



# UM 2111

**Incorporating updated standards:  
IEEE 1547-2018  
8-31-2022**



# Agenda



Item	Schedule	Time
Welcome		
Approach/Process	9:00	15 min
IREC Presentations <ul style="list-style-type: none"><li>• Decision Adoption Matrix</li><li>• Prioritization of Mid-Term issues and scheduling</li><li>• Requirements in Rule vs. Manual</li></ul>	9:15	105 min
Discussion of Near-Term issues	11:00	50 min
Next Steps	11:50	10 min
Adjourn	12:00	

# Approach



- Phase 1 Topics (adopted by Commission)
  - Modernizing the screening and interconnection study practices;
  - Incorporating advanced inverters, storage, islanding, and other modern configurations;
  - Incorporating updated standards, such as IEEE 1547-2018;
- Expectations – move process forward, everyone expected to work towards solutions
  - Goal to have actionable items at six-month and twelve-month marks

# Initial prioritization strategy



1. New, quick win policies
2. IREC matrix to guide discussion
3. Other quick wins from parties
4. Mid- and longer-term goals

Use incorporation of DER as the driver for prioritizing IEEE 1547 – 2018 Updates in appropriate manner – [see Staff Report on HB 3141 with PPC going to "distribution system connected technology" \(DSCT\)](#)

- Incorporate via
  - Guidelines
  - OARs (Oregon SGIP [OAR 860-082](#); Oregon NEM [OAR 860-039](#))
  - Utility Interconnection Requirements/documents
- Then, consider next steps

While working through sections of the OARs referencing IEEE 1547 standards, identify differences between current OARs and best practices for incorporating

Consider additional quick win proposals from parties

# Process



- First workshop discussing specific topic
  - Introduce topic, discuss goals and general concepts, identify parties interested in drafting a proposal for rule language and encourage collaboration amongst aligned parties to avoid multiple competing drafts
- Interested stakeholders collaborate on proposal following workshop
- Proposal circulated among service list one week (or more) prior to second workshop
- Second workshop – discuss proposal and provide feedback
- Opportunity for counter-proposal, or further refinement of initial proposal following second workshop (circulate both one week prior to next meeting)
- If consensus not achieved by third workshop:
  - Continue refining proposal if consensus possible, or
  - Stakeholders to submit competing proposals with written justification
- Develop Final Report
  - Document consensus or competing rule language proposals
  - Include supporting justification for consensus and/or competing proposals
  - Final Report should include sufficient record for Commission decision

# Presentations



- IREC – Midhat Mafazy and Brian Lydic
  - Decision Adoption Matrix
  - Prioritization of Mid-Term issues and scheduling
  - Requirements in Rule vs. Manual

# UM 2111: Incorporating updated standards, IEEE 1547

*Background/supporting slides  
for the Kickoff workshop on  
8/31/22*

# More references/guidance available



**IEEE 1547 Adoption: Decision Options Matrix**

IREC’s Decision Option Matrix is intended to be a resource for Public Utilities Commissions, utility personnel, and other DER stakeholders interested in adopting and implementing IEEE 1547-2018 in their jurisdictions. The matrix includes an exhaustive list of Decision Options (DO’s) that stakeholders should consider before implementing the updated standard. The DO’s provide a step-by-step guidance to incorporating the updated standard into the interconnection rules and procedures. The DO’s translate technical content within the standard, as well as related issues, into easily digestible decisions that impact DER interconnection reviews and operations (i.e., timeline, voltage regulations, interoperability). The matrix includes over thirty DO’s, organized into three IEEE 1547-2018 adoption categories, namely:

- A. Near-term items (actions needed as first steps in the adoption process),
- B. Mid-term items (actions that should, for the most part, be taken before the implementation date), and
- C. Long-term items (actions that may be taken after the implementation date, may require formal roadmap, or may require ongoing reevaluations).

It may take more than six months for a working group to select the near-term DO’s, including education, discussion and formalization of consensus. Further time will then be needed for the Commission to take related actions. This matrix can be used to help guide the schedule of working groups and select a feasible implementation date. Any jurisdictions going through IEEE 1547-2018 adoption can use this DO matrix. Its use should help streamline the adoption of IEEE 1547-2018 and provides a means to transparently communicate key decision points. Users can download the matrix and use the DO items to communicate and keep track of key decisions. Users may also tailor the matrix and its DO’s to respective jurisdiction and preferences (i.e., color code individual DO based on whether such decision falls within interconnection rules and procedures vs. whether the DO’s falls within a utility interconnection handbook/manual). IREC’s publication Making the Grid Smarter: Primer on Adopting the New IEEE 1547™-2018 Standard for Distributed Energy Resources dives deeper on many of these topics, and references to relevant sections of the paper are given in brackets. Other references are mentioned as needed. Notably, The Toolkit and Guidance for the Interconnection of Energy Storage and Solar-Plus-Storage (“BTRIES Toolkit”)<sup>1</sup> offers potential solutions for several DO’s.

	Topic	What to consider?	Decision Option (DO) Description	Utilize?
Near-Term	Adoption timeline	Consider equipment availability, the use of UL 1741 SA certification in the interim (if needed), and whether naming a date certain is necessary before certified equipment is widely available. Compliance requirements are usually based on the interconnection application submission date. Compliance may be based on interconnection	<b>DO 1a-1:</b> Comply with IEEE 1547-2018 beginning [some date before April 1, 2023].	<input type="checkbox"/>
			<b>DO 1a-2:</b> Comply with IEEE 1547-2018 beginning ~April 1 <sup>st</sup> , 2023 or a later date.	<input type="checkbox"/>



See NREL for further resources:  
<https://www.nrel.gov/grid/ieee-standard-1547/>

See BTRIES Toolkit for Interconnection of Energy Storage, Chapter VIII is dedicated to Standards:  
<https://irecusa.org/programs/btries-storage-interconnection/>





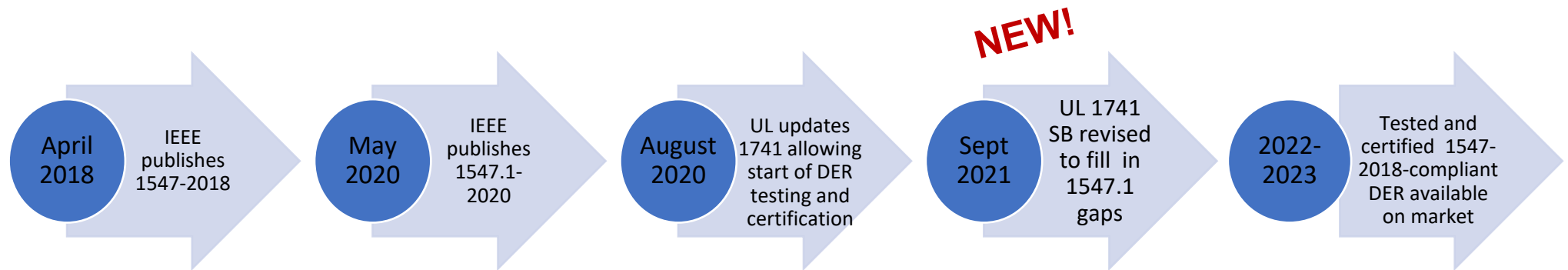
# Agenda

- Near-Term topics & issues (meant to complement IREC's Matrix)
  - Adoption Timeline
  - Abnormal (I, II, III) and Normal (A, B) performance category
  - Alternative performance category
  - Voltage/frequency trips settings
  - Frequency droop settings
  - Voltage regulation modes
- Scheduling and Prioritization
- Where will the technical requirements reside?

# Near-Term issues



# Adoption Timeline



*It is challenging to get certified equipment to market in less than 18 months.*

# Adoption Timeline

Weeks	Expected Accumulation
0	0.0%
12	1.9%
24	12.3%
36	47.1%
48	67.1%
60	80.6%
72	84.5%
144	100.0%



*Chart shows cumulative certifications for each NRTL testing pathways over time. Vertical line represents one year*

