WIRAB Webinar

Implementation of IEEE 1547 Standard: Interconnection of DERs and Utility Electric Power Systems

Tuesday, August 21, 2018

2:00 - 3:00 Mountain Time

1:00 - 2:00 Pacific Time
Outline of Today’s IEEE 1547 Webinar

- Debbie Lew, GE: The revised 1547: Opportunities for Energy Regulators (The Why)
- Jens Boemer, EPRI: How regulators may apply the revised 1547 standard; Decisions that need to be made (The How)
- Michelle Rosier, Minnesota PUC: Example of the Minnesota PUC process in developing stakeholder process and applying the revised 1547 (A Leading Practice)
The Revised 1547: Opportunities for Energy Regulators

Debbie Lew, GE Energy Consulting

WIEB Webinar, 21 August 2018
The DER Interconnection Standard IEEE 1547 has been revised

### IEEE 1547-2003

- A traditional DER paradigm
- DER is passive
- DER provides only energy
- Owners are incentivized to provide as much energy as they can
- No communications
- No control

### IEEE 1547-2018

- Unlocks smart inverter capabilities so that DER can act like conventional, transmission-connected resources
- DER may now be active
- Two-way communications
- Can control power output and provide ancillary services
- Supports bulk system reliability

What capabilities do you want?
What does IEEE 1547-2018 cover?

- Specifies performance of interconnection, not design
- Specifies capabilities, not necessarily utilization of capability

**Area Electrical Power System (EPS)**

**Distributed Energy Resource (DER) – connected to distribution system (eliminates 10MVA cap)**

**1547**

**Power interface**

**Communication interface**

Lew, GE, WIEB Webinar
Hand-in-hand with *use* of these new features is *compensation* for them

**Capabilities**

- Two-way communications: visibility and control
- Control reactive power: voltage regulation
- Control active power: curtail
- Frequency response: increase power if low frequency
- Regulation reserves
- Spinning and non-spinning reserves

**Compensation**

- Requirements
- Compensation for each service
- Pay for performance
- Equity issues for different level of service at different locations

*Align compensation with provision of services*
IEEE 1547-2018
What you still need to be careful of

- Requires some capabilities (functionalities), not the actual utilization (provision)
- Doesn’t control active power output of (curtail) DER but allows for it
- Doesn’t require two-way communication but requires certain communication protocol capabilities
- Legacy systems will still exist!
Applying IEEE Std 1547-2018: What Public Utilities Commissions Need To Decide and Do

Dr. Jens C. Boemer, Principal Technical Leader, EPRI
WIRAB Webinar
August 21, 2018
Summary: IEEE 1547-2018 — What Does It Mean for Me?

- **Opportunities** to integrate DER reliably, securely, and efficiently into the grid
- **Actions required** to
  - Assign performance categories per DER technology and use case
  - Specify “preferred” utility-required profiles for DER functional settings
  - Specify certification for DER equipment and possibly verification for DER facilities

- **Opportunities** to interconnect larger amounts of DER
- **Clarity** regarding
  - Interconnection capabilities
  - Reference point of applicability
  - Functional settings
- **Potential need** for more sophisticated DER facility evaluations to verify compliance

- **Opportunities** to utilize advanced DER capabilities
  - Increase distribution hosting capacity
  - Improve bulk system reliability

- **Actions required** to specify
  - Functional settings ≠ “preferred”
  - Performance categories
  - Communication interface
  - **Coordinate across T&D**

- **Opportunities** for new business
  - Testing and certification of advanced DER units
  - Evaluation and verification of DER facilities
  - Support utilities in distribution planning with advanced DER functions
  - Support reliability coordinators in transmission planning with DER
  - Support DER developers in verification / compliance through DER evaluations

- **Utilities** (both T + D)

- **Energy Regulators** (e.g., PUCs)

- **Others** (NRTLs, certifiers, consultants)
What you need to decide and do

1. When does this voluntary IEEE standard apply to you?

- How are your interconnection requirements specified and do they need to be revised?
- Do you want to take advantage of advanced capabilities of new DERs going forward?
- How many DERs may be installed prior to you adopting the new standard?
- Do you want to go beyond leading interconnection requirements like CA Rule 21 and Hawaiian Rule 14H?
What you need to decide and do

1. When does this voluntary IEEE standard apply to you?
2. Form a stakeholder process! A single voice cannot make these decisions because various stakeholders are affected.

