RECOMMENDATIONS FOR ADOPTION OF ADVANCED INVERTERS

NEW MEXICO ADVANCED INVERTER WORKING GROUP

VERSION1 – DRAFT, AUG. 4, 2022

Contents

SUMMARY

The New Mexico Advanced Inverter Working Group prepared a set of recommendations during Phase II of the New Mexico Public Regulation Commission's Interconnection stakeholder engagement efforts. These recommendations support the integration of distributed energy resources into the state's electric power system through adoption of IEEE 1547™-2018 (entitled "*IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces*") and implementation of advanced inverters.

The recommendations are summarized below:

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MOTIVATION AND PROCESS

Interconnection of Distributed Energy Resources (DER) into New Mexico's electricity system is guided by many laws, statutes, rules, and technical standards. One of these standards is IEEE 1547™-2018. This standard for interconnection and interoperability of distributed energy resources with associated electric power systems interfaces, is substantially updated from the previous version, IEEE 1547™-2003, the standard referenced in New Mexico's current interconnection rule and manual.

In late 2020, the New Mexico Public Regulation Commission recognized the need for updating the state's distributed energy resources interconnection rules and embarked on a significant stakeholder engagement effort on this topic in 2021 as part of case 20-00171-UT. Case 21-00266-UT replaced case 20-00171-UT as the Interconnection Rulemaking evolved. Phase I stakeholder engagement activities related to this rulemaking resulted in a Report of the NM Interconnection Rules: Report and Recommendations, October 2021. Though this report included basic recommendations regarding adoption of the IEEE 1547™-2018, it was clear that adoption would involve decisions on many complex technical and operational subjects.[1] A Phase II effort was initiated in February of 2022 to continue to engage stakeholders in this topic with the goal of developing a set of recommendations for the NM PRC to consider. In parallel the Commission continued its formal process regarding the state's Interconnection Rules.

During Phase II, the New Mexico Advanced Inverter Working Group met 12 times, over 8 months to develop the recommendations in this report. Two subgroups met between working group meetings to create proposals for the working group to consider. Over 50 individuals representing 20 organizations participated through attendance at meetings and contributions to the recommendations. Meetings were facilitated by Gridworks and a DOE Solar Fellow on assignment at the NM PRC. For more details on the meetings and participating organizations, see Annex C.

RECOMMENDATIONS

RECOMMENDATION 1. Elements Recommended for Policy and Elements Recommended for Technical Interconnection & Interoperability Requirements Documents

The working group acknowledges the technical complexities and dynamic nature of IEEE 1547™-2018 adoption. Key decisions, regulatory direction/oversight, or statements of policy are advised for 7 elements and 2 elements are recommended to be incorporated into electric system providers' Technical

[1] A decision matrix which lists the many decisions and choices associated with adoption of IEEE 1547™-2018, prepared by the Interstate Renewable Energy Council, is included in Annex B.

Interconnection & Interoperability Requirements (TIR) documents.[2] These elements are summarized in Table 1.

TABLE 1. Suggested Policy Elements and Elements for Electric System Provider's TIR Documents

Policy Elements	**Elements for ESPs TIR Documents**
Applicable to DERs up to and including 10 MW and as defined by IEEE 1547™-2018	
Reference Point of Applicability	
Category Determination	
Functions and Default Activations (Table 2)	
Setting Ranges (as prescribed by IEEE 1547™-2018)	Specific settings for functions
Allowance of all three eligible communication protocols.	Communication protocol requirements (for specific site locations)
Phased approach to communications interoperability.	

RECOMMENDATION 2. Applicability

All distributed energy resources up to and including systems of 10 MW in size,[3] installed after March 28, 2023, or date when certified equipment is widely available, and connected to a New Mexico electric system, shall comply with the IEEE 1547™-2018 requirements. Existing inverters are not required to conform to IEEE 1547™-2018 requirements but upon replacement due to end-of-life-cycle or other reasons, must be replaced with advanced inverters that meet these requirements. Some emergency backup power and standby DER systems are exempt from some requirements defined by the standard (See subclause 4.13 of IEEE 1547™-2018 for more information.)

RECOMMENDATION 3. Reference Point of Applicability

The Reference Point of Applicability (RPA) for all performance requirements shall be the Point of Common Coupling (PCC) unless allowed by alternate options described in IEEE 1547™-2018. The proposed RPA shall be identified in the interconnection application and one-line diagram. If the electric service provider determines that the applicant's preferred RPA is inappropriate because it is not in conformance with IEEE 1547™-2018, subclause 4.2, the applicant may select a different RPA that will bring the system into conformance. In all cases, the RPA shall be documented in the Interconnection Agreement. See Annex D for additional information pertaining to this recommendation.