# Abnormal operating performance category: Category I

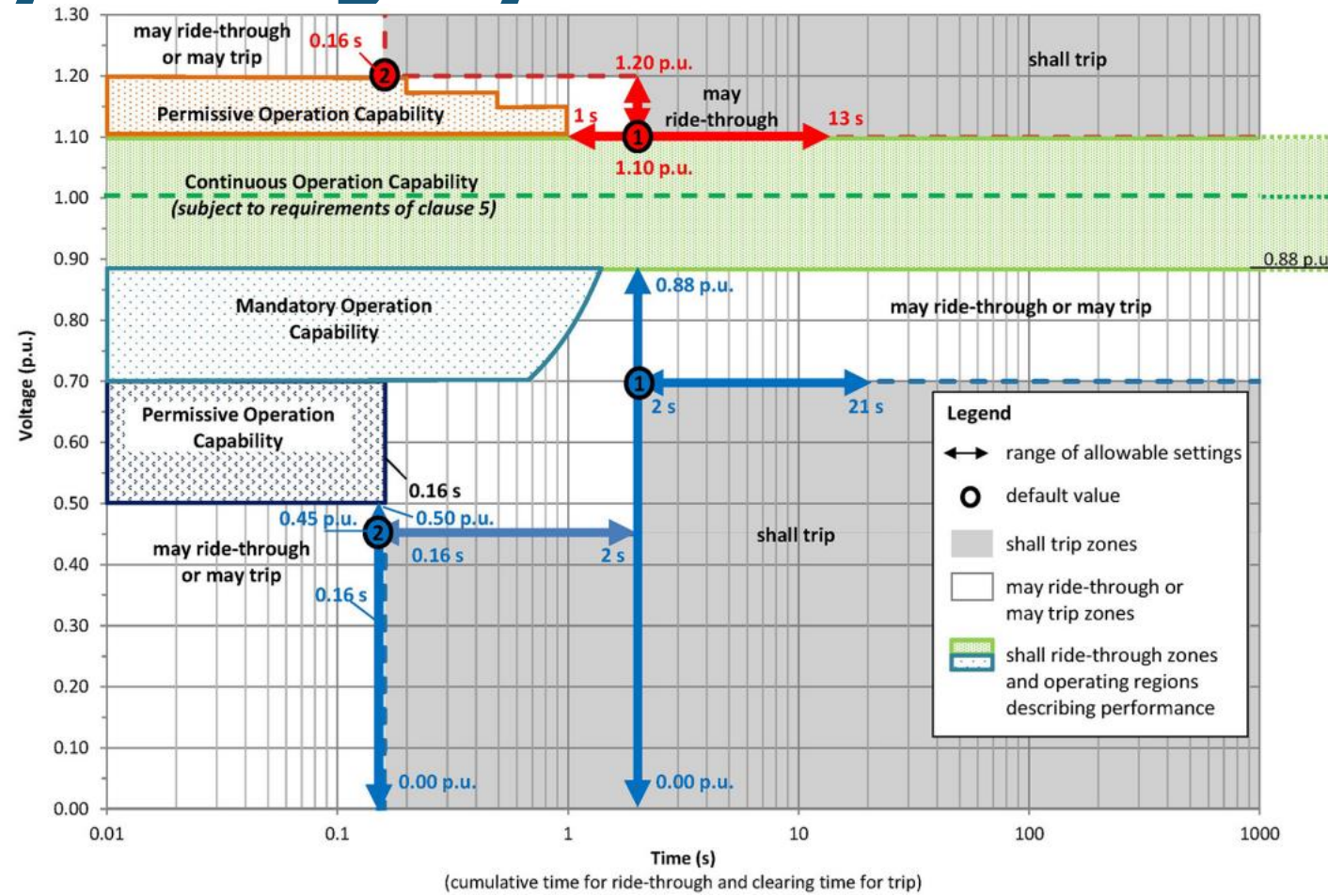


Figure H.7 of IEEE 1547-2018

# Abnormal operating performance category: Category II

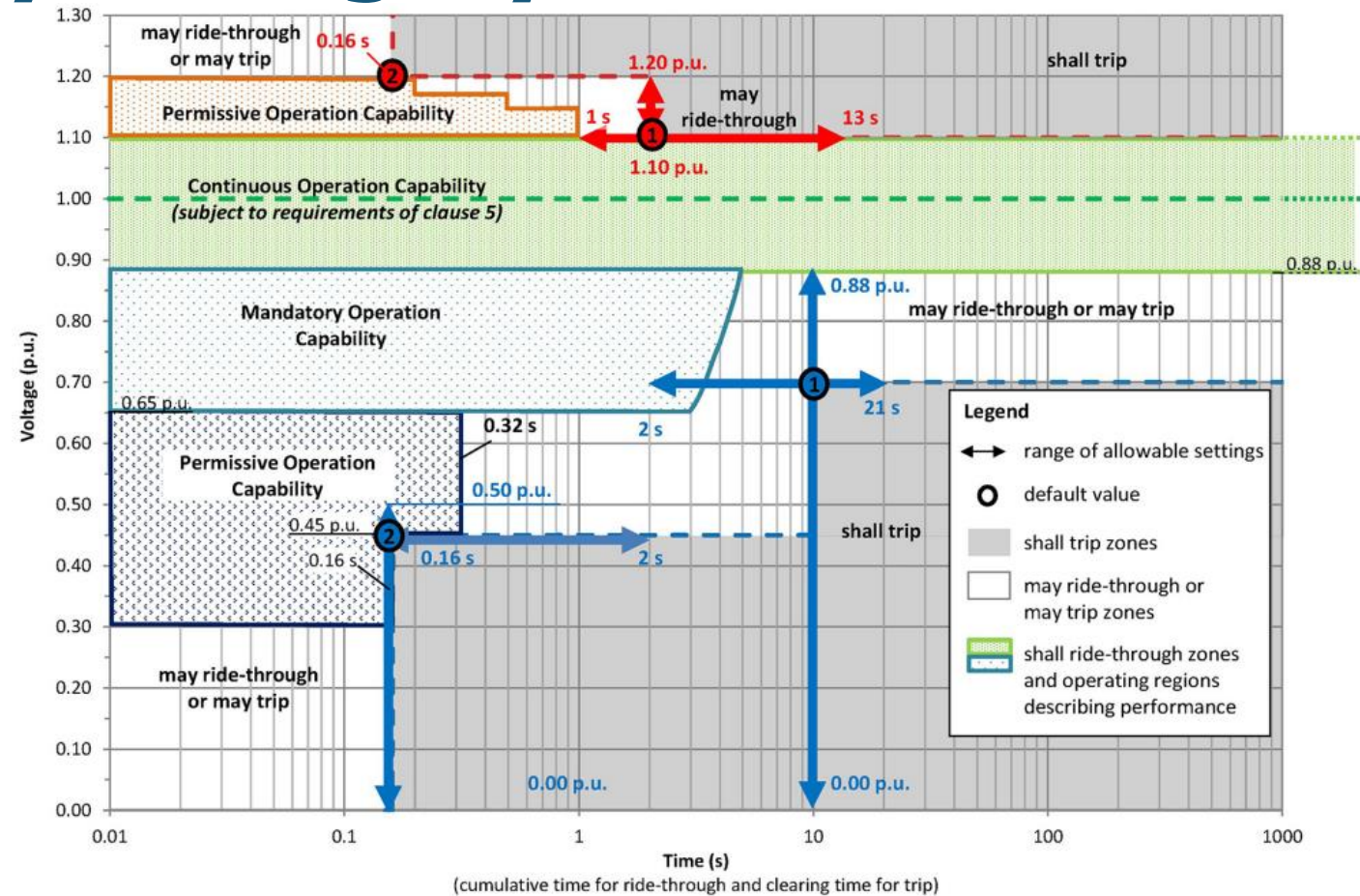


Figure H.8 of IEEE 1547-2018

# Abnormal operating performance category: Category III

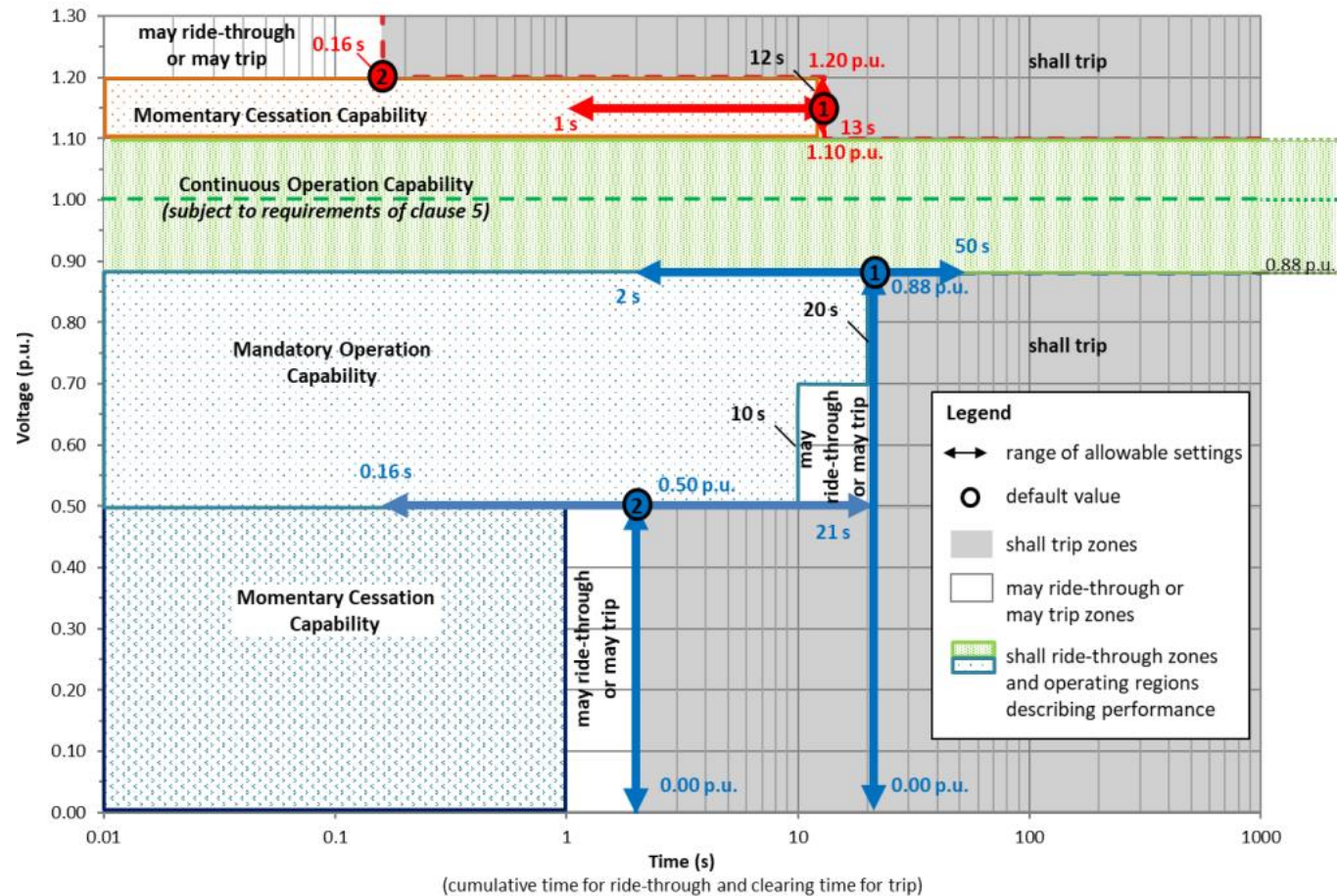


Figure H.1 of IEEE 1547a-2020 (replacing figure H.9 of IEEE 1547-2018)

# Abnormal operating performance category: Category I, II and III default

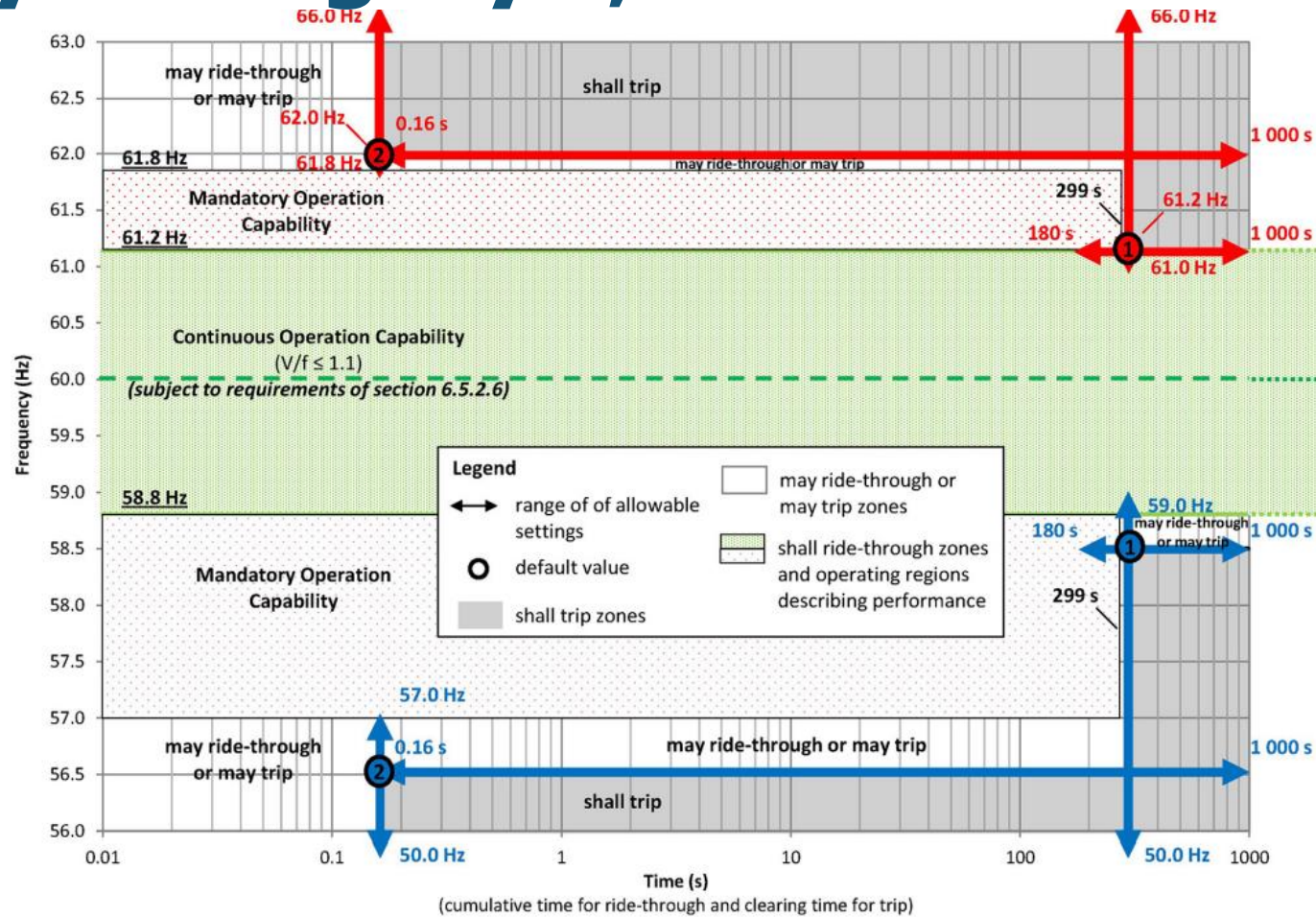


Figure H.10 of IEEE 1547-2018



# Normal operating performance category

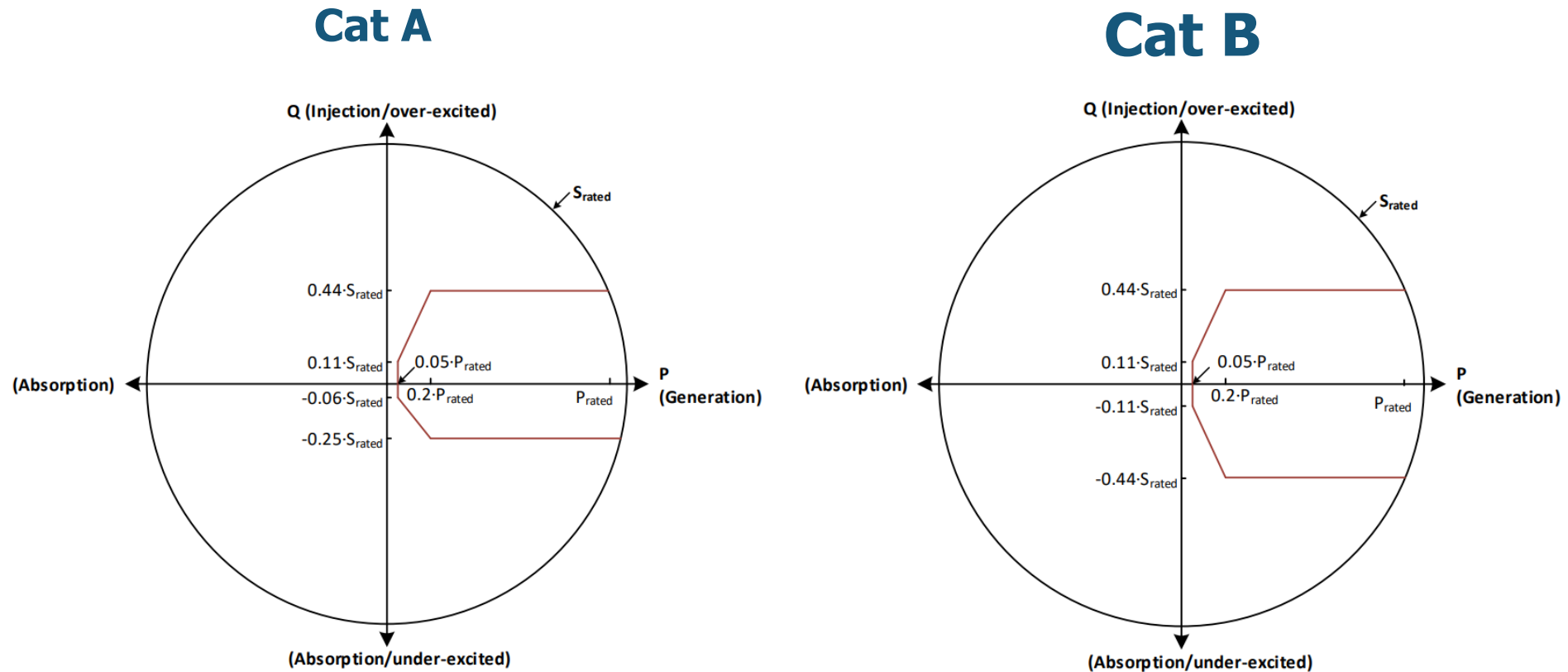


Figure H.3 of IEEE 1547-2018: Minimum reactive power capability of Cat A and B DER

# Cat A/B sets the stage for voltage and reactive/active power control functions

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

<sup>a</sup>Voltage-reactive power mode may also be commonly referred to as “volt-var” mode.

<sup>b</sup>Active power-reactive power mode may be commonly referred to as “watt-var” mode.

*Table 6 of IEEE 1547-2018*

# Alternative performance category

- Per IEEE 1547-2018, requirements can be established under mutual agreement between Area EPS operator and DER operator
  - One technology may not be able to meet the specified Abnormal or Normal performance category
- How should this be handled?

# Frequency droop settings

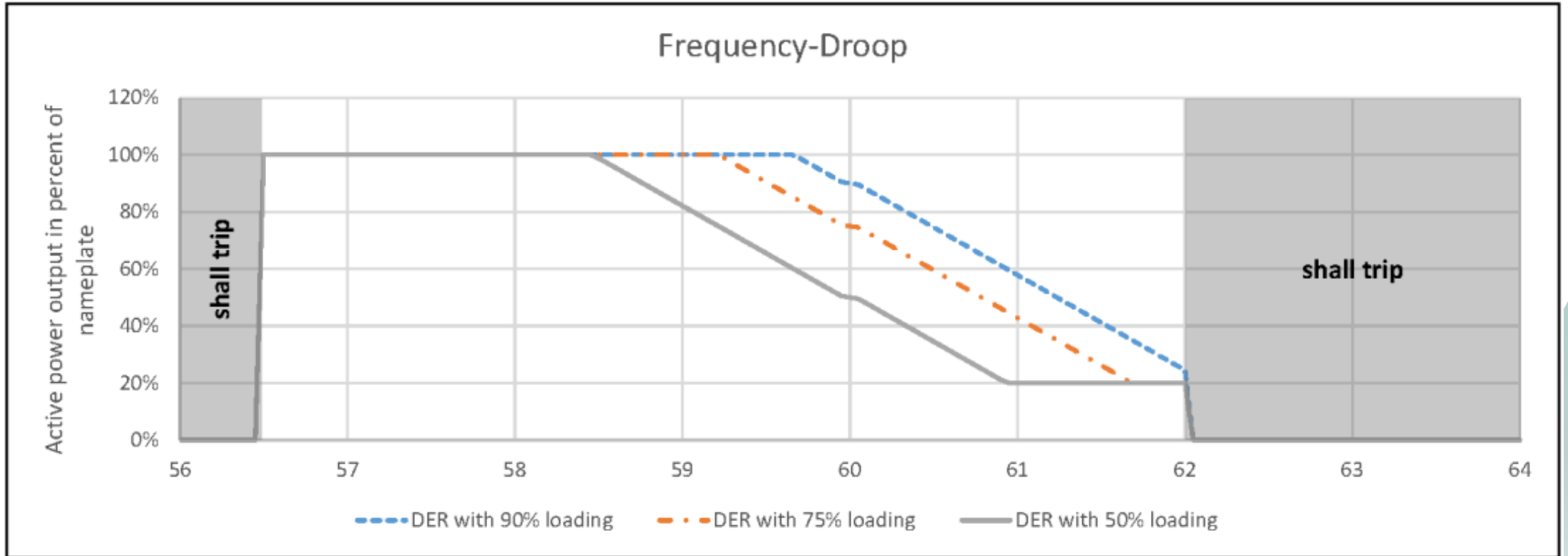


Figure H.11 of IEEE 1547-2018

# Voltage regulation consideration

- IEEE 1547-2018 default is the constant power factor mode with PF=1
  - i.e., **no reactive power = no voltage support**
  
- States/utilities to clarify which voltage regulation function DERs should use; adjust from Standard defaults accordingly
  
- Potential for DER customer impacts

# Voltage regulation modes by reactive power

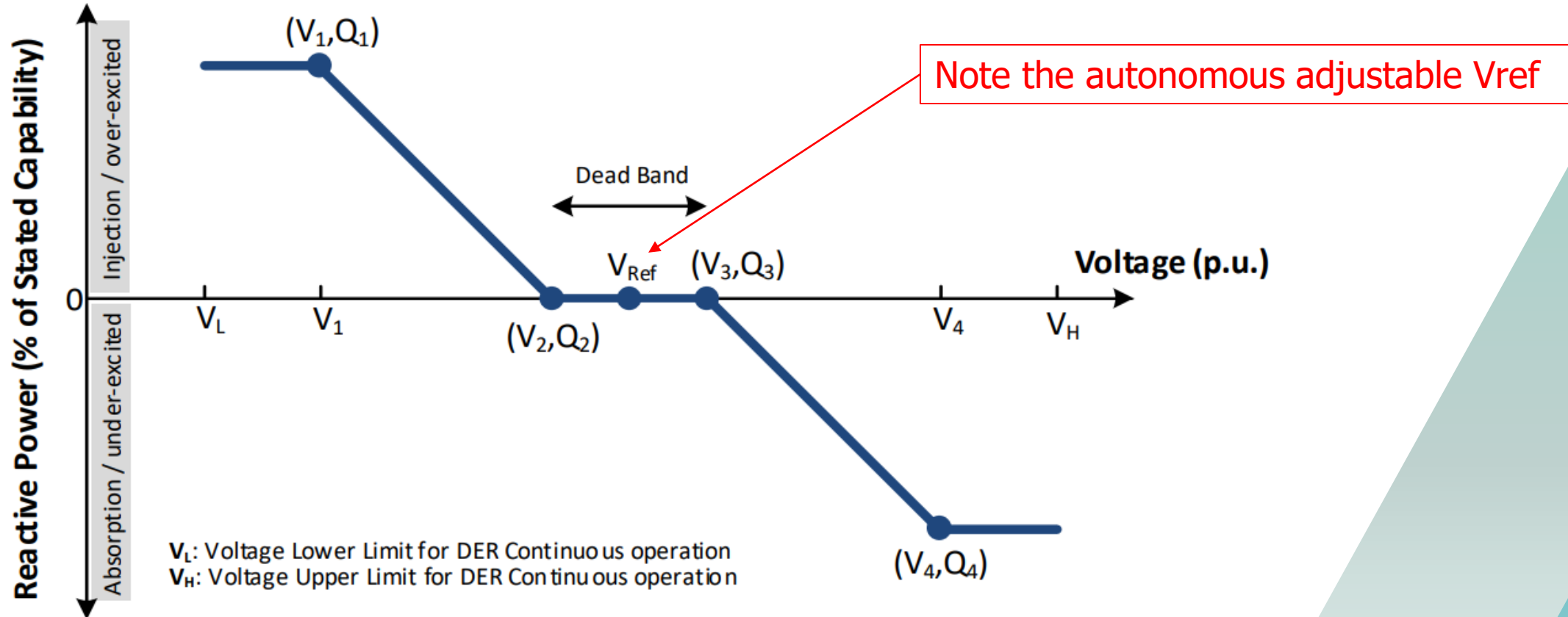
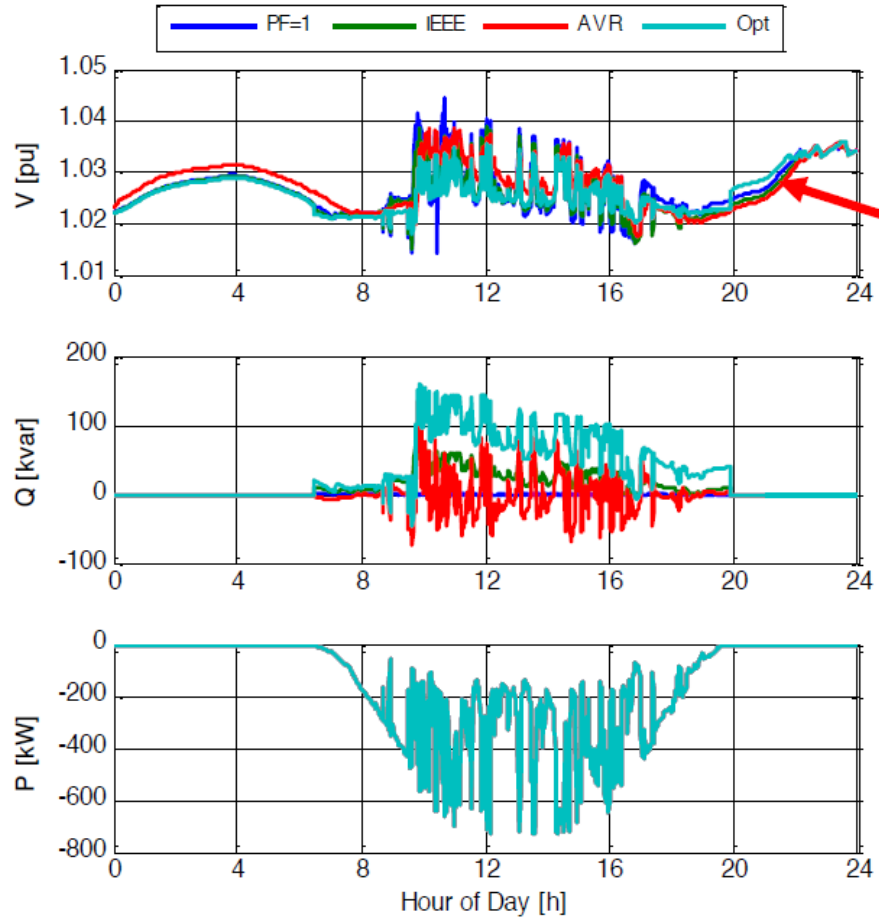


Figure H.4—Example voltage-reactive power characteristic

# Volt-var: Autonomously Adjustable Vref



	$\Sigma P$	$\Sigma Q$	$\Delta V$
	kwh	kvarh	%
<b>Unity PF</b>	-3561	0	1.90
<b>IEEE</b>	-3561	293	1.48
<b>Optimal Fixed</b>	-3561	774	0.96
<b>Adaptive (AVR)</b>	-3561	-7	<b>0.58</b>

Image Credit T.McDermott and S.Abate of PNNL; <https://ieeexplore.ieee.org/document/8981277>

# Voltage regulation modes by reactive power

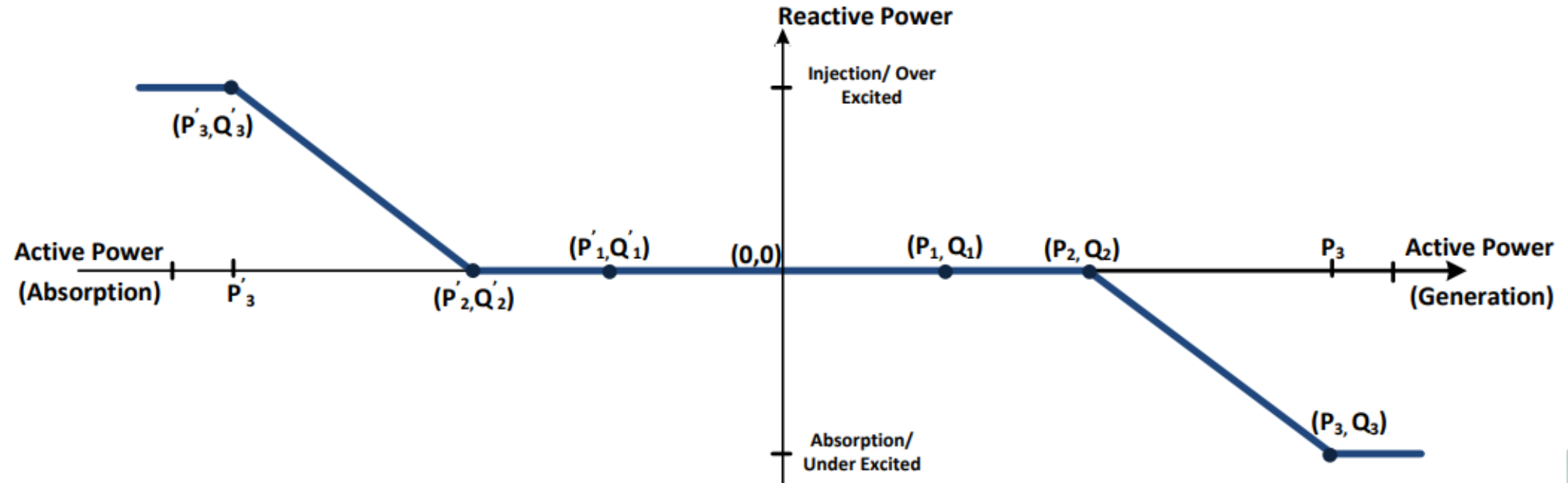


Figure H.5—Example active power-reactive power characteristic



# Voltage regulation mode by active power

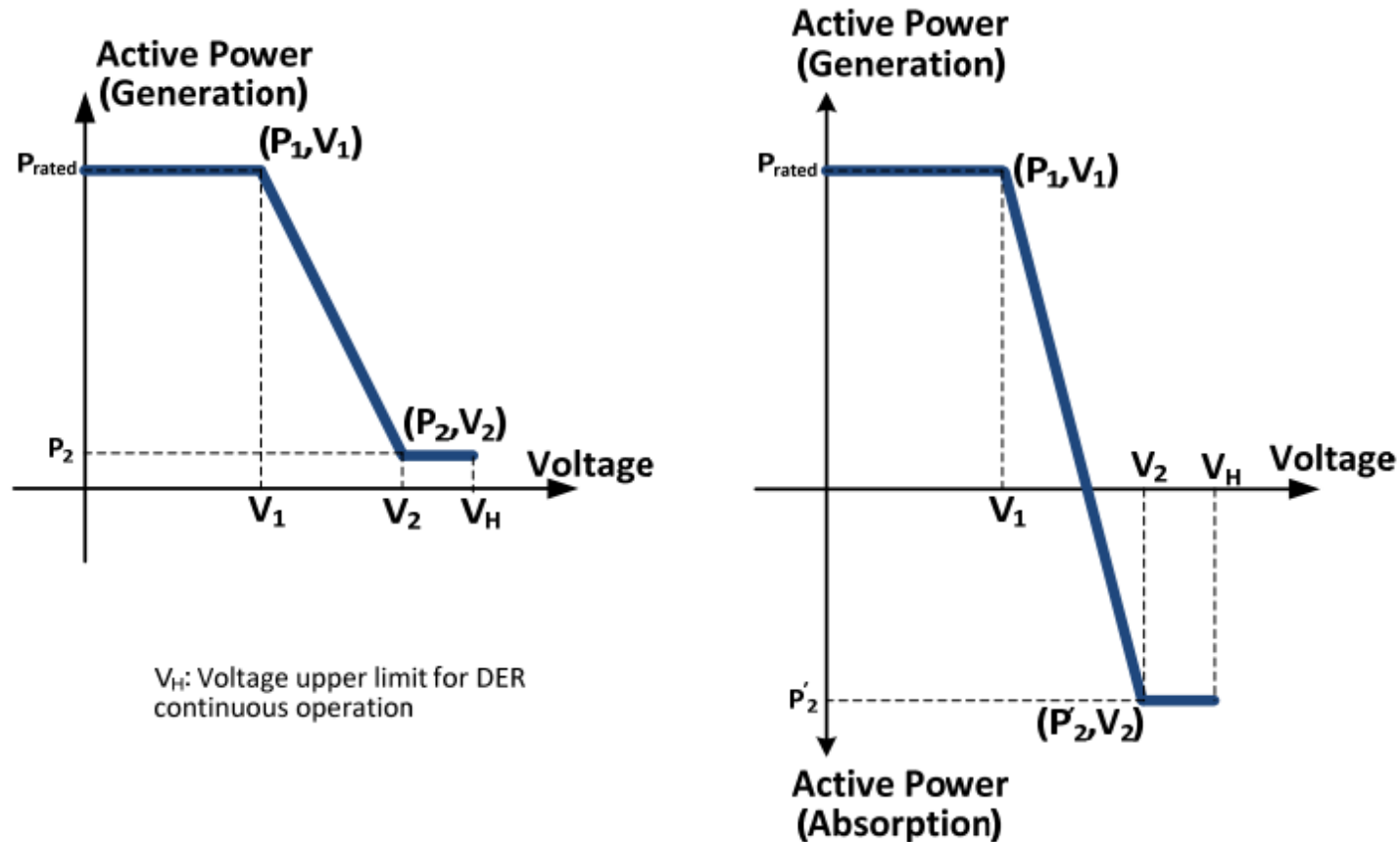


Figure H.6—Example voltage-active power characteristic

# Scheduling and Prioritization of issues

# Scheduling and Prioritization of Topics

## ■ Scheduling:

- Should we tackle multiple topics for each workshop?
- What is the timeline for implementation vs. the schedule of the workshop?
- Do we want all these answers by XX/XX/202X? This can help drive the implementation timeline
- Does this timeline coincide with efforts in the other WG (screens/processes)?

## ■ Prioritization (use spreadsheet):

- Does the layout of Near/Mid/Long term issues make sense?
- Are the mid-term issues prioritized correctly?

# Rule vs. Manual

*Where will the technical requirement reside?*

# What to consider on Rule Vs. Manual

- Commission Oversight
  - Authority Governing Interconnection Requirements (AGIR)
  - Stakeholder engagement
- Flexibility
  - Evolution of the grid
  - Locational specificity
- Default settings/functions
  - Statewide
  - Utility specific



## If you have any questions, contact:

### **Brian Lydic**

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### **Midhat Mafazy**

Regulatory Engineer | IREC  
[midhatm@irecusa.org](mailto:midhatm@irecusa.org)

# Discussion



- Discuss Near-Term Issues (as time allows)
  - Evaluate level of consensus at high level
  - Gather names of stakeholders for subgroup(s)

# Next Steps



- Interested Stakeholders collaborate on proposal
  - Via email or,
  - Virtually
- Circulate proposal(s) to service list by September 21
- Next workshop in this workstream on September 28 9am-noon
  - Discussion of proposal(s) received
  - Potential discussion of other topics
- Further refinement of initial proposal(s), and
- Development of proposal(s) for new topics
- Continuation cycle of proposals-workshops-refinements as needed
- Develop Final Report



# Save the Date(s)



## Workshop 2: Screens, Study Methods, and Modern Configurations

- Date: September 14
- Time: 9:00 AM – 12:00 PM
- Location: Zoom
  - [Link to Meeting](#)
  - Dial-in: 1-971-247-1195
  - Meeting ID: 815 1290 4309
  - Passcode: 5464541110

## Workshop 2: Incorporating Updated Standards

- Date: September 28
- Time: 9:00 AM – 12:00 PM
- Location: Zoom
  - [Link to Meeting](#)
  - Dial-in: 1-971-247-1195
  - Meeting ID: 881 9272 2528
  - Passcode: 0060565574

# Appendix – IREC Decision Matrix



The following slides include the IEEE 1547 Adoption: Decision Options Matrix. This was provided to the service list on August 25, 2022. The version circulated on 8/25 should be relied on in case of errors or omissions.

## IEEE 1547 Adoption: Decision Options Matrix

IREC's Decision Option Matrix is intended to be a resource for Public Utilities Commissions, utility personnel, and other DER stakeholders interested in adopting and implementing IEEE 1547-2018 in their jurisdictions. The matrix includes an exhaustive list of Decision Options (DO's) that stakeholders should consider before implementing the updated standard. The DO's provide a step-by-step guidance to incorporating the updated standard into the interconnection rules and procedures. The DO's translate technical content within the standard, as well as related issues, into easily digestible decisions that impact DER interconnection reviews and operations (i.e., timeline, voltage regulations, interoperability). The matrix includes over thirty DO's, organized into three IEEE 1547-2018 adoption categories, namely:

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## IEEE 1547 Adoption: Decision Options Matrix - Near-term

Topic	What to consider?	Decision Option (DO) Description	Utilize?
Adoption timeline	Consider equipment availability, the use of UL 1741 SA certification in the interim (if needed), and whether naming a date certain is necessary before certified equipment is widely available. Compliance requirements are usually based on the interconnection application submission date. Some projects have long interconnection review and lead times and may not be installed long after the application date. A mechanism to require some of those projects with earlier application dates to be 1547-2018 compliant once installed could be beneficial for grid support. Installed MW with 1547-2018 compliance could be increased if compliance is based on installation date, but this may be challenging for developers from a planning perspective, as they may have to specify equipment that is not yet certified for 1547-2018. This issue may be mitigated if UL 1741 SA inverters are utilized, which can have similar features as those required by UL 1741 SB/1547-2018. Also consider how an interim adoption period will be implemented, allowing for 1547-2018 compliance before the deadline. Widely available UL 1741 SB certified equipment is expected on the market by around April 1, 2023. More information is available on <a href="#">IREC's research on equipment availability</a> . [MTGS II]	<b>DO 1a-1:</b> Comply with IEEE 1547-2018 beginning [some date before April 1, 2023].	<input type="checkbox"/>
		<b>DO 1a-2:</b> Comply with IEEE 1547-2018 beginning ~April 1 <sup>st</sup> , 2023 or a later date.	<input type="checkbox"/>
		<b>DO 1a-3:</b> Comply with IEEE 1547-2018 when the equipment is readily available (TBD by Commission action).	<input type="checkbox"/>
		<b>DO 1b-1:</b> Base compliance date on application submission.	<input type="checkbox"/>
		<b>DO 1b-2:</b> Base compliance date on installation (may be useful for larger projects with long lead times).	<input type="checkbox"/>
		<b>DO 1b-3:</b> Differentiate compliance date mechanism between smaller and larger projects.	<input type="checkbox"/>
		<b>DO 1c-1:</b> Allow interim compliance with IEEE 1547-2018 beginning April 1, 2022.	<input type="checkbox"/>
<b>DO 1c-2:</b> Define another interim compliance pathway.	<input type="checkbox"/>		
Abnormal operating performance category	Consider input from transmission operators or regional reliability coordinator when assigning ride-through categories, plus local distribution utility protection practice. Since there can be conflict between distribution utility desires and bulk system reliability, 1547-2018 designates oversight of this selection to the Authority Governing Interconnection Requirements – often the Public Utilities Commission. [MTGS V.A]	<b>DO 2-1:</b> IEEE 1547-2018 Category III Ride-Through capabilities must be supported for inverter-based DER. Rotating DER must meet Category I Ride-Through capabilities.	<input type="checkbox"/>
		<b>DO 2-2:</b> IEEE 1547-2018 Category II Ride-Through capabilities must be supported for inverter-based DER. Rotating DER must meet Category I Ride-Through capabilities.	<input type="checkbox"/>
Normal operating performance category	The selection of A or B will impact the use of voltage regulation controls. Some DER types cannot meet the full scale of reactive power support. Consider specifying category assignment based on technology type. [MTGS V.A]	<b>DO 3-1:</b> Inverter-based DER shall meet reactive power requirements with 1547-2018 Category B. Rotating DER must meet Category A.	<input type="checkbox"/>
		<b>DO 3-2:</b> All DER types (Inverter-based and rotating) shall meet reactive power requirements with 1547-2018 Category A.	<input type="checkbox"/>
Alternative performance category	If a technology that cannot meet the specified Abnormal or Normal Operating Performance Category, a defined process may be useful for determining that the technology can safely interconnect without unduly impacting grid support requirements.	<b>DO 4-1:</b> Define process for how exceptions to these category assignments are handled (e.g., for an inverter-based technology that cannot meet Category III capabilities).	<input type="checkbox"/>
		<b>DO 4-2:</b> Leave process undefined for how exceptions to these category assignments are handled.	<input type="checkbox"/>
Voltage trip settings & ranges	Consider local distribution utility protection practices and make sure appropriate trip settings are selected. As desired, select default settings or settings within the adjustable range. Trip settings should not hinder ride-through capability required at the transmission level.	<b>DO 5-1:</b> Align default settings with 1547.	<input type="checkbox"/>
		<b>DO 5-2:</b> Select other default settings within 1547 ranges of adjustment.	<input type="checkbox"/>

## IEEE 1547 Adoption: Decision Options Matrix - Near-term

Topic	What to consider?	Decision Option (DO) Description	Utilize?
Frequency trip settings & ranges	Ensure that the under/over frequency trip settings are coordinated between the utility and transmission operator. As desired, select default settings or settings within the adjustable range. Trip settings should not hinder ride-through capability required at the transmission level.	<b>DO 6-1:</b> Align default settings with 1547.	<input type="checkbox"/>
		<b>DO 6-2:</b> Select other default settings within 1547 ranges of adjustment.	<input type="checkbox"/>
Frequency droop Settings	This capability is required for all DERs (with some limitations on Category I types) during the under/over frequency conditions. Consider using default settings or adjust within ranges of allowable settings. Consider input from transmission operators or regional reliability coordinator. [MTGS V.A]	<b>DO 7-1:</b> Align default settings with 1547.	<input type="checkbox"/>
		<b>DO 7-2:</b> Select other default settings within 1547 ranges of adjustment.	<input type="checkbox"/>
Voltage regulation modes by reactive power	If desired, consider activating a non-unity power factor, volt-var, watt-var, or constant var function. Also, consider statewide (or similar) default settings for such mode. [MTGS V.B, VI]	<b>DO 8a-1:</b> Adjustable constant power factor is activated.	<input type="checkbox"/>
		<b>DO 8a-2:</b> Utilize volt-var without autonomously adjusting Vref.	<input type="checkbox"/>
		<b>DO 8a-3:</b> Utilize volt-var with autonomously adjusting Vref.	<input type="checkbox"/>
		<b>DO 8a-4:</b> watt-var is activated.	<input type="checkbox"/>
		<b>DO 8a-5:</b> constant var is activated.	<input type="checkbox"/>
		<b>DO 8b-1:</b> Align default settings with 1547.	<input type="checkbox"/>
		<b>DO 8b-2:</b> Select other default settings within 1547 ranges of adjustment.	<input type="checkbox"/>
		<b>DO 8c-1:</b> Specify process for selecting settings on site-by-site basis.	<input type="checkbox"/>
Voltage regulation modes by active power	If desired, consider statewide (or similar) activation of volt-watt function (with default setting). Notably, the utilization of volt-watt will require changes to the interconnection applications forms (online portals) to allow an applicant to specify how volt-watt is implemented. [MTGS V.B, VI]	<b>DO 8c-2:</b> Leave process for selecting settings on site-by-site undefined.	<input type="checkbox"/>
		<b>DO 9-1:</b> Volt-watt is activated with default 1547 settings.	<input type="checkbox"/>
		<b>DO 9-2:</b> Volt-watt is activated with non-default settings.	<input type="checkbox"/>
		<b>DO 9-3:</b> Volt-watt is not activated.	<input type="checkbox"/>
Interconnection rule	Update the interconnection rule to be inclusive of IEEE 1547-2018. To be clear which version of a standard applies and when it takes effect, it is recommended that standards be dated (and with edition number, if applicable), and that the implementation date is made clear either within the rule or by Commission order. In addition to implementing adoption of the standard within the rule, requirements or references to other standards that are now addressed by IEEE 1547 should be updated to be inclusive of 1547's requirements. Note that this latter issue is reflected in DO 10c, and no alternatives are offered.	<b>DO 10a-1:</b> Change 1547 date and title in standards references.	<input type="checkbox"/>
		<b>DO 10a-2:</b> Leave 1547 standard reference undated.	<input type="checkbox"/>
		<b>DO 10b-1:</b> Define timeline for adoption of new requirements in line with IEEE 1547-2018 per DO 1.	<input type="checkbox"/>
		<b>DO 10b-2:</b> Leave timeline for adoption open dependent on, e.g., Commission order (in line with DO 1a-3).	<input type="checkbox"/>
		<b>DO 10c-1:</b> Update applicable power quality or other references (such as IEEE 519 or IEEE 1453 in SGIP's Supplemental Review Voltage and Power Quality Screen) to IEEE 1547-2018.	<input type="checkbox"/>

<sup>[1]</sup> Per IEEE 1547-2018, this function cannot be disabled.

<sup>[2]</sup> The voltage support functions by reactive power (constant power factor, volt-var, watt-var, constant var) are mutually exclusive. By default, these functions are deactivated – meaning certified equipment will come out of the box to operate at unity power factor.

<sup>[3]</sup> Note: constant var mode is only required for normal performance Category B.

<sup>[4]</sup> The voltage support by active power (volt-watt) is deactivated by default – if desired, consider statewide (or similar) default setting for volt-watt.

<sup>[5]</sup> Note: volt-watt mode is only required for normal performance Category B.

## IEEE 1547 Adoption: Decision Options Matrix - Mid-term

Topic	What to consider?	Decision Option (DO) Description	Utilize?
Reference point of applicability (RPA)	Consider process related improvement that allows RPA designation by applicant and for utility to review. This may involve changes to application forms (such as online application portals), initial reviews processes and provision to allow RPA review/discussion during scoping meeting. [MTGS IV]	<b>DO 11-1:</b> Require RPA to be noted in the application forms and use RPA recommended language from Appendix E and F of BATTRIES Toolkit as a starting point.	<input type="checkbox"/>
		<b>DO 11-2:</b> Specify elsewhere how the RPA information is processed.	<input type="checkbox"/>
		<b>DO 11-3:</b> Do not introduce new requirements related to the RPA.	<input type="checkbox"/>
Enter service settings	It is important to consider whether non-default enter service settings are preferred for voltage and frequency ranges, delay time, and ramp rate. The standard allows for the duration of <i>enter service</i> period (ramp rate) to be adjustable over 1-1000 second with a default time of 300 seconds. For DERs less than 500kVA, individual DER units may use a randomized time delay with a default maximum interval at 300 seconds as an alternative to ramping. It is likely even the smallest inverter-based DER can utilize the enter service ramp. Enter Service ramp rate is also known as connect/reconnect or soft start ramp rate.	<b>DO 12a-1:</b> Utilize 1547 default settings for voltage range, frequency range, delay and duration.	<input type="checkbox"/>
		<b>DO 12a-2:</b> Specify default settings within the ranges allowed by 1547.	<input type="checkbox"/>
		<b>DO 12b-1:</b> Give further guidance on how randomized delay times are to be used for DER smaller than 500 kVA (consider application form addition).	<input type="checkbox"/>
		<b>DO 12b-2:</b> Leave process for randomized delay selection undefined for DER smaller than 500 kVA.	<input type="checkbox"/>
Utility required profile (URP)	Finalize URP with all default settings and consider posting that in the EPRI URP database (publicly available). Implement use of EPRI's Common File Format for DER Settings Exchange and Storage. [MTGS IV, VI]	<b>DO 13a-1:</b> Utility to create and post URP of default settings.	<input type="checkbox"/>
		<b>DO 13a-2:</b> Do not create and post URP of default settings.	<input type="checkbox"/>
		<b>DO 13b-1:</b> Utility to implement use of common file format to transmit specified settings to customer and verify applied settings.	<input type="checkbox"/>
		<b>DO 13b-2:</b> Do not implement common file format.	<input type="checkbox"/>

<sup>[1]</sup> <https://dersettings.epri.com/>

<sup>[2]</sup> <https://www.epri.com/research/products/000000003002020201>

## IEEE 1547 Adoption: Decision Options Matrix - Mid-term

Topic	What to consider?	Decision Option (DO) Description	Utilize?
Requirements for replacement units	For end-of-life or other equipment replacements, define whether or not the most recent technical requirements, certifications and settings must be followed. It could be beneficial to ensure that “legacy” interconnection equipment (such as an inverter) is upgraded to the most recent standards over time. However, warranty replacements are usually like-for-like and should be accommodated. Additionally, DER owners may keep spare parts on hand for future use to limit downtime during repair. Contractual obligations for notifying the utility of equipment changes and the requirements for updated equipment should be clear at the time of interconnection. Note that “material modification” guidelines could be developed to ensure an easy transition to new equipment and note under which circumstances further evaluation must be conducted by the utility. [MTGS VI]	<b>DO 14a-1:</b> Allow replacement equipment to match the certification and technical requirements of originally evaluated and installed equipment. Require settings to match those specified in the Interconnection/Operating Agreement.	<input type="checkbox"/>
		<b>DO 14a-2:</b> Require replacement equipment to conform to certification and technical requirements of rule in effect at time of replacement. Make exception for warranty work (and potentially for previously acquired equipment). Require settings to match those specified in the Interconnection/Operating Agreement.	<input type="checkbox"/>
		<b>DO 14a-3:</b> Require replacement equipment to conform to certification and technical requirements of rule in effect at time of replacement. Make exception for warranty work (and potentially for previously acquired equipment). Require settings to match those specified by the utility or default URP at the time of replacement.	<input type="checkbox"/>
		<b>DO 14b-1:</b> Update definitions of material modification for already interconnected DERs. Establish when notification or further evaluation (and related fees) must occur dependent on replacement type and power specifications.	<input type="checkbox"/>
		<b>DO 14b-2:</b> Leave material modification process unchanged or undefined.	<input type="checkbox"/>
		<b>DO 14c-1:</b> Establish process for determining changes to settings when replacement equipment is updated.	<input type="checkbox"/>
		<b>DO 14c-2:</b> Do not define process for determining changes to settings when replacement equipment is update.	<input type="checkbox"/>
Standard interconnection agreements	As required, include provisions for adhering to required functional settings and updating settings or equipment over time.	<b>DO 15a-1:</b> Update standard interconnection agreement to meet contractual obligations (operating requirements) regarding functional settings.	<input type="checkbox"/>
		<b>DO 15a-2:</b> Do not update standard interconnection agreement to meet contractual obligations regarding functional settings.	<input type="checkbox"/>
		<b>DO 15b-1:</b> Update standard interconnection agreement to meet contractual obligations (operating requirements) regarding future replacement equipment.	<input type="checkbox"/>
		<b>DO 15b-2:</b> Do not update standard interconnection agreement to meet contractual obligations regarding replacement equipment.	<input type="checkbox"/>

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Requirements for replacement units	For end-of-life or other equipment replacements, define whether or not the most recent technical requirements, certifications and settings must be followed. It could be beneficial to ensure that “legacy” interconnection equipment (such as an inverter) is upgraded to the most recent standards over time. However, warranty replacements are usually like-for-like and should be accommodated. Additionally, DER owners may keep spare parts on hand for future use to limit downtime during repair. Contractual obligations for notifying the utility of equipment changes and the requirements for updated equipment should be clear at the time of interconnection. Note that “material modification” guidelines could be developed to ensure an easy transition to new equipment and note under which circumstances further evaluation must be conducted by the utility. [MTGS VI]	<b>DO 14a-1:</b> Allow replacement equipment to match the certification and technical requirements of originally evaluated and installed equipment. Require settings to match those specified in the Interconnection/Operating Agreement.	<input type="checkbox"/>
		<b>DO 14a-2:</b> Require replacement equipment to conform to certification and technical requirements of rule in effect at time of replacement. Make exception for warranty work (and potentially for previously acquired equipment). Require settings to match those specified in the Interconnection/Operating Agreement.	<input type="checkbox"/>
		<b>DO 14a-3:</b> Require replacement equipment to conform to certification and technical requirements of rule in effect at time of replacement. Make exception for warranty work (and potentially for previously acquired equipment). Require settings to match those specified by the utility or default URP at the time of replacement.	<input type="checkbox"/>
		<b>DO 14b-1:</b> Update definitions of material modification for already interconnected DERs. Establish when notification or further evaluation (and related fees) must occur dependent on replacement type and power specifications.	<input type="checkbox"/>
		<b>DO 14b-2:</b> Leave material modification process unchanged or undefined.	<input type="checkbox"/>
		<b>DO 14c-1:</b> Establish process for determining changes to settings when replacement equipment is updated.	<input type="checkbox"/>
		<b>DO 14c-2:</b> Do not define process for determining changes to settings when replacement equipment is update.	<input type="checkbox"/>
Standard interconnection agreements	As required, include provisions for adhering to required functional settings and updating settings or equipment over time.	<b>DO 15a-1:</b> Update standard interconnection agreement to meet contractual obligations (operating requirements) regarding functional settings.	<input type="checkbox"/>
		<b>DO 15a-2:</b> Do not update standard interconnection agreement to meet contractual obligations regarding functional settings.	<input type="checkbox"/>
		<b>DO 15b-1:</b> Update standard interconnection agreement to meet contractual obligations (operating requirements) regarding future replacement equipment.	<input type="checkbox"/>
		<b>DO 15b-2:</b> Do not update standard interconnection agreement to meet contractual obligations regarding replacement equipment.	<input type="checkbox"/>



## IEEE 1547 Adoption: Decision Options Matrix - Mid-term

Topic	What to consider?	Decision Option (DO) Description	Utilize?
Application forms	Update application forms (including online portals) for the following items: RPA selection Enter service randomized delay Volt-watt implementation Limit active maximum power function implementation Frequency droop implementation Intentional islanding Emergency backup systems DER communication capabilities Export/import limiting Power Control Systems (PCS) Inverter fault current	<b>DO 16-1:</b> Update application forms (use recommended language from Appendix F of BATTRIES Toolkit as a starting point).	<input type="checkbox"/>
		<b>DO 16-2:</b> Do not update application forms.	<input type="checkbox"/>
Volt-watt process/reporting	Volt-watt can have impact on the DER customer's energy production. Curtailment is based on utility voltage that the customer has no control over. Consider a reporting process to understand if volt-watt curtailment becomes an issue for customers now or in the future. [MTGS V.B]	<b>DO 17a-1:</b> Ensure volt-watt curtailment complaints are tracked through the utilities' voltage/power quality complaint process.	<input type="checkbox"/>
		<b>DO 17a-2:</b> Do not specify a process to track volt-watt curtailment complaints.	<input type="checkbox"/>
		<b>DO 17b-1:</b> Implement a reporting process to Commission to review volt-watt complaints on a regular basis (e.g., yearly).	<input type="checkbox"/>
		<b>DO 17b-2:</b> Do not implement a reporting process.	<input type="checkbox"/>
Normal ramp rate	This capability is based on UL 1741 SA certification (not UL 1741 SB), consider whether the capability is utilized (if available). Though not required by IEEE 1547-2018, this feature may be useful, especially for energy storage technologies. Per CA Rule 21, the default value is 100% of maximum current output per second (with an adjustable range of between 1% to 100%).	<b>DO 18a-1:</b> Normal ramp rate certification is required, and ranges of adjustment are specified.	<input type="checkbox"/>
		<b>DO 18a-2:</b> Normal ramp rate capability/certification is optional, and ranges of adjustment are specified.	<input type="checkbox"/>
		<b>DO 18a-3:</b> Normal ramp rate is not required.	<input type="checkbox"/>
		<b>DO 18b-1:</b> Normal ramp rate is activated by default using specified settings.	<input type="checkbox"/>
		<b>DO 18b-2:</b> Normal ramp rate is not activated by default.	<input type="checkbox"/>

<sup>11</sup> The normal ramp rate is used when transitioning between energy output levels over the normal course of operation.

## IEEE 1547 Adoption: Decision Options Matrix - Mid-term

Topic	What to consider?	Decision Option (DO) Description	Utilize?
Nameplate ratings	Consider addressing nameplate ratings issues related to volt-watt, limit maximum active power, and frequency droop. The interconnection application forms may need to allow applicants to describe how the functions are achieved.	<b>DO 19a-1:</b> Provide guidance on volt-watt implementation i.e., whether the DER unit(s) implement volt-watt based on the same or different per unit curves, and individual or total nameplate ratings (see BATTRIES Toolkit Chapter VIII and IEEE 1547.2).	<input type="checkbox"/>
		<b>DO 19a-2:</b> Do not provide further guidance on volt-watt nameplate ratings designation.	<input type="checkbox"/>
		<b>DO 19b-1:</b> Provide guidance on how limit maximum active power function is implemented i.e., via PCS, via plant controller, or other means (see BATTRIES Toolkit Chapter VIII and IEEE 1547.2).	<input type="checkbox"/>
		<b>DO 19b-2:</b> Do not provide further guidance on how limit maximum active power is implemented.	<input type="checkbox"/>
		<b>DO 19c-1:</b> Provide guidance on frequency droop implementation i.e., whether the DER unit(s) implement frequency droop based on individual or total nameplate ratings (see IEEE 1547.2).	<input type="checkbox"/>
		<b>DO 19c-2:</b> Do not provide further guidance on how frequency droop is implemented.	<input type="checkbox"/>
Communication protocols & ports	Consider specifying protocols and ports if known and of interest to utilities at this time. Requirements for having the necessary communications equipment (e.g., gateway with a specific port) could cause DER to include “stranded” equipment that is never used if it is never connected to a communications system. On the other hand, having the equipment installed ensures that it is available to connect at a future date, if desired. See communications/control roadmap in the Long-Term topic. [MTGS V.C]	<b>DO 20a-1:</b> Specify protocols and/or ports to be used at the DER interface or aggregator.	<input type="checkbox"/>
		<b>DO 20a-2:</b> Do not specify protocols or ports at the DER interface or aggregator.	<input type="checkbox"/>
		<b>DO 20b-1:</b> Specify that systems which require “telemetry” must comply with communication equipment requirements.	<input type="checkbox"/>
		<b>DO 20b-2:</b> Specify that systems of all sizes must comply with communication equipment requirements.	<input type="checkbox"/>
		<b>DO 20b-3:</b> Implement equipment requirements in the future when ready to implement 1547-standardized communications.	<input type="checkbox"/>