- Distribution Utilities (Area Electric Power System Operators)
- Regulators (Authorities Governing Interconnection Requirements, AGIRs)
- DER owners/developers
- RTOs/ISOs (Regional Reliability Coordinator)
- May need input from DER vendors/equipment manufacturers
What you need to decide and do

1. When does this voluntary IEEE standard apply to you?
2. Form a stakeholder process! A single voice cannot make these decisions because various stakeholders are affected.
3. Collaboratively determine what performance/functional capability is needed from DERs?

- Voltage regulation – Utilities’ and/or DER owners’ interest
- Ride-through - Reliability coordinators’ interest
- Communications – Utilities’ and Market Operators’ interest
What you need to decide and do

1. When does this voluntary IEEE standard apply to you?
2. Form a stakeholder process! A single voice cannot make these decisions because various stakeholders are affected.
3. Collaboratively determine what performance/functional capability is needed from DERs?
4. Determine ‘preferred’ utility-required profile (URP) for autonomous functions.

- **Utility-Required Profiles (URPs)**

  - **IA-URP** (site specific)
  - **DU-URP** (distribution utility specific)
  - **Preferred URP**¹ (state-wide or similar)
  - **Adopted SRD**¹ (state-wide or similar)
What you need to decide and do

1. When does this voluntary IEEE standard apply to you?

2. Form a stakeholder process! A single voice cannot make these decisions because various stakeholders are affected.

3. Collaboratively determine what performance/functional capability is needed from DERs?

4. Determine ‘preferred’ utility-required profile (URP) for autonomous functions.

5. Determine DER communication protocol(s).

- SunSpec Modbus
- IEEE Std. 1815 (DNP3)
- IEEE Std. 2030.5
You need to decide how *stringent* requirements should be for different resources

Normal and Abnormal Performance Categories
Performance categories for Normal Operation

Reactive power and voltage regulation

Regulators (AGIRs) need to work with:

- Distribution utilities, because voltage affects the local distribution grid
- DER owners/developers, because this can affect costs (e.g., inverter sizing) and benefits (active power output)

Decisions to be made:

- May assign technology-specific normal DER performance categories (e.g., Cat. B for inverters)
- May activate certain functions and specify ‘preferred’ functional settings for a region (e.g., how aggressively the DER tries to manage voltage)
Performance categories for Abnormal Operation

**Frequency ride-through**

- **Category I**: Single frequency ride-through requirement that meets all bulk system needs, coordinated with NERC reliability and UFLS standards, harmonized with CA/HI rules.

**Challenge: Coordination with unintentional islanding prevention**
Performance categories for Abnormal Operation

Voltage ride-through

Decision criteria:
- Technology limitations
- Benefits & costs
- Expected regional DER penetration / bulk system modeling

Abnormal Operation

Category I
Essential voltage ride-through capabilities
All state-of-art DER technologies can meet this

Category II
DER voltage ride-through for all bulk system needs
Consideration of FIDVR

Category III
Bulk + distribution grid needs
Coordinated with CA/HI rules
Adjustable trip ranges limited

Challenge: Coordination with utility reclosing practices

1 fault-induced delayed voltage recovery, e.g., caused by single-phase air-conditioning systems.
You may need to coordinate functional settings between distribution and transmission utilities

Functional settings, ranges of allowable settings, and default values
What are ranges of allowable settings?

Voltage Reactive-Power Control Settings

- Increase hosting capacity
  - by addressing voltage issues with exchange of reactive power.
  - may require feeder-specific settings.

Voltage/Frequency Trip Settings
Moving forward…

- Need for education and knowledge transfer prior to opening formal proceedings:
  - Distribution and transmission owners/planners
  - State regulators, policymakers

- May use a stopgap solution for equipment certification while IEEE P1547.1 (test & verification procedures) still being revised
  - Adopt parts of IEEE 1547-2018 with UL 1741 SA-certified “grid support utility interactive” inverters

- Collaborative learning opportunities in
  - EPRI project “Navigating DER Interconnection Standards & Practices” (near-term, EPRI members only)
  - IEEE P1547.2 (Application Guide for IEEE 1547) (mid-term, public stakeholders)
Together…Shaping the Future of Electricity

jboemer@epri.com
206.471.1180
Extra slides
Road Map to Unlock Benefits of “Advanced DERs”

1. Decide on DER capabilities (i.e., adopt IEEE Std 1547-2018)
   - Specify DER performance & functional capabilities / categories.
   - Specify DER communication protocol(s).
   - Specify ‘preferred settings’ for autonomous functions.