RECOMMENDATION 4. Categories, Functions and Settings

The advanced inverter working group prepared a three-part recommendation for adoption of the IEEE 1547™-2018 standard as it pertains to the categories, functions, and settings of advanced inverters. Technical details of this recommendation are included in Annex E and additional background information is

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[2] Technical Interconnection & Interoperability (TIR) documents are public documents, often utility-specific. According to EPRI, they can include requirements for interconnection, interoperability, capabilities, and their utilization (settings), and grid integration (e.g., protection coordination, telemetry). For more information, see "*Generic Technical Interconnection and Interoperability Requirements (TIIRs): A Generic Template Including DER Interconnection Technical Review Criteria and Standardized Forms for DER Functional Settings*," EPRI Technical Update, Aug. 13, 2021. https://www.epri.com/research/products/000000003002022563

[3] New Mexico Interconnection Rules do not apply to systems over 10MW in size.

available from the Interstate Renewable Energy Council.[4] The recommendation is intended to ensure that DER systems shall be capable of actively regulating voltage, shall ride-through abnormal voltage/frequency, and are able provide the greatest degree of grid support possible. In addition, the recommendation provides an interconnection framework that accommodates the largest amount of DER penetration while preserving electric system reliability and safety. Finally, the recommendation aims to make advanced inverter settings transparent to all interested parties.

This recommendation addresses the definitions, activations and settings of the autonomous functions required by IEEE 1547™-2018 and its amendment 1547a-2020. A recommendation regarding the categories for performance, specific functionalities, and settings are included, as these determinations are critical for implementation of the IEEE 1547™ requirements.

Recommendation 4.a – Category Determination: Rotating equipment-based systems (both induction and synchronous) must meet Category A requirements for normal performance and Category I requirements for abnormal performance. Inverter-based systems must meet Category B requirements for normal performance and Category III requirements for abnormal performance.

Recommendation 4.b – Function Activation: Inverter and rotating equipment functions shall be activated according to Table 2. Note that the term "disabled" means that an advanced inverter is likely to have this capability, but this function is initially disabled to comply with New Mexico interconnection requirements.

The recommendation for voltage regulation is to enable volt-var as the reactive power function and volt-watt as the active power function. This combination of functions provides active adjustment of the DER as conditions change on the circuit, thus allowing for better voltage regulation as DER penetration increases over time. In addition, implementation of these two voltage regulation functions avoids the need to study and determine a static control setting, thus possibly simplifying the interconnection application review process. Selection of an alternative voltage regulation strategy, if warranted by a distribution system study, may be documented by a system operator, submitted as a variance for commission approval, and if approved, reflected in an ESP's published TIR documents.

Default activation status may be modified ……under what circumstances, by what process, how often, and how documented? NOTE LANGUAGE IN NOPR IN CASE 21-00266-UT… "E. The utility shall notify the DER owner of the need to modify ride-through settings. The request for setting modification shall not exceed one per year."

TABLE 2. Functions, Default Activation, and Purpose

Function	**Default Activation and Purpose**
Reactive Power Functions. Only one of the four options below can be activated:	**Voltage regulation**
Voltage-Reactive Power Control (volt-var)	Enabled for Categories A & B. Modulates reactive power in relation to measured grid voltage.
Constant Power Factor	Disabled. No voltage support is realized when this function is enabled with its default setting. Constant Power Factor does not respond directly to voltage and as such, in this mode, the

[4] Interstate Renewable Energy Council. See *"Making the Grid Smarter, Primer on Adopting the New IEEE 1547™-2018 Standard for Distributed Energy Resources,"* January 2019. https://irecusa.org/resources/making-the-grid-smarter-primer-on-adopting-the-new-ieee-standard-1547-2018/

	DER might be injecting or absorbing reactive power when it is not needed.
Active Power-Reactive Power Control (watt-var)	Disabled. Modulates reactive power in relation to active power output (and absorption of active power for systems that can store energy). Watt-var does not respond directly to voltage and as such, in this mode, the DER might be injecting or absorbing reactive power when it is not needed.
Constant Reactive Power Control	Disabled. Does not allow reactive power to adjust as power output from DER fluctuates.
Active Power Function	**Voltage regulation**
Voltage-Active Power Control (volt-watt)	Enabled for Category B. Reduces active power to reduce voltage (normally only once voltage is outside of the normal range)
Voltage and Frequency Disturbance Functions	**Supports bulk system stability and maximizes grid support from DERS**
Voltage Disturbance Ride-Through and Trips	Required for both inverter-based & rotating DER systems
Frequency Disturbance Ride-Through and Trips	Required for both inverter-based & rotating DER systems
Enter Service Functions	**Avoids abnormal voltages**
Enter Service	Enabled
Enter Service Ramp Rate or Randomized Start Time, depending on system size	Enabled
Anti-Islanding Function	**Avoids unintentional islanding**
Anti-Islanding	Enabled