## IEEE 1547 Adoption: Decision Options Matrix - Mid-term

Topic	What to consider?	Decision Option (DO) Description	Utilize?
Interconnection screens and study	<p>The Fast Track, Supplemental Review (SR) and detailed study interconnection review processes should be updated to reflect IEEE 1547-2018. The existing Fast Track’s:</p> <ul style="list-style-type: none"> <li>• “Shared secondary transformer screen” may not reflect voltage regulation (i.e., volt-var settings) activated by the DER.</li> <li>• The "Line configuration screen" may not recognize the difference between inverters vs. rotating machines [MTGS V.D]</li> </ul> <p>For projects that fail the existing “Line configuration screen” within Fast Track,</p> <ul style="list-style-type: none"> <li>• SR may lack new or alternate ways to evaluate effective grounding or provide means to properly evaluate the need for supplemental grounding [MTGS V.D].</li> </ul> <p>Similarly, screening for “inverter fault current” needs updating to reflect 1547.1 certification testing. Inverter manufacturers may have additional information supplied by 1547.1 certification testing that indicate fault values (fault current test data). Where fault current values are made available through test certification, it should be understood and agreed if review practices (for screens and detailed study) can utilize such data.</p> <p>In addition, best practices for rapid voltage change (RVC) and flicker evaluation should be developed. While DO 10c-1 would update the power quality references in the Supplemental Review Voltage and Power Quality Screen, the actual practices used to evaluate these issues have previously been left undefined. It is likely that utilities across the US utilize varying practices, some of which may be unnecessary or overly conservative. For instance, EPRI has found that it is largely unnecessary to perform flicker screening for PV systems. It is advised that Public Utilities Commissions review these practices to ensure current learnings and the requirements of IEEE 1547-2018 are taken into account appropriately. [MTGS V.D]</p>	DO 21a-1: Update “shared secondary transformer screen” based on likelihood of overvoltage occurring with default voltage regulation settings.	<input type="checkbox"/>
		DO 21a-2: Keep screen conservative as is.	<input type="checkbox"/>
		DO 21a-3: Determine alternative methods for screening overvoltage risk with voltage regulation.	<input type="checkbox"/>
		DO 21b-1: Update line configuration screen to treat inverters and rotating machines distinctly (see BATTRIES Toolkit Chapter VIII).	<input type="checkbox"/>
		DO 21b-2: Use existing or alternative line configuration screens.	<input type="checkbox"/>
		DO 21c-1: Revise Supplemental Review to include new grounding review for three-phase inverters based on LN connected load (see BATTRIES Toolkit Chapter VIII).	<input type="checkbox"/>
		DO 21c-2: Revise Supplemental Review to utilize a tool to determine supplemental grounding needs for inverters (see BATTRIES Toolkit Chapter VIII).	<input type="checkbox"/>
		DO 21c-3: Use existing or alternative grounding review practices.	<input type="checkbox"/>
		DO 21d-1: Review practices for provision of inverter fault current test data (see BATTRIES Toolkit Chapter VIII).	<input type="checkbox"/>
		DO 21d-2: Rely on existing or undefined practices for determining inverter fault current values.	<input type="checkbox"/>
DO 21e-1: Review flicker, RVC and other power quality screening practices to ensure they are in alignment with the standards as well as best practice.	<input type="checkbox"/>		
DO 21e-2: Leave power quality screening practices undefined and open to interpretation.	<input type="checkbox"/>		

<sup>[1]</sup> Note: Fast Track is the terminology used in SGIP and some states to categorize the second tier of interconnection reviews. Other states refer to such second-tier process as “Level 2”

<sup>[2]</sup> Xiaojie Shi et al., Can Photovoltaic Plants Cause Voltage Flicker? – Field Measurement and Screening, IEEE (June 2019) (“We found that PV ramping is too slow to cause light flicker in cases measured. Even the relatively large PV installations do not contribute in a noticeable way because of relatively slow power output changes.”), <https://ieeexplore.ieee.org/document/8980601>

## IEEE 1547 Adoption: Decision Options Matrix - Mid-term

Topic	What to consider?	Decision Option (DO) Description	Utilize?
Export control and Power Control Systems (may be optional or long-term)	While not strictly required for IEEE 1547 adoption, export controls and Power Control Systems (PCS) may be used for some aspects of IEEE 1547 implementation, including RPA selection, volt-watt implementation (see DO 18a-1) and limit maximum active power implementation (see DO 18b-1), in addition to other interconnection or tariff-related reasons. These export controls can be considered part of the interconnection system, and certification or compliance with certain requirements could be considered necessary in certain “fast track” or “simplified” interconnection processes. [MTGS V.H, BTRIES Toolkit]	<b>DO 22a-1:</b> Include specific technical and certification requirements for export controls and PCS in the interconnection rule (see BTRIES Toolkit Chapter III).	<input type="checkbox"/>
		<b>DO 22a-2:</b> Leave technical and certification requirements for export controls undefined.	<input type="checkbox"/>
		<b>DO 22b-1:</b> Add information on PCS and export limiting equipment to application forms (see BTRIES Chapter VIII).	<input type="checkbox"/>
		<b>DO 22b-2:</b> Do not update application forms with export controls information.	<input type="checkbox"/>
		<b>DO 22c-1:</b> Implement other elements of BTRIES Toolkit export control recommendations (e.g., Chapters II, IV, VI, VII, IX).	<input type="checkbox"/>
		<b>DO 22c-2:</b> Do not implement other BTRIES Toolkit elements at this time.	<input type="checkbox"/>

## IEEE 1547 Adoption: Decision Options Matrix - Long-term

Topic	What to consider?	Decision Option (DO) Description	Utilize?
DER communications/ control roadmap	Identify goals and strategies for deploying IEEE 1547 standardized communications/control of DER over time. Consider timeline for utilization of monitoring data, changes to autonomous function settings, scheduled function changes, and continuous direct control. Consider deployment for larger systems versus numerous small systems, and utility communications infrastructure versus DER aggregator model. Will communications infrastructure, DER equipment requirements and protocols be harmonized to any degree amongst utilities? How can investments in ADMS, DERMS or AMI be optimized to meet various goals? Consider the linkage to grid modernization discussions. [MTGS V.C]	<b>DO 23-1:</b> Establish a formal roadmap development process to take into account Commission’s, stakeholders’ and utilities’ DER management goals.	<input type="checkbox"/>
		<b>DO 23-2:</b> Allow individual utilities to determine needed communications investments based on internal DER management goals without external direction.	<input type="checkbox"/>
		<b>DO 23-3:</b> Avoid directive management of communications deployment.	<input type="checkbox"/>
Communications deployment	DER communications deployment is still nascent and best practices for interconnection rules and technical requirements are still in development. The decision option list at right is a list of potential actions to consider, but is not intended to be exhaustive. Consider the need to change the interconnection rule’s “telemetry,” “SCADA,” or “monitoring” DER size threshold. What requirements apply to the DER site/equipment? What actions need to be taken to adopt a DER aggregator model? [MTGS V.C]	<b>DO 24a:</b> If not done previously, specify protocols and ports to be used at the DER interface or aggregator.	<input type="checkbox"/>
		<b>DO 24b:</b> Define equipment requirements for DER or aggregator, and whether or not those apply to systems below the “telemetry” size threshold.	<input type="checkbox"/>
		<b>DO 24c:</b> Create or reference a guide for utilization of communications protocol (e.g., California Common Smart Inverter Profile).	<input type="checkbox"/>
		<b>DO 24d:</b> Update “telemetry” requirements to change size threshold.	<input type="checkbox"/>
		<b>DO 24e:</b> Update “telemetry” and/or other communication requirements to reference IEEE 1547 communications requirements.	<input type="checkbox"/>
		<b>DO 24f:</b> Include certification/validation requirements for communications equipment (e.g., California Common Smart Inverter Profile).	<input type="checkbox"/>
		<b>DO 24g:</b> Define standard aggregator requirements and agreements.	<input type="checkbox"/>
Interconnection agreement updates for communications/ control	As DER communications becomes deployed more widely, standard interconnection agreements should reflect such utilization. Control of the reactive power, volt-watt, limit maximum active power, permit service and other functions can affect energy production/delivery and have financial repercussions on the affected DER. It should be understood and agreed as to how these functions will be used. These aspects should be memorialized in the interconnection agreement. A standardized agreement can be developed to help establish expectations and limits while streamlining the interconnection process.	<b>DO 25a-1:</b> Develop standard interconnection agreement language to define whether a communications pathway is required and of which type it will be (e.g., utility direct to inverter, utility direct to gateway, or aggregator participation).	<input type="checkbox"/>
		<b>DO 25a-2:</b> Establish communication requirements within each individual interconnection agreement.	<input type="checkbox"/>
		<b>DO 25b-1:</b> Define expectations for control in the standard interconnection agreement (e.g., when and how long will the DER be curtailed or controlled and over what range of adjustment for specific parameters).	<input type="checkbox"/>
		<b>DO 25b-2:</b> Establish expectations for control within each individual interconnection agreement.	<input type="checkbox"/>

## IEEE 1547 Adoption: Decision Options Matrix - Long-term

Topic	What to consider?	Decision Option (DO) Description	Utilize?
Prioritization vs. export limiting	Export limits can potentially interfere with DER systems providing full grid support capability. For example, a non-exporting storage system may not be able to fully increase power output in line with frequency droop requirements for underfrequency events if output would exceed local load. IEEE 1547-2018 does not address situations related to export limiting in its prioritization of DER responses in subclause 4.7. Since this can affect bulk grid reliability, seek input from transmission operators or regional reliability coordinator when assigning priority of functions. See discussion in IEEE 1547.2.	<b>DO 26-1:</b> Create prioritization to be used for all export-limiting DER.	<input type="checkbox"/>
		<b>DO 26-2:</b> Allow utility and customer to agree on prioritizations for each individual interconnection application as needed.	<input type="checkbox"/>
		<b>DO 26-3:</b> Do not address prioritization for export-limited DER until national standards are established.	<input type="checkbox"/>
Ongoing reevaluation of default settings	Investigate whether fielded functional settings (voltage regulation and voltage/frequency settings) are optimized. Address the following: Are voltage regulation settings and trip settings working well or should they be revised? Are volt-watt issues present that need to be addressed? Are new insights available that can be leveraged to improve grid integration?	<b>DO 27a-1:</b> Collect field data, perform modeling and present findings at regularly scheduled meetings once IEEE 1547-2018 compliant DER systems have had significant time in the field. Determine if default settings should be updated.	<input type="checkbox"/>
		<b>DO 27a-2:</b> Do not review effectiveness of fielded DER settings.	<input type="checkbox"/>
		<b>DO 27b-1:</b> Regularly review nationally available research on voltage regulation deployment to determine if adjusted DER settings or voltage regulation practices may be desirable.	<input type="checkbox"/>
Evaluation/ commissioning	IEEE 1547-2018 and 1547.1-2020 contain expanded guidance on how evaluation of DER systems should be performed and what commissioning tests are to be completed. The different options for type tests, DER evaluations and commissioning tests are dependent on the RPA of the DER system, whether or not it is fully certified and other factors. Interconnection rules often do not explicitly require specific commissioning tests or give direct guidance on how evaluations should be performed by the utility. Utility handbooks may address commissioning in more detail. [MTGS IV]	<b>DO 27b-2:</b> Do not review DER voltage regulation research.	<input type="checkbox"/>
		<b>DO 28-1:</b> Update interconnection rule to address different evaluation and commissioning concepts introduced by the standards.	<input type="checkbox"/>
		<b>DO 28-2:</b> Update utility handbooks to address evaluation and commissioning.	<input type="checkbox"/>
		<b>DO 28-3:</b> Do not address evaluation or commissioning updates.	<input type="checkbox"/>