2. Update interconnection procedures & screenings
   - Criteria for “fast track”, new supplemental screens.
   - Utilization of autonomous functions: activate certain functions and determine ‘custom settings’.

3. Deploy communication infrastructure
   - Determine when it is time to integrate DER via communications.
   - Select communication networks and architecture.

4. Integrate DERs into grid operations and markets
   - Clarify compensation and market rules.
   - Utilization of communication-based functions.
Scope of 1547 Session

**Interconnection & Communication Capability**
- Examples
  - IEEE Std 1547-2018 ✓
  - IEEE Std 2030.5 (SEP2) ✓
  - IEEE Std 1815 (DNP3) ✓
  - SunSpec Modbus ✓
  - IEC 61968-5 Distributed Energy Optimization ✗
  - IEEE p2030.11 (DERMS) ✗

**Informed Policy & Regulation**
- Examples
  - IEEE Std 1547-2018 adoption (voluntary industry std)
  - Assigning normal & abnormal performance categories
  - Potential customer impacts & benefits from utilization of DER new capabilities

**Grid Modernization**
- Examples
  - Communication infrastructure
  - Federated Architecture for DER
  - Reclosing practices

**Integrated Planning & Ops**
- Examples
  - DER modeling in T & D
  - DER visibility & control
  - ADMS/DERMS ↔ SCADA
  - DER interconnection procedures & screening

**Compensation & Markets**
- Examples
  - Compensation rules
  - DER in wholesale markets
  - Markets at distribution level
## Example of assigning performance categories for Abnormal Operation

<table>
<thead>
<tr>
<th>DER Type</th>
<th>Retail Self Generation</th>
<th>Combined Heat and Power</th>
<th>Waste Fuel Recovery</th>
<th>Renewable Energy</th>
<th>Merchant Generation(^a)</th>
<th>Critical Backup(^b)</th>
<th>Peak Shaving</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Engine or turbine driven synchronous generator</td>
<td>Category I</td>
<td><strong>Category I</strong></td>
<td>Category I</td>
<td>Category I</td>
<td>Category I</td>
<td>Category I</td>
<td>Category I</td>
</tr>
<tr>
<td>2 Wind turbines (all types)</td>
<td>Category II</td>
<td>N/A</td>
<td>N/A</td>
<td>Category II</td>
<td><strong>Category II</strong></td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3 Inverters sourced by solar PV</td>
<td>Category II(^c)</td>
<td>N/A</td>
<td>N/A</td>
<td><strong>Category II(^c)</strong></td>
<td>Category II</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>4 Inverters sourced by fuel cells</td>
<td>Category I</td>
<td>Category I</td>
<td>Category I</td>
<td>Category I</td>
<td>Category II</td>
<td>Category I</td>
<td>N/A</td>
</tr>
<tr>
<td>5 Synchronous hydrogenerators</td>
<td>Category I</td>
<td>N/A</td>
<td>N/A</td>
<td>Category I</td>
<td>Category I</td>
<td>Category I</td>
<td>N/A</td>
</tr>
<tr>
<td>6 Other inverter applications</td>
<td>Category II</td>
<td>Category II</td>
<td>Category II</td>
<td>Category II</td>
<td>Category II</td>
<td>Category II</td>
<td>N/A</td>
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<tr>
<td>7 Inverters sourced by energy storage</td>
<td>Category II</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Category II</td>
<td>Category II</td>
<td>Category II</td>
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<tr>
<td>8 Other synchronous generators</td>
<td>Category I</td>
<td>Category I</td>
<td>Category I</td>
<td>Category I</td>
<td>Category I</td>
<td>Category I</td>
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<tr>
<td>9 Other Induction generators</td>
<td>Category II</td>
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</table>

**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].

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# Comparison of Existing Standards, State/PUC Rules, and Listing/Certification Standards for Distributed Energy Resources