Recommendation 4.c –Settings: Default settings for the functions outlined in Table 2 above are to be based on IEEE 1547™-2018 (as amended in IEEE 1547a-2020). Allowed settings also include site-specific settings as determined by System Impact Study and documented in the Interconnection Agreement. File formats for settings shall conform to the EPRI guidelines documented in “Common File Format for Distributed Energy Resources Settings Exchange and Storage.”[5] Site specific settings shall be documented in TIR documents and be made available by the ESPs to WHOM (PRC, DER Operators/Owners, public?).

RECOMMENDATION 5. Communications Protocols

The Advanced Inverter Working Group proposes that a communications interoperability policy include the following elements:

a) DERs up to and including 10MW are to be enabled with a communications interoperability capability as specified in IEEE 1547™-2018.
b) New Mexico electric service providers (ESP) shall be allowed to use any of the three eligible protocols defined by IEEE 1547™-2018 (but no others)

[5] Common File Format for Distributed Energy Resources Settings Exchange and Storage (epri.com), EPRI Technical Update, Dec 10, 2020. https://www.epri.com/research/products/000000003002020201

c) Equipment interoperability shall be tested and certified according to IEEE 1547.1-2020 and UL 1741 3rd Edition, Supplement SB.

d) Communications interoperability of DER is expected to mature in the following three phases:

   i. Inverter autonomous functions enabled. Experiences, learnings, challenges, and best practices shall be reported to the PRC 12 months after adoption of the Interconnection Rule.

   ii. Electric service providers propose pilot programs to monitor and interact with DER equipment connected to their systems. Based on these pilot programs, suggestions for communication interoperability standards shall be submitted to the PRC 24 months after adoption of the Interconnection Rule.

   iii. After due consideration, decisions, and implementation of communication interoperability standards, ESPs and DER operators will the ability to exchange "interactive information" to enable full functionality of DER – electric system interactions.

This phased approach is warranted due to the lack of maturity of interoperability capabilities of both New Mexico ESPs as well as DER equipment providers. Evolution of interoperability must address information and control systems capabilities as well as cyber security.

It is recommended that a New Mexico-based technical working group be supported to continue the learning and dialogue on communications interoperability for at least 24 months following adoption of the Interconnection Rule. New Mexico also needs to stay informed of developments in electric power cyber security. Two standard efforts worthy of following are IEEE 1547.3 (Interoperability and Cyber Security, currently in balloting) and IEEE 1547.10 (Gateways, working group currently being formed.)

ANNEX A – Background

NOT SURE HOW TO PRESENT THIS INFORMATION OR MAKE TEXT IN MAIN DOCUMENT BE CONSISTENT WITH WHATEVER IS THE CURRENT RULEMAKING LANGUAGE AT TIME OF THIS REPORT.

Interconnection of distributed energy resources into New Mexico's electricity system is guided by many laws, statutes, rules, and technical standards. One of these standards is IEEE Std 1547™. This standard for interconnection and interoperability of distributed energy resources with associated electric power systems interfaces, as amended by IEEE 1547a-2020, including use of IEEE 1547.1-2020 testing protocols to establish conformity is substantially updated from IEEE 1547-2003, the standard referenced in New Mexico's current interconnection rule and manual.

The Final Report of the New Mexico Interconnection Rules: Report and Recommendations, October 15, 2021, in 20-00171-UT, page 45-46, included the following language:

Capability for the following three grid support functions provided by IEEE 1547™-2018 shall be required for all DER installed after December 31st, 2022.

1. Shall be capable of actively regulating voltage.
2. Shall be capable of frequency response. Frequency response is the capability to modulate power output as a function of frequency. Mandatory capability for Categories II and III under high-frequency conditions, mandatory for Categories II and III under low-frequency conditions, optional for Category I.
3. Shall ride-through abnormal voltage/frequency.

In addition, capability for a fourth grid support function shall be optional:

4. May provide inertial response. Inertial response is the capability for DERs to modulate active power in proportion to the rate of change of frequency.

While capabilities for functions (1) and (2) are mandatory, their utilization is at the discretion of the Area Electric Power System (EPS) Operator.

For function (3), when determining ride-through requirements, the Area EPS Operator shall specify which of abnormal operating performance Category I, Category II, or Category III performance is required. This may be subject to regulatory requirements that are outside the scope of this standard and may consider DER type, application purpose, future regional DER penetration, and the Area EPS characteristics.

The Area EPS Operator shall notify the DER owner of the need to modify ride-through settings. The request for setting modification shall not exceed one per year.

