Current Status

Today, DER installations are growing rapidly on a global scale, and the interconnection standards are being updated in an acknowledgement of the increased impacts DER is having on the bulk transmission system and distribution system. The application of advanced autonomous functions to mitigate distribution constraints arising from DER is thought to be a cost-effective solution, but it is not consistently or widely applied today because of limited field experience and lack of tools and knowledge to analyze impacts.

These standards will have a significant influence on the adoption of smart inverter functions and, therefore, a thorough understanding of their status is very important. This report will primarily describe the distribution voltage regulation capabilities of DER, but it will also introduce the capability of riding through voltage and frequency events that previously would have caused tripping of the DER. These requirements are extremely important to maintain bulk system stability with large aggregations of connected DER.

IEEE Std 1547™-2018 "IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces"

Overview and Background

IEEE Standard 1547™ [1] is the de-facto basis for interconnection standards for DER in the United States. It was first published in 2003 as a voluntary industry standard for interconnecting distributed energy resources with electric power systems (EPSs), focused on distribution system safety and power quality. Development on the standard began in 1999, then after nearly four years, ten revisions, and four balloting cycles, it passed in 2003, reflecting the complexity of interconnection of energy sources to the distribution grid [2]. Since DER penetration levels were low when IEEE Std 1547™-2003 was first published but grew quickly over the next decade, the standard received a minor amendment in 2014 to add advanced DER grid support capabilities, such as steady-state voltage control and some voltage and frequency ride-through requirements. The full revision of IEEE 1547 started in 2014, approved in February 2018 and published on April 6th, 2018.[3] It specifies new DER functional and communication requirements and is aimed at supporting grid codes that mandate interoperability of DER with both communications networks and the electrical grid. The 2018 standard is more than four times the length of the 2014 revision, approved by over 98% of balloters, and is considered one of the most complex

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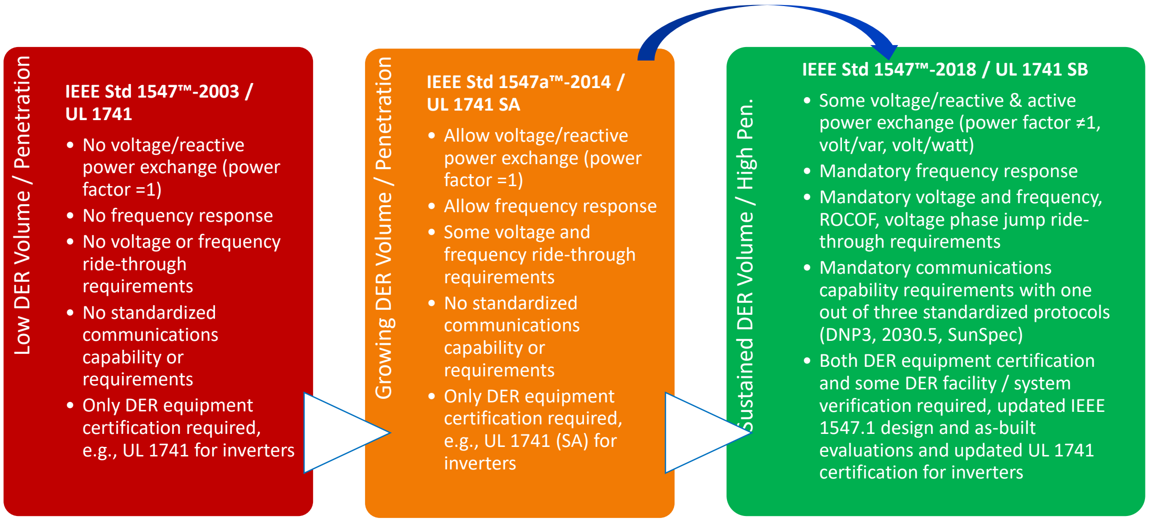
[1] "IEEE Std 1547™-2018 - IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces." *IEEE Xplore – Digital Library*, The IEEE Standards Association, 6 Apr. 2018, ieeexplore.ieee.org/servlet/opac?punumber=8332110.

[2] .IEEE 1547 National Standard for Interconnecting Distributed Generation: How Could It Help My Facility? *U.S. Department of Energy - Office of Scientific and Technical Information*, National Renewable Energy Laboratory, November 2003, https://www.osti.gov/biblio/15005821-ieee-national-standard-interconnecting-distributed-generation-how-could-help-my-facility-preprint.

[3] "IEEE Publishes Standard Revision for Interconnection and Interoperability of Distributed Energy Resources (DER) with Associated Electric Power Systems Interfaces." The IEEE Standards Association, 26 Apr. 2018, standards.ieee.org/news/2018/ieee_1547-2018_standard_revision.html.

IEEE standards available. Figure 1 shows the progression of the IEEE standard since 2003, and Table 1 shows some the major difference between the early and latest standards.



IEEE Std 1547™-2003 / UL 1741

- No voltage/reactive power exchange (power factor =1)
- No frequency response
- No voltage or frequency ride-through requirements
- No standardized communications capability or requirements
- Only DER equipment certification required, e.g., UL 1741 for inverters

IEEE Std 1547a™-2014 / UL 1741 SA

- Allow voltage/reactive power exchange (power factor =1)
- Allow frequency response
- Some voltage and frequency ride-through requirements
- No standardized communications capability or requirements
- Only DER equipment certification required, e.g., UL 1741 (SA) for inverters

IEEE Std 1547™-2018 / UL 1741 SB

- Some voltage/reactive & active power exchange (power factor ≠1, volt/var, volt/watt)
- Mandatory frequency response
- Mandatory voltage and frequency, ROCOF, voltage phase jump ride-through requirements
- Mandatory communications capability requirements with one out of three standardized protocols (DNP3, 2030.5, SunSpec)
- Both DER equipment certification and some DER facility / system verification required, updated IEEE 1547.1 design and as-built evaluations and updated UL 1741 certification for inverters

Figure 1 - Progression of IEEE 1547 Standard – Evolution Towards Grid Supportive

A shown in Table 1, there was a significant shift towards DER capabilities to be more "grid supportive" and play a more significant role during normal and abnormal system conditions. Figure 2 shows a more detailed timeline to the current state of IEEE Std 1547™-2018, suggesting anticipated release of compliant DER interconnection equipment.

Table 1- Changes in the scope of IEEE 1547™ from 2003 to 2018

IEEE Std 1547™-2003	IEEE Std 1547™-2018
Focused on distribution system aspects	Focused on distribution and bulk system aspects
Specifications for the "interconnection system" sufficiently achieve the standard's objective	Specifications encompass the more advanced DER control capabilities and communicability
Meant as DER interconnection standard but mainly used for equipment listing	Can be used for equipment listing as well as plant-level verification
Limited to electrical requirements	Includes both electrical as well as interoperability/communications requirements

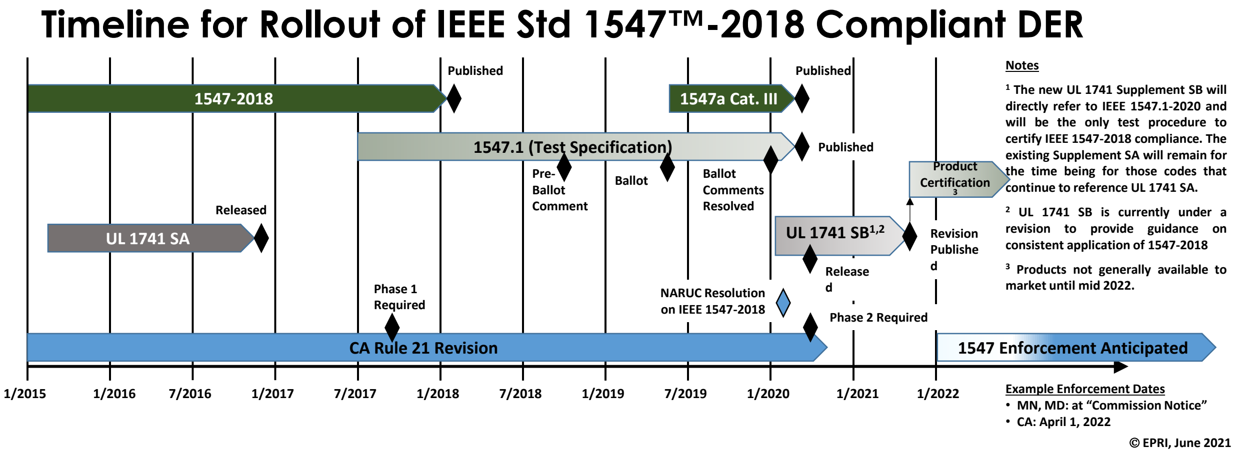


Figure 2 - Evolution of IEEE Std 1547™-2018 and Future Estimated Timeline

As a voluntary industry standard, IEEE 1547-2018 new requirements will not enter into effect until the standard is adopted by the Authority Governing Interconnection Requirements (AGIR), which can regulatory agency, public utility commission, municipality, cooperative board of directors, etc. For example, a public utility commission (PUC) may adopt and refer to IEEE 1547-2018 in their grid code – a specification defining safe, secure, and economical operation. The specific desired capabilities of the DER can then be implemented by the utilities that are regulated by that PUC that has adopted the standard. Since the issuance of IEEE Std 1547™-2018, many states are considering adoption of the standard such that the capabilities described become a requirement for interconnecting DER, as shown in Figure 3 (as of April 2021).

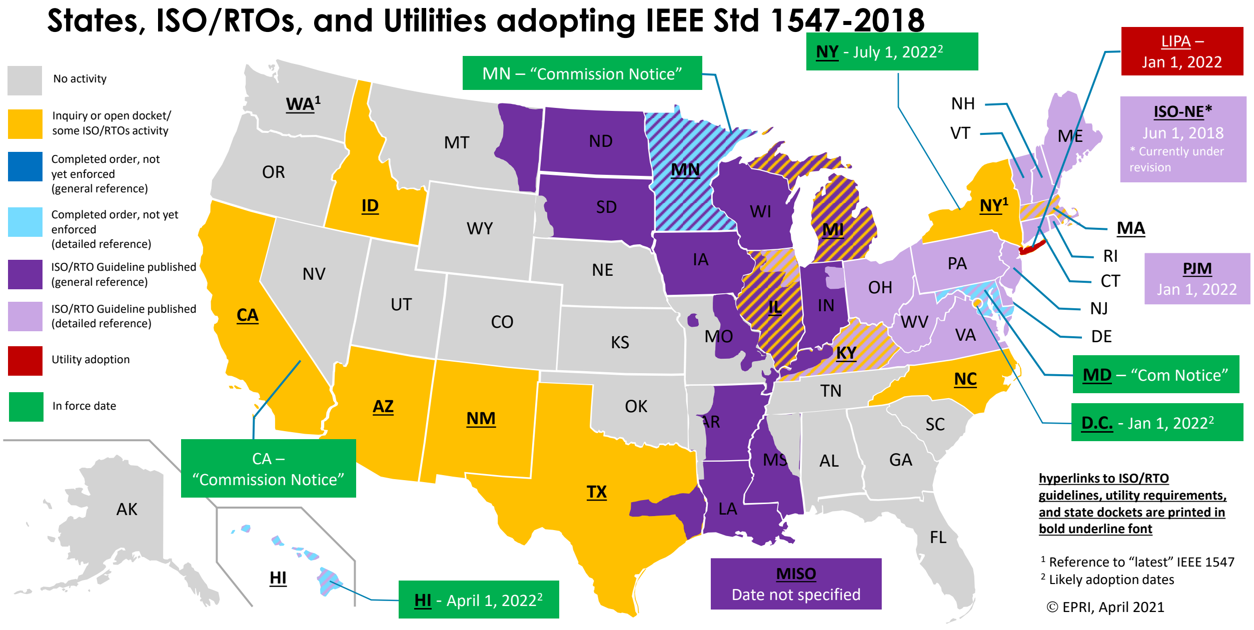


Figure 3 - National Adoption of IEEE 1547-2018™

Active Standards Revision Discussions

A conformance test procedure has been developed for IEEE Std 1547™-2018, referred to as IEEE 1547.1, or the Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces. While not used directly in product certification, 1547.1 is referenced extensively in the DER test requirements of Nationally Recognized Testing Laboratories (NRTL), such as Underwriters Laboratory (UL), Canadian Standards Association (CSA), TUV, and others.[4] NRTLs take IEEE 1547.1 and create test standards like UL1741 SA which include testing for compliance with IEEE Std 1547™-2018 (following IEEE 1547.1) requirements along with other safety requirements. This test standard was designed to ensure compliance while remaining flexible to developments of functional and communications capabilities. It ensures a consistent testing method for any DER control while allowing for enhancements to communications protocols. The testing procedure is a key element towards the release of certified products.

As referenced earlier, ride-through coordination of DER with bulk system operations is extremely important to maintain overall system stability. Stakeholder coordination between the utility and the responsible Transmission entity, i.e., the Regional Reliability Coordinator, is essential to ensuring that any active power-related DER settings coordinate reliably with regional transmission grid operational and planning practices. Such T&D coordination may take time, in some cases, up to two years. Therefore, it is important that it is started as early as possible in the adoption process.

Recent events, such as the Canyon Fire incident[5], have raised awareness regarding the potential reliability issues associated with widespread tripping of DER due to abnormal system events. Several of the regional electric reliability organizations (ERO) that are tasked with ensuring system reliability have been examining the potential impacts of similar events and concluded that there may be a need to adjust the trip settings of new DER interconnection as specified in IEEE Std 1547™-2018 to improve coordination and minimize trips.

In addition to IEEE 1547.1, there are several companion and related standards as shown in Table 2. These other standards provide guidance for topics such as design, integration, operation and interconnection of DER, as well as considerations for cybersecurity and impact studies.

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[4] *Current List of NRTLs*. Occupational Safety and Health Administration, United States Department of Labor, www.osha.gov/dts/otpca/nrtl/nrtllist.html.

[5] NERC (2018): 900 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report. Southern California Event: October 9, 2017. Joint NERC and WECC Staff Report. North American Electric Reliability Corporation (NERC); Western Electricity Coordinating Council (WECC). Atlanta, GA. Available online at https://www.nerc.com/pa/rrm/ea/October%209%202017%20Canyon%202%20Fire%20Disturbance%20Report/900%20MW%20Solar%20Photovoltaic%20Resource%20Interruption%20Disturbance%20Report.pdf

Table 2 - IEEE 1547™ Series and Related Standards

Standard	Name
1547	IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
1547.1	Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces
1547.2	Application Guide for IEEE Std 1547™, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems
1547.3	Guide for Cybersecurity of Distributed Energy Resources Interconnected with Electric Power Systems
1547.4	IEEE Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems
1547.6	IEEE Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks
1547.7	IEEE Guide for Conducting Distribution Impact Studies for Distributed Resource Interconnection
1547.8	Recommended Practice for 2 Establishing Methods and Procedures 3 that Provide Supplemental Support for 4 Implementation Strategies for 5 Expanded Use of IEEE Standard 1547
1547.9	Guide to Using IEEE Standard 1547 for Interconnection of Energy Storage Distributed Energy Resources with Electric Power Systems
2800	Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems
2030	IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads
2030.2	IEEE Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure

Advanced Autonomous Functions and Settings

IEEE Std 1547™-2018 defines two performance categories for reactive power capability and voltage regulation support functions. Category A covers minimum performance capabilities needed for Area Electric Power Systems (EPS) voltage regulation and are reasonably attainable by all DER technologies. This level of performance is deemed adequate for applications where the DER penetration in the distribution system is lower, and where the overall DER power output is not subject to frequent large variations. Category B covers all requirements within Category A and specifies supplemental capabilities needed to adequately integrate DERs in local Area EPSs where the aggregated DER penetration is higher or where the overall DER power output is subject to frequent large variations. DER is required to fit into either of these performance categories, and most inverter-interfaced DER can provide either Category A or B performance since the functionality is driven by the software of the inverter, not the physical hardware.

When applying autonomous DER functions and settings, there are many potential considerations:

- Objective of voltage regulation: primary or secondary
- Range of voltage present without DER
- Localized voltage magnitude needed to support customer voltages elsewhere
- Utility regulation equipment affected
- Correlation of system and local load with DER output
- Impedances, including transformers, service cables, and primary feeders
- Location where utility regulates voltage
- Variability of DER

Table 3 shows the voltage regulating functions required according to IEEE Std 1547™-2018. A detailed description of several of the advanced modes of operation is provided in this section.

Table 3 - DER Categories and Advanced Autonomous Functions

Voltage Regulation Control Type	Operating Mode	DER Category A	DER Category B
Reactive Power (Q) Control	Constant Power Factor	Mandatory[6]	Mandatory
	Voltage – Reactive Power (volt-var)	Mandatory	Mandatory
	Active Power – Reactive Power (watt-var)	Not Required	Mandatory
	Constant Reactive Power	Mandatory	Mandatory
Active Power (P) Control	Voltage – Active Power (volt-watt)	Not Required	Mandatory

IEEE Std 1547™-2018 Minimum Reactive Power Capability Requirements

Table 4 shows the minimum reactive power capability requirements, applicable to all control modes, outlined in IEEE Std 1547™-2018 for category A and B. It should be noted that the Category A reactive capabilities are limited to the DER nominal rated voltage while the Category B capabilities apply across the full ANSI C84.1 Range A voltage. The 44% capability was chosen to correspond to a 0.90 power factor at rated active power.

Table 4 - Category A and B Reactive Power Injection and Absorption Capabilities

Category	Voltage Range	Injection Capability (% of Apparent Power (kVA) Nameplate Rating)	Absorption Capability (% of Apparent Power (kVA) Nameplate Rating)
A	DER rated voltage	44	25
B	Full ANSI C84.1 Range A	44	44

Constant power factor mode

This control function maintains a consistent ratio of reactive power versus active power produced. Typically, this assumes reactive power is absorbed, in order to compensate for the voltage rise created from active power production.

Voltage – reactive power (volt-var) mode

The volt-var autonomous control function attempts to maintain the voltage at the RPA of a DER system within predefined voltage limit (e.g., statutory voltage limits) settings[7]. It essentially

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[6] Voltage regulation capability is mandatory, but the implementation is to be at the utility's discretion (The DER will provide this capability and the utility will decide to enable/disable it and choose the proper operating modes).

[7] Voltage measurement for this function is at the Reference Point of Applicability (RPA) as defined in IEEE Std 1547™-2018. This standard has a detailed set of criteria that determine whether the RPA is at the DER terminals or

allows DER systems to provide a unique reactive power response according to the voltage at the RPA and its available reactive power capability. The default volt-var set-points as illustrated in Figure 4 and Figure 5 for Categories A and B. Applying the default settings would result in absorption of reactive power to reduce voltage if it measures above the high setting, and reactive power would be injected to increase voltage if it measures below the low setting.

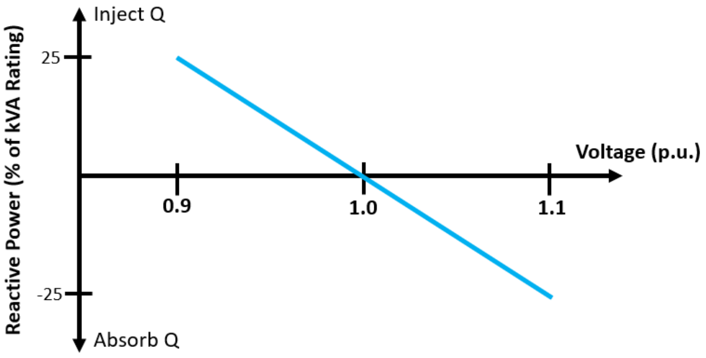

Figure 4 - Category A IEEE 1547™-2018 volt-var curve (default values shown)

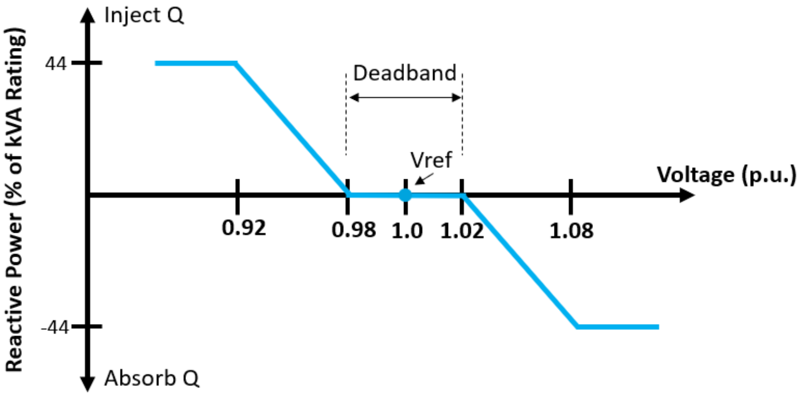

Figure 5 - Category B IEEE 1547™-2018 volt-var curve (default values shown)

Reference Tracking Voltage – reactive power (volt-var) mode

IEEE Std 1547™-2018 requires that the volt-var mode also have the capability for the voltage reference (Vref) to “track” the voltage at the RPA. The voltage reference tracking time constant is adjustable between 300 to 5000 seconds. For a step change of the system (e.g., active power change), the initial response is as rapid as the volt-var time constant allows, with an intentional “fading away” of the response over the longer time constant of the voltage reference tracking filter. Similar to other modes of operations, the settings (including the time constant) are to be specified by the Area EPS operator. The primary objective behind this function is to address

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at the Point of Common Coupling (PCC) with the utility system (Area EPS). As a generalization, the RPA is at the DER terminals (Point of Interconnection, POI) for DER facilities that do not export more than 500 kW to the utility system, otherwise the RPA is at the PCC.

short-term voltage variability that may lead to increased voltage regulating switching operations, but this function is not intended to provide long-term or steady-state correction of voltage. This function also has the potential to reduce overall reactive power consumption in comparison to traditional “static” volt-var, which does not have a Vref that tracks voltage.

Active power – reactive power (watt-var) mode

IEEE Std 1547™-2018 specifies a mode where reactive power is a function of active power, using a piecewise linear approximation of any Q = f(P) curve. Reactive power as a function of active power is widely used in Europe for smaller DER where establishing communications is not possible. This control has proven to be effective in mitigating voltage issues. See Figure 6 for a sample watt-var curve, in which reactive power is injected when the DER is absorbing real power, and reactive power is absorbed when the DER is generating real power. Note, absorbing real power is currently only a capability of energy storage DER (which would allow operations in all four of the power quadrants), and this graph is only a sample of what setpoints could be used within the capabilities of the DER system.

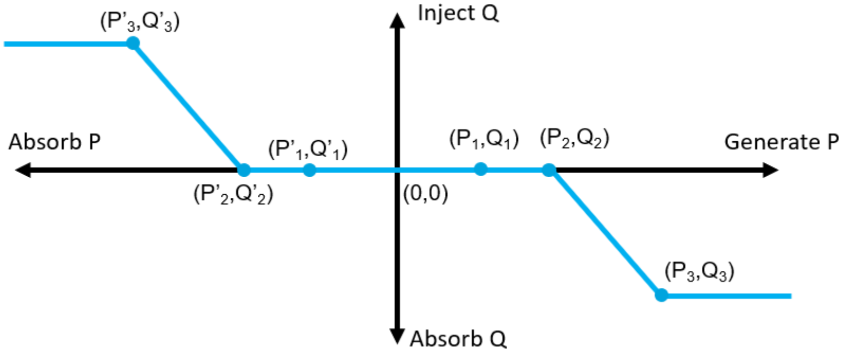

Figure 6 - IEEE Std 1547™-2018 watt-var curve

Voltage – active power (volt-watt) mode

The volt-watt function manages the active power output of the DER system by trying to maintain the voltage at the RPA of the DER within predefined voltage limits (e.g., statutory voltage limits). It essentially limits the maximum generation capability of the individual DER according to the voltage at the RPA and the set-points shown in Figure 7.

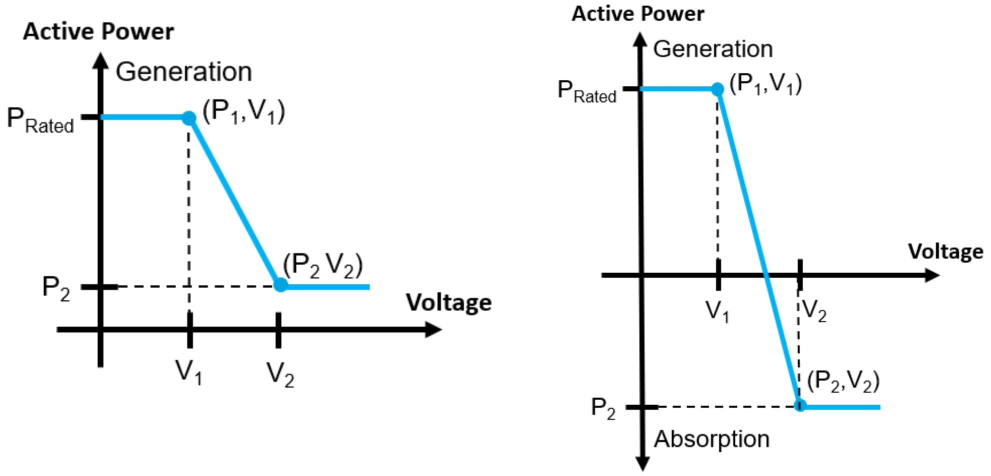

Figure 7 - IEEE Std 1547™-2018 volt-watt curve

Volt-watt is not intended to regulate voltage on a normal steady-state basis. However, when unusual or short-duration circumstances arise, curtailing DER power is preferable to abruptly tripping DER, which can result in wider system impacts. Therefore, this function is typically applied in conjunction with reactive power-controlling functions (i.e., volt-var, watt-var) as a last resort if the reactive power functions are inadequate in controlling an excessive voltage. This control can also be beneficial in situations where existing controls (e.g., voltage control through regulators or LTC) are not able to prevent the occurrence of high voltages. Curtailing power output to mitigate a distribution constraint has significant regulatory impacts and, therefore, should be applied with agreement from key stakeholders.

Actual Field Requirements, Key Trends, and Summary

IEEE Std 1547™-2018 is an approved standard, but as of this writing, certified DER equipment is yet available. However, many smart inverter equipment vendors have products available today that meet the requirements established by California, Hawaii, and Europe. A key question is what advanced autonomous functions are required to be enabled and active in the field today. The usage of advanced functions, particularly volt-var, seems to be more pervasive in Europe where some countries have much higher penetration levels of DER. Other countries, including portions of the United States, are beginning to take an earnest look at requiring advanced functions to be enabled in the near future. Table 5 provides a summary of the current status of regions requiring field deployment of these functions. This table is not meant to be exhaustive, but it shows that actual field usage is relatively limited. There is increasing interest among utilities to examine and understand the potential benefits of these modes of operation. As states choose to adopt IEEE Std 1547™-2018, the requirements to use advanced functions will most certainly extend to regions where significant DER growth is anticipated.

Table 5 - Advanced Functions Actually Required in The Field Today

Utility/Region	Required Activated Function	Notes
Ameren, ComEd, MidAmerican	Volt-var (similar to CA Rule 21)…must be able to accept external commands	Associated with FEJA, up to 2MW projects initially
PG&E, SCE, SDG&E	CA Rule 21 Volt-var	Since July 2018, applies to all systems
Idaho Power	Tailored Volt-var	Applies to large, utility scale systems
Hawaiian Electric Company (HECO)	HI Rule 14 Volt-var	Since Jan. 2017, Volt-watt on selected systems
Many European Countries (Germany, Austria, Italy, etc.)	Volt-var, Q(P)	One DSO requires communications for >500kVA allowing settings adjustments
Endeavour Energy, Australia	Volt-var	Per AS/NZS 4777
NY Utilities	**Unity PF where possible, no advanced functions**	**Some demonstrations and considering in the future**

The following section provides an overview of some of the key trends in the latest round of DER standards and a comparison of DER functionality between North America and the latest discussions in Europe.

Key Trends in DER Standards

Targeted Curtailment (or "Active Power Management") is receiving increased attention in function definition, implementation, and protocols – Initially, the sensitivity over DER technology causing generators to curtail their output (either directly through active power limiting or volt-watt, as well as indirectly through running out of inverter capacity while providing reactive power) likely caused under-development of active power management functions (i.e. such functions being left out of California Rule 21 Phase I requirements). Recently, those functions have become requirements in Rule 21, as well as IEEE 1547™. However, for curtailment to be a reasonable option, several components must be in place including the DER capability, the communication protocol, the central control system, and the interconnection agreement with the customer.

System operators are requesting more than just the minimum requirements – though many of the interconnection standards (including IEEE Std 1547™-2018 and the NC RfG) offer "minimum" requirements, utilities and other jurisdictions (such as individual countries within the European Union) have the ability to request additional functionality. In the case of IEEE 1547™, a clear example is the voltage ride-through function, under which 3 categories (I, II, and III) were offered. Each Category becomes successively more capable of supporting the grid, from providing essential bulk power system coordination up to more sophisticated wide-area and even distribution grid disturbances, eventually considering high penetrations of DER to enhance distribution reliability and power quality. While Category I was offered as a minimum that some manufacturers preferred, many utilities (thus far) are requiring at least Category II (and sometimes III) performance with ride-through for providing sufficient bulk grid support. Of note, Category III introduces a "momentary cessation" function to allow DER to return more quickly to operation if the disturbance clears relatively quickly and is not directly connected to the feeder serving the DER. In Europe, individual country codes developed thus far have had much more significant requirements than was required at the EU level for low- and medium-voltage systems.

Recognizing the need for standardizing on DER protocols – As the penetration of DER increases on the grid, utilities across the world are looking at methods to more effectively operate their grids in alignment with the increase of distributed energy resources like solar, storage, and controllable loads. This includes direct access to DER across a variety of makes and models of DER, algorithmic optimization of the dispatch of DER through advanced control systems like Distributed Energy Resourced Management Systems (DERMS) and Advanced Distribution Management Systems (ADMS), and analytics of DER-supplied data to improve modeling and unlock new analytics use cases. Development of standardized communications interfacing has become more apparent in recent years with standards like Rule 21 and IEEE 1547™ requiring detailed communications capabilities, including references to specific protocols. There are also standards like EN 50549 which recommend communications between DSO/TSO control centers and the DER/plant and even encourage the use of specific protocols.

Summary of Standard Capabilities

Table 6 provides a comprehensive summary of all United States standards in a single table. This is an excellent reference resource to aid in understanding the key functions available in each standard.

Table 6 - Summary of US-based DER Standards/Rules and Listings/Certifications for Capability Requirements

Standards/Rules for DER		Listing/Certification			Interconnection Standards (IS)			State/PUC/Utility Rules	
								CA	HI/HECO
Function Set	**Advanced Functions Capability**	**UL 1741 using: IS-1**	**UL 1741(SA) using: IS-1, IS-2, CA R21 & HI 14H/SRDv1.1**	**UL 1741(SB) using: IS-3 (Note 1)**	**(IS-1) IEEE 1547-2003 and 1547.1-2005**	**(IS-2) IEEE 1547a-2014**	**(IS-3) IEEE 1547-2018 and 1547.1-2020**	**Rule 21 (Phases)**	**Rule 14H & UL SRDv1.1**
All	Adjustability in Ranges of Allowable Settings		**	Δ		√	‡Δ		
Monitoring & Control	Ramp Rate Control		Δ	***			***	‡ (P1)	‡
	Communication Interface			Δ			‡Δ	‡ (P2)	‡
	Disable Permit Service (Remote Shut-Off, Remote Disconnect/Reconnect)		*Δ	Δ			‡Δ	‡ (P3)	‡
	Limit Active Power		*Δ	Δ			‡Δ	‡ (P3)	
	Monitor Key DER Data			Δ			‡Δ	‡ (P3)	
Scheduling	Set Active Power							[‡ (P3)]	
	Scheduling Power Values and Models							‡ (P3)	
Reactive Power & Voltage Support	Constant Power Factor	√	Δ	Δ	√	√	‡Δ	‡ (P1)	X
	Voltage-Reactive Power (Volt-Var)		Δ	Δ	X	√	‡Δ	‡ (P1)	‡
	Autonomously Adjustable Voltage Reference			Δ			‡Δ	!!!	!!!
	Active Power-Reactive Power (Watt-Var)			Δ	X		‡Δ		‡
	Constant Reactive Power	√		Δ	√	√	‡Δ		
	Voltage-Active Power (Volt-Watt)		Δ	Δ	X	√	‡Δ	‡ (P3)	‡
	Dynamic Voltage Support during VRT			Δ			√Δ	[‡ (P3)]	
Bulk System Reliability & Frequency Support	Frequency Ride-Through (FRT)		Δ	Δ			‡Δ	‡ (P1)	‡
	Rate-of-Change-of-Frequency Ride-Through			Δ			‡Δ	!!!	!!!
	Voltage Ride-Through (VRT)		Δ	Δ			‡Δ	‡ (P1)	‡
	Voltage Phase Angle Jump Ride-Through			Δ			‡Δ	!!!	!!!
	Frequency-Watt		Δ	Δ	X	√	‡Δ	‡ (P3)	‡
Other Advanced DER Functions	Anti-Islanding Detection and Trip		Δ	Δ	‡Δ		‡Δ	‡ (P1)	‡
	Transient Overvoltage			Δ			‡Δ		‡Δ
	Remote Configurability			Δ			‡Δ	‡ (P2)	‡
	Return to Service (Enter Service)			Δ			‡Δ	‡ (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
*Added in later edition for CA Rule 21 (P2) and (P3)
**Test procedure considered specified adjustment ranges
***Only included for enter service (refer to Return to Service)
Note 1 - Supplement SB in UL1741 refers to IEEE 1547.1-2020 for test procedures and also contains clarification to those test procedures

Source: EPRI

Figure 8 shows the default setpoints for the volt-var function in each of the standards discussed in the report. It is noteworthy that each of the standards consist of slightly different settings. The width of the dead-band and slope of the curve can significantly impact the reactive power compensation and, ultimately, the Area EPS voltage profile.

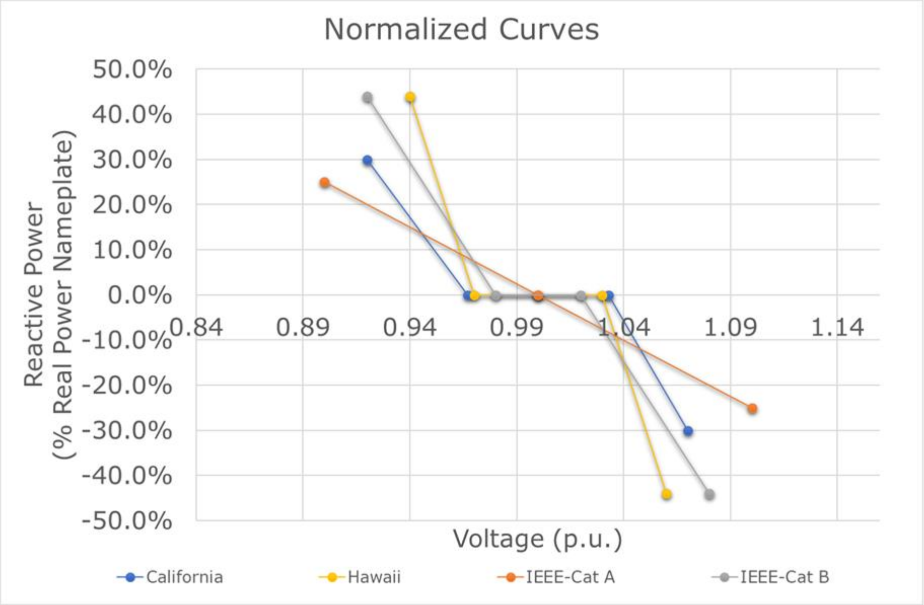

Figure 8 - Comparison of volt-var Default Setpoints for US-Based Standards