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<tbody>
<tr>
<td>Static</td>
<td>Adjustable Trip Settings</td>
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<td>Active Power Curtailment</td>
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<td>Disable Permit Service (Remote Shut-Off)</td>
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<td>Ramp Rate Control</td>
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<tr>
<td>Controlling</td>
<td>L/H Frequency Ride-Through</td>
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<td>ROCOF Ride-Through</td>
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<td></td>
<td>Frequency-Watt</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Freq. Support</td>
<td>L/H Voltage Ride-Through (L/H VRT)</td>
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<td>Dynamic Voltage Support during L/H VRT</td>
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<td></td>
<td>Voltage Phase Angle Jump Ride-Through</td>
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<tr>
<td></td>
<td>Fixed Power Factor</td>
<td>✓</td>
<td>✓</td>
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<td></td>
<td>Fixed Reactive Power</td>
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<tr>
<td>Voltage Support</td>
<td>Volt-Var</td>
<td>×</td>
<td>✓</td>
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<td>Volt-Watt</td>
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<td>Watt-Var</td>
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</tbody>
</table>

* Final requirements not confirmed.

Legend:  
- X Prohibited, ✓ Allowed by Mutual Agreement, ‡ Capability Required, Δ Test and Verification Defined

IEEE Std 1547-2018 is most comprehensive and makes all capabilities mandatory.

Testing / Verification is as important as the requirements.
Leading examples in application of IEEE Std 1547-2018

Massachusetts

- In early 2017, ISO-NE identified advanced DER requirements as urgent action. >60% of PV in MA.
- EPRI worked with MA’s Technical Standards Review Group, tasked by PUC with distribution interconnection requirements. No additional proc.
- Certification with UL 1741SA offers a practical stopgap solution until revised IEEE 1547.1-certified equipment becomes available (~2020).
- Completed Preferred Utility-Required Profile (URP) in Feb 2018. Now working with utilities, regulators, muni’s, and co-ops in each state to implement it.

PJM

- PJM needs new requirements in 1-2 years
- Most DER is under local jurisdiction, PJM has limited authority. One issue is that regulatory references to 1547 differ between states.
- EPRI is working with PJM to develop a technical consensus prior to entering regulatory proceedings: single set of “preferred” ride-through and trip settings, involvement of T & D planners
- Plan is to have final documentation of consensus in 2019. Subsequently, PJM rules and distribution utility discussions under local regulation

Minnesota PUC

- Very sophisticated, well-structured, and transparent stakeholder process.
- Revised DER interconnection screenings (Phase 1) last year.
- Now working on revision of interconnection requirements (Phase 2) this year.
Regulatory Perspective: IEEE 1547 Revision and DER Interconnection Standards

Spring 2018 Joint CREPC-WIRAB Meeting (August 21, 2018)
The ideas expressed are the views of the presenter, and not the Minnesota Public Utilities Commission.
• Identify a well-balanced workgroup or informal group of individuals from utilities, DER industry, and consumer advocates.

• Establish a clear process (scope and timeframe) that grounds recommendations in guiding principles and facts.

• Encourage shared learning and include Commission.

• Keep in mind future proofing versus driving specific outcomes.

• Engage outside expertise in a transparent way.
Future Proofing and Grid Modernization

Source: ICF, Integrated Distribution Planning, August 2016, prepared for MN PUC
• 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 Interconnection Update

## Phase I
Interconnection Process, Applications, Agreements

## Phase II
Technical Requirements consistent with newly revised IEEE 1547 (Published April 6, 2018)

## Phase III?
- Compensation?
- Rate Design?
- Incentive for the utility?

<table>
<thead>
<tr>
<th>Phase I</th>
<th>Phase II</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 initial documents (FERC SGIP/SGIA, Joint Movants’ Red-line of FERC; Dakota Electric Red-line of MN existing stds)</td>
<td>1 initial document (Regulated Utilities’ Technical Interconnection and Interoperability Requirements Proposal)</td>
</tr>
<tr>
<td>15 organizations (engineers, regulatory staff, lawyers, advocates)</td>
<td>9 organizations (engineers, technical experts)</td>
</tr>
<tr>
<td>5 full day In Person meetings – 1 year</td>
<td>8 half day web meetings – 7 months; 3 full day In Person mtgs</td>
</tr>
<tr>
<td>Draft staff recommendations (4 rounds of comments)</td>
<td>Edits as we go (~2 rounds of comments)</td>
</tr>
</tbody>
</table>