Not specified as part of this proposal, but still needing determination are:
Ride-through settings for abnormal voltage/frequency and frequency response
Settings for active voltage regulation

The NOPR under case 21-00266-UT, which replaced case 20-00171-UT, includes this language:

17.9.568.11 IEEE 1547™-2018 ADOPTION

A. Capability for the following three grid support functions provided by IEEE 1547™-2018 shall be required for all DER installed after March 28, 2023.

(1) Shall be capable of actively regulating voltage.
(2) Shall be capable of frequency response. Frequency response is the capability to modulate power output as a function of frequency.
(3) Shall ride-through abnormal voltage/frequency.

(4) In addition, capability for a fourth grid support function shall be optional: may provide inertial response. Inertial response is the capability for DERs to modulate active power in proportion to the rate of change of frequency.

D. While capabilities for functions one and two are mandatory, their utilization is at the discretion of the area electric utility. For function three, when determining ride-through requirements, the utility shall specify which of abnormal operating performance is required. This may be subject to regulatory requirements that are outside the scope of this standard and may consider DER type, application purpose, future regional DER penetration, and the area characteristics.

E. The utility shall notify the DER owner of the need to modify ride-through settings. The request for setting modification shall not exceed one per year.

F. Existing inverters are not required to conform to the standards adopted above in Subsection A., but upon replacement due to end-of-life-cycle or other reasons, must be replaced with advanced inverters. G. Replacement of existing inverters with those that conform to the standards adopted above in subsection A. will not be considered a major modification of operations, so long as the total output of the generating facility, or its export limits as previously approved remain unchanged.

[17.9.568.11 NMAC – Rp, 17.9.568.11 NMAC, xx/xx/2022]

ANNEX B – Advanced Inverter Adoption Decision Matrix

Insert IREC matrix here with credit to IREC.

ANNEX C – Working Group Process Description and Participants List

Twelve facilitated meetings of the Advanced Inverter Working Group were held between February and September of 2022. Over 50 people from 20 different organizations attended the working group's meetings which were facilitated by NM PRC staff and Gridworks.

The following organizations participated in the working group activities:

Electric Service Providers	Industry	Other
EPE	Affordable Solar	Community Solar Access
PNM	Enphase	EPRI
SPS/Xcel	Fronius	IREC
	Positive Energy	PACE Fund NM
	REIA of NM	NM PRC
	SMA-America	NM Office of the Attorney General
	Sunrun	NM State University
	Synapse Energy Economics	Sandia National Laboratories
	Tesla	
	Trimark	

The list of meetings below includes links to the meeting recordings and summaries.

Feb. 10, 2022
- https://www.youtube.com/watch?v=cEDbpI3_fUg
- https://onedrive.live.com/edit.aspx?cid=5891771fba4aff14&page=view&resid=5891771FBA4AFF14!2865&parId=5891771FBA4AFF14!2863&authkey=!AJKlY_S0wfPCqb8&app=Word

Feb. 24, 2022
- https://www.youtube.com/watch?v=iL9fitx55lo
- https://onedrive.live.com/?authkey=%21AJKlY%5FS0wfPCqb8&cid=5891771FBA4AFF14&id=5891771FBA4AFF14%212874&parId=5891771FBA4AFF14%212866&o=OneUp

Mar. 24, 2022
- https://www.youtube.com/watch?v=hV5G6_VDZg0
- https://onedrive.live.com/?authkey=%21AJKlY%5FS0wfPCqb8&cid=5891771FBA4AFF14&id=5891771FBA4AFF14%212874&parId=5891771FBA4AFF14%212866&o=OneUp

Apr. 14, 2022
- http://www.youtube.com/watch?v=b4fpVLg1Jus
- https://onedrive.live.com/edit.aspx?cid=5891771fba4aff14&page=view&resid=5891771FBA4AFF14!2894&parId=5891771FBA4AFF14!2882&authkey=!AJKlY_S0wfPCqb8&app=Word

May 26, 2022
- https://www.youtube.com/watch?v=4lMpCvG8aB0
- https://onedrive.live.com/edit.aspx?cid=5891771fba4aff14&page=view&resid=5891771FBA4AFF14!2909&parId=5891771FBA4AFF14!2896&authkey=!AJKlY_S0wfPCqb8&app=Word

Jun. 9, 2022
- https://us02web.zoom.us/rec/share/P7D4m27KU3fCQfWCVFpKN5MOcWj44pOB4HUUvPbGlu364YVYw8mmCjVOvgRO5XaS.WlGOAf37S3bjLtBp
  Passcode: NnGQi#L4

