEEE SA to make a decision by September regarding whether to initiate the amendment process.
- The schedule of MISO guideline document is now intentionally delayed to September to better align with the potential IEEE 1547 amendment.
- MISO will provide more information in August regarding the IEEE 1547 amendment effort. MISO encourages your engagement in the balloting process if the IEEE SA decide to initiate the amendment process.

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Writing Subgroup's Final Draft of TIIR

Jul 3rd Draft TIIR – Summary of Changes

- Writing Subgroup: Kristi Robinson (MREA), Craig Turner (DEA), Brian Lydic (IREC), Allen Gleckner (FE), Alan Urban (Xcel)
- Feedback received from Otter Tail Power and MNSEIA.
- Primary edits address: 1) TSM scope/purpose and 2) transition period to TIIR while IEEE 1547-2018 implementation in progress.
- Minor edits clarify definitions and make clear multiple RTOs serve Minnesota.
- Writing Subgroup provided responses on edits/comments not incorporated.

Jul 3rd Draft TIIR – Summary of Changes

Page	Edit	Group Comment
5	The Area EPS Operator's TSM documents are to be designed to provide utility specific details aligned with the TIIR requirements. The Area EPS Operators' TSM document shall be limited to detailing requirements which are in support of the requirements contained within the TIIR and MN DIP. Additional requirements not contemplated by the TIIR may be mutually agreed upon between the Parties.	Additional language to address the transition to the TIIR from the existing Technical Requirements.
6	**1.6 Transition Period** All requirements of the TIIR are immediately applicable unless requiring equipment that conforms with IEEE 1547-2018 advanced functionalities. Area EPS Operators cannot require the use of certified equipment that meets the requirements of IEEE 1547-2018 until such time the equipment is readily available. At such time certified equipment first becomes available, the Area EPS Operator and DER Owner may mutually agree to utilize the certified equipment and functionalities in conformance with the requirements of IEEE 1547-2018. At such time when certified equipment is readily available(7), the entire TIIR shall be applicable. (7) Refer to UL 1741 CRD for timeline of readily available certified equipment that meets the requirements of IEEE 1547-2018.	Additional language to address the transition to the TIIR from the existing Technical Requirements.

Jul 3rd Draft TIIR – Summary of Changes

Page	Minor Edits	Group Comment
15	NOTE – This definition is based on the IEEE 1547 regional reliability coordinator definition. In Minnesota, i.e. the Midcontinent Independent System Operator (MISO) and Southwest Power Pool (SPP), perform this function based on territory .	**Otter Tail Power**: Minor edit to definition. **Group**: Accepted edit.
16	~~state of~~ Minnesota ~~DER~~ Technical ~~standards~~ Requirements.	Align with MN DIP terminology. **Group**: Accepted edit.
19	Until a decision is made by the Regional Transmission Operator within that region , all synchronous machine DER shall be assigned Category I and all inverter-based DER shall be assigned Category II.	**Otter Tail Power:** Minor additional wording to recognize the multiple RTOs in MN **Group:** Accepted edits.

Jul 3rd Draft TIIR – Summary of Unincorporated Feedback

Page	MNSEIA	Group Comment
20	Provided written comments concerned about the Area EPS Operators "controlling" versus "confirming" of DER control settings. No specific language was provided for review.	The ability to request future control settings is necessitated by the need to adjust performance as DER growth grows or to address distribution system changes. The Interconnection Agreement could have terms that limit the control requests. Timeframe on requested changes are to be aligned with the priority of the request by the Area EPS Operator. (i.e. 3 months allowed for a setting change to occur if not time-sensitive settings change.) It is recognized that the Area EPS Operator should limit the frequency of setting changes.
21	Provided comments regarding the installation to have a constant power factor mode that is enabled with a .98 PF.	Any DER that meets IEEE 1547-2018 shall meet the constant power factor requirement. This requirement is for the DER only, disregarding the load connected at the RPA.
25	"At the DER's election, proof that the DER will not result in an open phase condition occurring directly at the RPA and that the DER will not result in unintentional islands, and the monitoring of both therein, shall be possible through real world testing, diagrams, digital models, or other theoretical models that will confidentially illustrated the DER's abilities to adhere to IEEE 1547 and the TIIR."	It was discussed the concept of "paper" reviews of the open phase functional test. At this time IEEE 1547-2018 requires this actual functional test and the Group feels the actual test shall remain. The proposed edits were not accepted. MNSEIA's concern about open-phase testing appears to be more of an implementation issue on how the open phase testing is performed safely
29	Comment was made that storage that does not export to the distribution system should be eliminated from review	Storage that does not export to the distribution system not having to be reviewed is more of an Interconnection Process issue, and is out of scope for the TIIR. Section 11 does discuss the configuration of non-export

Jul 3rd Draft TIIR – Summary of Unincorporated Feedback

Page	MNSEIA	Group Comment
32	Comment was provided requiring test result of UL1741 was redundant and an overreach	This functionality is not part of every UL 1741 certified system. Power control limiting and power control systems are additional equipment that interact with a DER unit and would have their own testing requirements
35	Comment on the practicality of testing impedance.	There is no specific test for impedance. It appears with MNSEIA's comments that source impedance is confused with physical equipment impedance. This is a requirement of IEEE 1547-2018 and should not be eliminated. IEEE 1547 11.3.2 see footnote in that section.
37	Updates to firmware and software occur frequently and could be a burden on the DER Operator to notify the Area EPS Operator.	This is a concern of burden for both the Area EPS Operator and the DER Operator, however both software and firmware changes can drastically change the way the DER operates. Until further guidance is provided by IEEE, it is unrealistic for the TIIR to narrow down the types of software/firmware changes that should be reported to the Area EPS Operator. (IEEE 1547.2 workgroup may address this concern in the future)
Page	**Otter Tail Power**	**Group Comment**
30	"xi. Abnormal system configuration that may limit the output of the generator" OTP has used this provision to allow a generator to come on-line prior to all upgrades being completed in the MISO world.	The Group believed that item ii in the list states that same concept as the OTP proposed language. The Group did not accept the edit. *ii. Documenting at the time of application the charge/discharge profile(s) or use case(s) intended to be utilized by the ESS owner. This information may be collected through an Area EPS Operator specific document or the Area EPS Operator's online application portal*

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Utility Technical Specification Manuals

Jun 2019 DRAFT – Utility TSM Outline

1	Introduction	
2	Performance Category Assignment	Normal performance category, Assignment of abnormal performance category
3	Reactive Power Capability and Voltage/Power Control Performance	Voltage and reactive power control, Voltage and active power control
4	Response to Abnormal Conditions	Voltage ride-through and tripping, Frequency ride-through and tripping
5	Protection Requirements	AC disconnect, Protection
6	Signage and Labeling	Residential roof top, Residential ground mount, Large scale
7	Metering Requirements	Meter socket placement and type, Location and access of metering
8	Interoperability	Local DER communication interface, Cyber security
9	Energy Storage	Considerations not covered by industry standards
10	Test and Verification Requirements	Procedure, Documentation, Failure protocol, Testing procedure
11	Power Quality	Operations on start-up and shutdown, Resolving power quality issues found after interconnection, Normal operating bounds of expected power quality.
12	Modifications to Existing DER system	Process for notification of ESS Control Modes
13	Required Documentation	Information required on one-line diagram, Site diagram, Nameplate capacity documentation

Source: Craig Turner, DEA. TSM-Technical Specification Manual_draft Outline June 2019.docx

Phase II Next Steps

Aug. 2019	Notice of Comment on Draft TIIR Issued
Sept. 24, 2019	Initial Comment Deadline on Draft TIIR
Oct. 11, 2019	Reply Comment Deadline on Draft TIIR
Nov. 2019	Agenda Meeting on Draft TIIR
~1Q 2020	Order on Phase II Issued

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Thank You!