8/21/2018

https://mn.gov/puc
## Workgroup Topics & Timeline

<table>
<thead>
<tr>
<th>2017</th>
<th>PHASE I In-Person Topics</th>
<th>2018</th>
<th>PHASE II Web Meeting Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>June 2</strong></td>
<td>Pre-app report; Application requirements; Queue type &amp; process; Material Modification Definition; Fast Track; Site Control</td>
<td><strong>March 23</strong></td>
<td>Scope/Overview; Inventory of Definitions to Discuss</td>
</tr>
<tr>
<td><strong>July 28</strong></td>
<td>Definitions; Transmission Provider’s role; Engineering screens; Study process; process timelines/extensions; dispute resolution</td>
<td><strong>April 13</strong></td>
<td>Performance Categories; Response in Normal and Abnormal Conditions; MISO Bulk Power System</td>
</tr>
<tr>
<td><strong>Sept 15</strong></td>
<td>Insurance; Disconnect Switch; metering; Commissioning/inspection, testing, authorization; Design, procure, install, construct facilities/upgrades; advanced inverters</td>
<td><strong>May 18</strong></td>
<td>Reactive Power and Voltage/Power Control Performance; Protection Requirements</td>
</tr>
<tr>
<td><strong>Dec 1</strong></td>
<td>Interconnection Agreement; process for updating; Transition issues; any outstanding issues</td>
<td><strong>Sept 14</strong></td>
<td>Test and Verification; Witness Test Protocol</td>
</tr>
<tr>
<td></td>
<td>Webinar for feedback on some of the draft staff recommendations and descriptions of outstanding issues</td>
<td><strong>Sept 21</strong></td>
<td>Full Day In Person to Revisit and Reconcile Edits</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Oct 3</strong></td>
<td>References; Definitions; 1-line diagram requirements; Agreements</td>
</tr>
</tbody>
</table>
• Definition and application of limits to a DER’s “capacity” versus nameplate rating.

• Non-export or Limited export; including inadvertent export.

• Metering requirements

• Distribution upgrades for remote control and monitoring

• 1-line diagrams
Phase II Preliminary Take Aways

1. Familiarize yourself with IEEE 1547.

2. Establish a technical subgroup with utility and DER expertise.

3. Work with your RTO/ISO and neighboring states.

4. Recognize the elephant in the room (may not be in scope) and frame your process appropriately.

5. Work with technical experts in a transparent way.

6. Interim implementation requires consideration.
1. Familiarize yourself with IEEE 1547

• Authority Governing Interconnection Requirements:

  authority governing interconnection requirements (AGIR): A cognizant and responsible entity that defines, codifies, communicates, administers, and enforces the policies and procedures for allowing electrical interconnection of DER to the Area EPS. This may be a regulatory agency, public utility commission, municipality, cooperative board of directors, etc. The degree of AGIR involvement will vary in scope of application and level of enforcement across jurisdictional boundaries. This authority may be delegated by the cognizant and responsible entity to the Area EPS operator or bulk power system operator.

  NOTE—Decisions made by an authority governing interconnection requirements should consider various stakeholder interests, including but not limited to Load Customers, Area EPS Operators, DER Operators, and bulk power system Operator.

• Capabilities → Enabling Capabilities → Utilization → Reporting

• Annex B is an informational guide for setting performance categories

• Provide engineering support to your staff.

2. Establish a Technical Subgroup w/ Utility & DER Expertise

- 6 utility representatives (IOU, cooperative, municipal) and 5 non-utility representatives (DER, customers, etc.)

- **Green** formed “Regulated Utilities” and submitted a draft MN Technical Interconnection and Interoperability Requirements proposal that serves as the working document for edits.

- 3 representatives participated in IEEE 1547 revision (including 2 from “Regulated Utilities”).

- EPRI and NREL participate as technical assistance with goal of creating a road map for other utilities and states going through this update.