- https://onedrive.live.com/?authkey=%21AJKlY%5FS0wfPCqb8&cid=5891771FBA4AFF14&id=5891771FBA4AFF14%212917&parId=5891771FBA4AFF14%212902&o=OneUp

Jun. 30, 2022

- https://www.youtube.com/watch?v=70auf67yKb4
- https://onedrive.live.com/edit.aspx?cid=5891771fba4aff14&page=view&resid=5891771FBA4AFF14!2922&parId=5891771FBA4AFF14!2903&authkey=!AJKlY_S0wfPCqb8&app=Word

Jul. 14, 2022

- http://www.youtube.com/watch?v=Ml1I543nHPw
- https://onedrive.live.com/edit.aspx?cid=5891771fba4aff14&page=view&resid=5891771FBA4AFF14!2933&parId=5891771FBA4AFF14!2904&authkey=!AJKlY_S0wfPCqb8&app=Word

Jul. 28, 2022

- https://www.youtube.com/watch?v=pjjeGcTaugs
- https://onedrive.live.com/edit.aspx?cid=5891771fba4aff14&page=view&resid=5891771FBA4AFF14!2937&parId=5891771FBA4AFF14!2905&authkey=!AJKlY_S0wfPCqb8&app=Word

Aug. 11, 2022

- recording
- summary

Aug. 25, 2022

- recording
- summary

Sept. 8, 2022

- recording
- summary

Two subgroups were formed during this process: a functions and settings proposal subgroup and a communications interoperability subgroup. The working group appreciates the work of the people who provided their time and expertise to develop Recommendation 4 (Functions and Settings). Key contributors were Travis Dorr (SPS), Brian Lydic (IREC), Midhat Mifazy (IREC) and Michael Ropp (SNL). Critical input was also received from Tom Key (EPRI) and Steve Wurmlinger (SMA). Jose Cordova (EPRI) supported the effort as well by making a presentation to the group on June 9.

The working group also appreciates the knowledge and participation of the following individuals for developing the basis of Recommendation 5 (Communications Interoperability). Key individuals were Travis Dorr (SPS), Jon Hawkins (PNM), Michael Ropp (SNL), Tracy VanSlyke and Jerry Delgado (EPE). Bob Fox (SunSpec Alliance) also provided invaluable assistance in this effort.

ANNEX D – Technical Details and Definitions for Recommendation 3 (Reference Point of Applicability)

Per IEEE 1547-2018, the reference point of applicability (RPA) is the location where the interconnection and interoperability performance requirements specified in this standard apply. The location of the RPA is affected by system rating and export capability, load demand, and zero-sequence continuity. The point of common coupling (PCC) is the point of connection between the Area EPS and the Local EPS. The point of DER connection (PoC) is the point where a DER unit is electrically connected in a Local EPS and meets the requirements of this standard exclusive of any load present in the respective part of the Local EPS. Figures H.1 and H.2 of IEEE 1547™-2018 provide decision trees regarding the determination of the RPA and the IREC BATTRIES Toolkit[6] includes recommendations on this topic.

Definitions from IEEE Std 1547-2018

Point of DER connection (PoC): "The point where a DER unit is electrically connected in a local EPS and meets the requirements of this standard exclusive of any load present in the respective part of the local EPS."

Supplemental DER device: "Any equipment that is used to obtain compliance with some or all of the interconnection requirements of this standard."

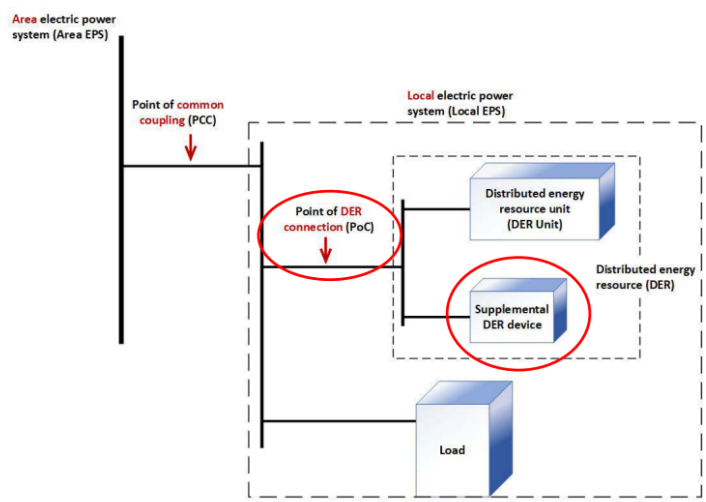

Figure courtesy of NREL

[6] https://energystorageinterconnection.org/resources/batries-toolkit/

ANNEX E – Technical Details for Recommendation 4 (Categories, Functions and Settings)

The three-part proposal is intended to ensure that DER systems shall be capable of actively regulating voltage, shall ride-through abnormal voltage/frequency, and are able provide the greatest degree of grid support possible. In addition, it provides an interconnection framework that accommodates the largest amount of DER penetration while preserving electric system reliability and safety. Finally, the proposal aims to make advanced inverter settings transparent to all interested parties.

Selection of categories for both normal and abnormal operating performance impacts which advanced inverter functions are to be enabled as well as the settings for these control functions. The normal operating performance category (choices are Category A or B) specifies how the Distributed Energy Resource (DER) system should perform with regards to voltage control during normal grid operations, and therefore impacts the use of voltage regulation controls. The abnormal operating performance category (choices are Category I, II, or III) specifies DER performance or "ride-through" capabilities during a grid disturbance such as a transmission fault or loss of a generator.

Recommendation 4.a – Category Determination: Rotating equipment-based systems (both induction and synchronous) must meet Category A requirements for normal performance and Category I requirements for abnormal performance. Inverter-based systems must meet Category B requirements for normal performance and Category III requirements for abnormal performance.

Equipment is allowed to meet the requirements of the highest category it is capable of being certified to, with category B being higher than category A (under normal performance) and category III being the highest under abnormal performance.

Recommendation 4.b – Function Activation: Inverter and rotating equipment functions shall be activated according to Table 1. Note that the term "disabled" means that an advanced inverter is likely to have this capability, but this function is initially disabled to comply with New Mexico interconnection requirements.

The recommendation for voltage regulation is to enable volt-var as the reactive power function and volt-watt as the active power function. This combination of functions provides active adjustment of the DER as conditions change on the circuit, thus allowing for better voltage regulation as DER penetration increases over time. In addition, implementation of these two voltage regulation functions avoids the need to study and determine a static control setting, thus possibly simplifying the interconnection application review process. Selection of an alternative voltage regulation strategy, if warranted by a distribution system study, may be documented by a system operator, submitted as a variance for commission approval, and if approved, reflected in an operator's published interconnection requirements.

TABLE 3. Functions, Activations, and Settings Summary

Function	Activation	Purpose
Voltage-Reactive Power Control (volt-var)**	Enabled for Categories A & B; utilize category-appropriate default settings in IEEE 1547-2018, Table 8	Voltage Regulation
Constant Power Factor	Disabled***	Voltage Regulation
Active Power-Reactive Power Control (watt-var)	Disabled	Voltage Regulation
Constant Reactive Power Control	Disabled	Voltage Regulation

Voltage-Active Power Control (volt-watt)	Enabled for Category B; use default settings in IEEE 1547-2018, Table 10	Voltage Regulation
Voltage Disturbance Ride-Through and Trips	Rotating DERS use Category I defaults, inverter-based DERS systems, use Category III defaults	Bulk System Stability; maximum grid support from DERS
Frequency Disturbance Ride-Through and Trips	Rotating DERS use Category I defaults, inverter-based DER systems, use Category III defaults	Bulk System Stability; maximum grid support from DERS
Enter Service	Use default settings from IEEE 1547-2018, Table 4	Avoidance of abnormal voltages
Enter Service Ramp Rate	DER installations shall use the ramp rate specified in IEEE 1547-2018, 4.10.3. DERS smaller than this limit may use the randomized start time described in IEEE 1547-2018, 4.10.3, Exception 1 if mutually agreed to by the system operator.	Avoidance of abnormal voltages
Anti-Islanding	Enabled	Avoid unintentional islanding

**Regarding volt-var settings: the autonomously adjusting Vref function should also be turned off by default unless otherwise determined as advantageous by System Impact Study.
***Under normal circumstances, the Constant Power Factor control function will be disabled by default. However, in some cases, the Area EPS Operator has the jurisdiction to specify in the Interconnection Agreement (IA) when Constant Power Factor control function is to be enabled. If this function is enabled, Voltage-Reactive Power Control (volt-var) must be disabled. If the IA does not specify a power factor or if an interconnection agreement is not required for interconnection, then assume -0.98 (absorbing).

Recommendation 4.c –Settings: Default settings for the functions outlined in Table 2 above are to be based on IEEE 1547™-2018 (as amended in IEEE 1547a-2020). Allowed settings also include site-specific settings as determined by System Impact Study and documented in the Interconnection Agreement. Settings, formatted per EPRI Utility Required Profile guidelines (REFERENCE EPRI), are to be made available to WHOM (PRC, DER Operators/Owners, public?) by the ESPs.

ANNEX F – Technical Detail for Recommendation 5 (Communication Protocols)

Recommendation 5.a – Applicability:

DERs up to and including 10MW are to be enabled with a communications interoperability capability as specified in IEEE 1547™-2018.

EXPLANATION: DER systems up to and including 10MW are included in this communications interoperability requirement. (Systems larger than 10MW are outside the scope of the NM Interconnection Rules). If a collection of DER equipment is aggregated and interfacing with the electric service provider as if it were one system, a single communications interface is allowed.

RATIONALE: taking advantage of the aggregated resources represented by DER systems will require them to be visible and interactive with the distribution system.

Recommendation 5.b – Allowed Protocols:

New Mexico allows any of the three IEEE 1547™-2018 eligible protocols (but no others) to be employed by the electric service providers.[7] Providers are allowed to implement any of the three in different parts of the distribution system, depending on the use case and infrastructure in place at a given location. Guidance regarding allowed protocols shall be documented in the electric service provider's TIR documents.

It is recommended that the protocol for a specific interconnection be identified by the ESP and communicated to the interconnection applicant. If a Pre-Application Report is requested, the communications protocol shall be identified in the report.

EXPLANATION: A summary of eligible protocols is included in Annex F, and highly simplified version is shown in Table 1. Communications interfaces may be different depending on the infrastructure available at the DER system interconnection site. For example, in some locations, connection to the electric service provider's SCADA system might be preferred and hence, the IEEE Std 1815 (DNP3) may be the chosen protocol. In another location a DER inverter that uses the SunSpec Modbus protocol will need a gateway device to communicate with an electric service provider's demand side management system that uses the IEEE Std 2030.5 (SEP2) protocol.

Table 1. Eligible protocols (see IEEE 1547™-2018, subclause 10 for additional details)

	Current uses include…	**Considerations**
IEEE Std 2030.5 (SEP2)	Many AMI and home energy mgt devices	Common web interface platform.
IEEE Std 1815 (DNP3)	Utility SCADA systems	Allows for granular level control, high speed communications. Must have the appropriate DER information content integrated to be IEEE 1547 compliant.
SunSpec Modbus	Many modern inverters	Submaps (content) added for specific applications.

Note that cyber security challenges are present regardless of the chosen protocol and must be addressed in partnership with the involved entities across the entire communications and control system.

[7] The IEC 61850 standard, though used in some electrical system communication infrastructures, is not currently included in the list of eligible protocols.

RATIONALE: It is expected that gateway devices will be available to translate between the communications protocol used by the DER equipment and the electric service provider's communications network to which the DER will be connected, whereas the ESP's communication system has limited configurability. In addition, communications technologies are evolving, so some flexibility is recommended.

Recommendation 5.c – Interoperability Testing:

Interoperability capabilities of advanced inverters shall be tested according to IEEE 1547.1-2020 and UL 1741 3rd Edition, Supplement SB.

Recommendation 5.d – Information Management:

Communications interoperability of DER is expected to mature in the following three phases:

i. Inverter autonomous functions enabled.
ii. Electric service providers propose pilot programs to monitor and interact with DER equipment connected to their systems.
iii. After due consideration, decisions, and implementation of communication interoperability standards, ESPs and DER operators will the ability to exchange "interactive information" to enable full functionality of DER – electric system interactions.

Phase i) relies on the autonomous functions of the IEEE 1547™-2018 compliant inverters to manage the performance of the DER system. It also offers the ESPs and DER operators opportunities to learn how the two interact based on the advanced inverters autonomous functions. Most of New Mexico's electric service providers do not yet have visibility of DER resources and this first step is necessary before "interactive" capabilities can be implemented. Experiences, learnings, challenges, and best practices shall be reported to the PRC 12 months after adoption of the Interconnection Rule.

Phase ii) enables the ESPs to design and implement explicit pilot programs for communications interoperability. Pilot programs could include both monitoring as well as interactive management and should be identify best practices and develop solutions to challenges (e.g., cyber security). Note that cyber security (which was out of scope for IEEE 1547-2018) is a critical issue that is being worked at the national level. Suggestions for communication interoperability standards shall be reported to the PRC 24 months after adoption of the Interconnection Rule.

Phase iii) enables full functionality of distributed resource - system interactions, takes advantage of the DER to support grid operations.

Reference Information Regarding Communications Interoperability Protocols

The working group expresses great appreciate to Bob Fox, Principal Engineer at the SunSpec Alliance, for his attendance at the working group's July 14, 2022, meeting. Mr. Fox summarized the history, uses, and considerations regarding the IEEE 1547™-2018 compliant communications protocols. The synopsis below was developed by the Gridwork's meeting facilitator.

SunSpec Modbus

Modbus was developed in the 1970's as an industrial control protocol and is used across millions of devices, mostly in industrial automation applications. It is a simple to implement. It is a command-response model and is a vehicle for exchange of information. A requestor makes requests from Modbus compliant devices, which are organized as a set of registers. Content is added via Modbus "maps" to allow for interactions with specific devices. Modbus was popular among many, but not all, DER manufacturers. SunSpec modified

Modbus by adding standardized submaps (information arrays) that could be defined and chosen by equipment manufacturers. Submaps were developed for functional groups such as inverters, environmental devices, metering, trackers, storage, and others. SunSpec also provides a discovery mechanism to find needed submap content for specific applications. In other words, SunSpec added maps (information models) to the original Modbus exchange protocol. This updated version of Modbus can be deployed using the physical layer of RS-485 (serial layer) or TCP/IP over Ethernet. Specific documents pertaining to IEEE 1547-2018 and implementation of SunSpec Modbus to comply with the standard are available. More information is available at www.sunspec.org.

With regards to security, Modbus can be contained in a (physically secure) gateway which can translate between 2030.5 and Modbus formats. Modbus can also operate over TCP/IP with Transport Layer Security (TLS) for added security.

IEEE Std 1815 (DNP3)

This command response protocol was developed in the 1980's and it involves a requester sending or receiving information to or from a device. It is, like Modbus, a vehicle for exchanging information, and has a register model for storing information. All application specific information must be supplied separately. This protocol has more functionality than Modbus but is more complicated to deploy and may be more expensive to deploy. DNP3 has the capability of exchanging information asynchronously. A DER application node organizes the relevant information for DNP3 compatibility. See DNP3.org users group for more information about such an application. The Modular Energy Storage Association/Alliance (MESA) also developed a DNP3 information application that is harmonized with this protocol. DNP3 is commonly used in SCADA systems, where control functions are required at a granular level. An equipment manufacturer usually supplies the information content map, or it can be customized by the user. These applications typically involve higher speed communications commensurate with control functions. Customization and high-speed control features are the reasons for the higher costs. There are likely many DNP3 systems currently in use, but they will not be IEEE 1547-2018 compliant unless they have the appropriate DER information content integrated. This protocol gets the least amount of attention, currently, but is being seen in many large-scale storage systems. Support for the *DNP3 Profile for Communications with Distributed Energy Resources (DERs)* (referenced as DNP3-AN-2018-001 at DNP3.org) is required for 1547-2018 DNP3 support.

IEEE Std 2030.5 (SEP2)

This protocol was developed by ZigBee (meter manufacturer) as a smart energy protocol (SEP1) and was revised to manage home energy management devices (SEP2). (Note: the US National Institute of Standards and Technology, NIST, selected SEP2 as a standard for home energy management devices in 2009.) The 2030.5 (SEP2) protocol runs HTTP (application layer) over TCP/IP and uses a RESTful webservice paradigm, which is now very common in many web-interfacing systems. It also runs with a TLS layer.

In 2015 this protocol was transferred to IEEE where it became IEEE 2030.5-2015. It was updated in 2018 to support the IEEE 1547-2018 standard. DER related content (metering, demand control, pricing, and many other functions) has been developed and the information models are integrated into the 2030.5 protocol. This is in contrast with the Modbus and DNP3 protocols where additional information models are required to be integrated. In contrast to Modbus and DNP3 which are command and response protocols, a 2030.5 client (DER in this case) pulls configuration and control information from the 2030.5 server either periodically or when notified of a change. The technology used in the 2030.5 protocol stack (TCP/IP, HTTP, TLS) is proven, well-worn, and understood by many engineers today. It is also currently being updated. For more information on this protocol, see www.sunspec.org.

California has adopted 2030.5 as the default interface for resources interfacing with electric utilities. CA has developed a Common Smart Inverter Profile for defining how 2030.5 is used for DER deployment and outlining certification requirements. Australia is adopting this protocol with some additions to the CA profile.

Other Topics

Security Discussion - It was noted that many entities have a role to play in cyber security of these systems and partnerships among parties to address the whole system are critical. The physical environment as well as the communications environment are to be considered. Security will be an active conversation for the foreseeable future and will have different approaches in different applications. This is true for all three protocols. Other industries (e.g., banking) have had to address similar security challenges. Protocols that are broadly deployed and continuously being updated may have stronger security profiles. One source of information on this topic is a workgroup that SunSpec and Sandia currently lead. For more information see: https://sunspec.org/cybersecurity-work-group/

AMI Implications – Bandwidth of some AMI systems has historically been a constraint for interoperability with DER control protocols, but this could be changing.

Applicability – An option to consider is to use SunSpec Modbus locally for individual, small DER systems and consider another protocol, such as 2030.5 for larger, wide area systems that will interface with the utility in a more sophisticated way. SunSpec Modbus is the simplest way to achieve IEEE 1547-2018 compliance in the short term, particularly for local applications.

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