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<thead>
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<tbody>
<tr>
<td>Lise Trudeau, Dept of Commerce</td>
<td>Kevin McLean/Jenna Warmuth, MN Power</td>
<td>Tam Kemabonta/Professor Mahmoud Kabalan, Academic/unaffiliated</td>
</tr>
<tr>
<td>Brian Lydic/Sky Stanfield/Laura Hannah – Interstate Renewable Energy Council, Fresh Energy, Environmental Law &amp; Policy Center (Joint Movants)</td>
<td>Dean Pawlowski, Otter Tail Power</td>
<td>Commissioner Matt Schuerger; Staff: Michelle Rosier; Cezar Panait.</td>
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</tbody>
</table>
IEEE 1547 considers and seeks to address bulk power system issues.

Establish contact early and identify the right people.

Ask for an update on: 1) DER impact analysis efforts, and 2) Existing Bulk Power System voltage and frequency concerns and causes.

If possible, work collaboratively with respect for each other’s roles.
4. Capabilities vs. Utilization and State Requirements

• Utilization of IEEE 1547 required capabilities brings questions re: compensation; visibility; dispute resolution.

• How do you address the gap between setting a performance requirement (re: capability) and the Area EPS utilizing those capabilities?

• FERC Order 842: Frequency Response
  • “While we are requiring newly interconnecting generating facilities to install equipment capable of providing frequency response and adhere to specified operating requirements, we are not mandating headroom, which is a necessary component for the provision of primary frequency response service.”

• Utilization can have impacts on DER owners (active power curtailment, reactive power exchange, head room) and distribution utilities (voltage or frequency ridethrough with extended trip settings)

• Utilizing interoperability and communication enabled with IEEE 1547 at the DER local interface may require additional equipment and investment in areas outside IEEE 1547’s scope by utility and/or DER customer/operator.

• What should the role of statewide technical requirements be?
5. Work w/ Technical Experts in Transparent Way

• National Renewable Energy Laboratory (NREL), Electric Power Research Institute (EPRI), Regulatory Assistance Project (RAP), and Dept of Energy Solar Energy Innovator Program have provided significant technical assistance to our process.

• Check IEEE 1547 list to see who participated in the revision.
  • MN PUC is fortunate to have a Lead Commissioner and engaged utility and DER representatives who participated in the IEEE 1547 revision. They help provide additional insights into what is meant by IEEE 1547 and suggestions on how to work through the state requirements.

• If possible, offer shared learning opportunities.
  • IEEE has hosted 3 full day trainings on IEEE 1547 in the US; including one MN PUC and Organization for MISO states jointly hosted. IEEE also has a webinar series.
  • EPRI has a number of white papers and webinar content.
  • NREL has the Distributed Generation Interconnection Collaborative (white papers, webinars) and lessons learned from other states.
  • Our local experts provided their insights during the drafting and helped identify areas of crossover with Phase I update.
Interim Implementation?

<table>
<thead>
<tr>
<th>Step</th>
<th>Timeline</th>
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<tbody>
<tr>
<td>IEEE 1547 2nd Edition (2018) Published</td>
<td>April 6, 2018</td>
</tr>
<tr>
<td>MN Statewide Technical Requirements Approved</td>
<td>1Q 2019</td>
</tr>
<tr>
<td>IEEE 1547.1 Published</td>
<td>Mid-to-late 2019</td>
</tr>
<tr>
<td>UL 1741 Certified Products Available on Market</td>
<td>18 months after IEEE 1547.1 Published (~2020)</td>
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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 (SRD):

<table>
<thead>
<tr>
<th>Location</th>
<th>SRD</th>
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<tbody>
<tr>
<td>California</td>
<td>Rule 21</td>
</tr>
<tr>
<td>Hawaii</td>
<td>14H</td>
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<tr>
<td>ISO-NE</td>
<td>1547-2018</td>
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</tbody>
</table>
• FERC Small Generator Interconnection Process (SGIP) & Interconnection Agreement (SGIA):
https://www.ferc.gov/industries/electric/indus-act/gi/small-gen.asp

• NREL Distributed Generation Interconnection Collaborative:
https://www.nrel.gov/dgic/

• Database of State Incentives Renewable Energy (DSIRE) Interconnection Pages:
http://programs.dsireusa.org/system/program?type=14&

• NERC and IEEE Workshop on IEEE 1547-2018 – Sept 26, 2018 in Atlanta, GA
http://standards.ieee.org/events/interconnection-eps.html

• IEEE 1547 available for purchase: