PNM
Technical Interconnection and Interoperability Requirements (TIIR)

February 1, 2024

Contents

1. Introduction

The following are the technical requirements for interconnecting Distributed Energy Resources (DER) to PNM's electric distribution system in compliance with IEEE Std 1547-2018 and IEEE 1547.1-2020 as certified by a nationally recognized testing laboratory (NRTL) as well as 17.9.568.11 of the New Mexico Administrative Code (NMAC). Equipment installed before March 28, 2023 will also be considered certified as "legacy systems" and are not required to conform to IEEE 1547-2018 requirements. A legacy system will be considered certified if it has been tested and certified by a NRTL in accordance with IEEE 1547-2003 and 1547.1-2005. Replacement of legacy systems shall conform to the IEEE 1547-2018 standard, or shall be reviewed by PNM as a "like-kind" equipment to accommodate warranty replacements, system compatibility issues for larger integrated DER systems, or previously acquired spare parts. This document is to be used in conjunction with PNM's Electric Service Guide[1] and other applicable industry standards, including the National Electric Code (NEC), National Electric Safety Code (NESC), applicable IEEE standards and UL Standards as stated in 17.9.568.10 NMAC. To demonstrate compliance with 17.9.568.11(A) NMAC, applications are required to include the UL 1741-SB certification certificate(s), as applicable. This document contains utility-specific standards and requirements. This TIIR document is only applicable to Distributed Energy Resource (DER) applications of generating facilities with a nameplate rating up to and including 10MW connecting to a utility system, which are governed by the New Mexico Public Regulation Commission (Commission).

The settings contained in this document are to be considered default settings for most DERs interconnecting to PNM's Distribution System. However, specific settings for systems that require a Supplemental Review or Detailed Study may be required by PNM. It should be noted that PNM may seek to modify these default settings or implement feeder specific settings as PNM develops and implements the results of its Hosting Capacity Analysis, gains more experience with advanced inverters and the Commission's new interconnection rules (17.9.568 NMAC), or makes other modifications to its distribution system.

2. Definitions, Abbreviations, and Common Terms

The definitions of terms used in this document are consistent with the IEEE 1547, IEEE 1547.1, and 17.9.568 NMAC.

2.1 Definitions

Abnormal Operating Performance Category: The grouping for a set of requirements that specify technical capabilities and settings for a DER under abnormal operating conditions, i.e., outside the continuous operation region.

Area Network: a section of an electric power system served by multiple transformers interconnected in an electrical network circuit, generally used in large, densely populated metropolitan areas to provide high reliability of service. Also referred to as a grid network, street network, or spot network.

[1] https://www.pnm.com/documents/396023/396191/ESG_no-drawings.pdf/5d70c33e-822c-4864-bc34-dbbd2cd9d0a3?t=1583856457268

Nameplate Rating: the sum total of maximum rated power output of a DER's constituent generating units and/or electric storage system as identified on the manufacturer's nameplate, regardless of whether it is limited by an approved means.

Normal Operating Performance Category: The grouping for a set of requirements that specify technical capabilities and settings for DER under normal operating conditions, i.e., inside the continuous operation region.

System Impact Study: The study conducted pursuant to 17.9.568 NMAC and as defined by 17.9.568.7(R)(6).

2.2 Acronyms

BPS	Bulk Power System
DER	Distributed Energy Resource
EPS	Electric Power System
ESS	Energy Storage System
NMPRC	New Mexico Public Regulation Commission
PoC	Point of Distributed Energy Resource Connection
PCC	Point of Common Coupling
RPA	Reference Point of Applicability
RTO	Regional Transmission Operator
TPS	Transmission Power System

3. Performance Categories

The IEEE 1547 standard provides a technology-neutral approach in which performance categories are assigned to specify required capability for reactive power performance, voltage regulation performance, and response to abnormal conditions. Performance categories describe minimum equipment capability and the required ranges of allowable settings.

Category A and B specify reactive power capability and voltage regulation performance requirements. Category B is intended for use where DER penetration is higher and where the DER power output is subject to frequent large variations. Category B encompasses all of Category A capabilities. Category A and B assignment is specified by PNM.

Categories I, II, and III differentiate performance requirements for DER response to abnormal conditions. Category III is the highest capability and can inherently meet the ride-through requirements of the lower categories. In contrast, the voltage and frequency trip requirements of higher categories may not be met by lower categories as the range of allowable settings are different.

I. Category I encompasses minimum BPS essential needs and reasonably attainable by all DER technologies that are in use today.

II. Category II coordinates with North American Electrical Reliability Corporation (NERC) PRC-024-2 with a modification to the voltage ride-through to account for characteristics of distribution load devices.

III. Category III covers all BPS reliability needs and also introduces ride-through requirements aimed at addressing high DER penetration integration issues such as power quality events and other abnormal system conditions that may arise from DER tripping in the local EPS.

Table 1 shows the equipment capability performance categories required for interconnection to PNM's Distribution System.

3.1 Normal – Category A and B

The normal performance category specifies reactive power capability and voltage regulation performance requirements. For interconnection on PNM's Distribution System, synchronous machine-based DER shall comply with normal performance Category A. For interconnection on PNM's Distribution System, inverter-based DER shall comply with normal performance Category B.

3.2 Assignment of Abnormal Performance Category I, II, or III

The abnormal performance category specifies trip and ride-through performance requirements. For interconnection on PNM's Distribution System, synchronous machine-based DER shall comply with abnormal performance Category I. For interconnection on PNM's Distribution System, inverter-based DER shall comply with abnormal performance Category III. Table 1 summarizes these specifications.

Table 1: PNM Normal and Abnormal Performance Categories

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

4. Locational Constraints

On or before June 14, 2024, interconnections to PNM's Area Network in Downtown Albuquerque, New Mexico (Downtown Network) will require a supplemental review to be allowed to connect to the Downtown Network. These interconnections shall be non-exporting DER including prohibiting inadvertent export. The nameplate rating of the DER must be less than half the verified minimum demand of the building for the last 12 months measured at 15-minute intervals. Additionally, a standalone, utility grade reverse power protection relay (Device 32R) shall be installed to prohibit power across the PoC. Protective settings for this relay must be coordinated with PNM based on the interconnection study done for connecting to the Downtown Network.

5. Reactive Power Capability and Voltage/Power Control Performance

Synchronous machine-based DER shall be capable of the following IEEE 1547-2018 Category A voltage and reactive/active power control functions: constant power factor mode, voltage-reactive power mode, and

constant reactive power mode.

Inverter-based DER shall be capable of IEEE 1547-2018 Category B voltage and reactive/active power control functions: constant power factor mode, voltage-reactive power mode, active power-reactive power mode, constant reactive power mode, and voltage-active power mode.

DER shall meet the performance and settings specified in IEEE 1547-2018, the TIIR, and other industry standards for each voltage and reactive/active power control function. The required default settings for each voltage and reactive/active power control function will depend greatly on the size and location of the DER within the distribution feeder. For larger DER that proceeds through the System Impact Study phase of the interconnection process, a specified default setting will often be identified in the study results.

5.1 Reactive Power Capability of the DER

DER reactive power capability shall be available for use by the PNM operator and compliant with IEEE 1547-2018 Section 5.2 for the applicable performance category for the specific DER type. Figure H.4 of IEEE 1547-2018 is applicable.

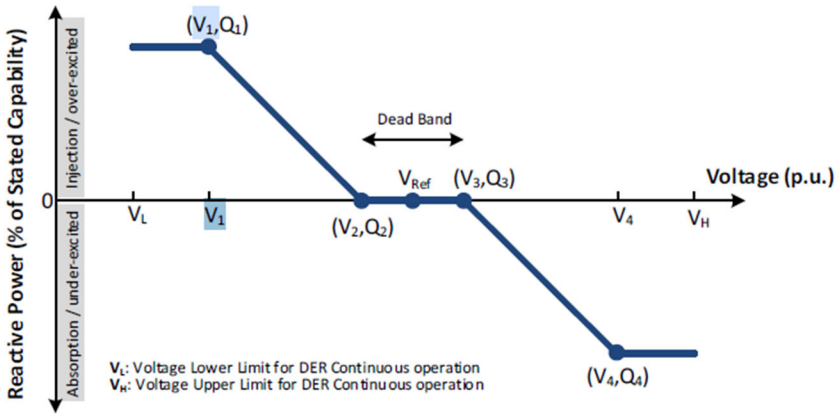

Figure H.4—Example voltage-reactive power characteristic

5.2 Constant Power Factor

The Constant Power Factor Mode shall be disabled unless otherwise specified by PNM. The target power factor shall be specified by PNM and shall not require reactive power exceeding the reactive capability requirements. The power factor settings are allowed to be adjusted locally and/or remotely as specified by PNM. The maximum DER response time to maintain constant power factor shall be 10 seconds or less.

5.3 Voltage-Reactive Power Control

PNM requires the settings for Voltage-Reactive Power Control to be enabled,[2] unless otherwise specified in the Interconnection Agreement.

The Voltage-Reactive Power mode default setting shall be set to the IEEE 1547-2018 default setting as shown in Table 2 unless otherwise specified by the System Impact Study conducted by PNM.

Table 2: Voltage-Reactive Power Default Setting

Voltage-Reactive Power Parameters	Default Settings	
	Synchronous Machine-Based DER	Inverter-based DER
V_{Ref}	V_N*	V_N*
V_1	0.9 V_N	V_{Ref} – .08V_N
V_2	V_N	V_{Ref} – 0.02 V_N
V_3	V_N	V_{Ref} + 0.02 V_N
V_4	1.1 V_N	V_{Ref} + 0.08 V_N
Q_1[a]	25% of nameplate apparent power rating, injection	44% of nameplate apparent power rating, injection
Q_2	0	0
Q_3	0	0
Q_4	25% of nameplate apparent power rating, absorption	44% of nameplate apparent power rating, absorption
Open Loop Response Time	10 s	5 s

*V_N is assumed to be set at DER nominal operating voltage
[a]The DER reactive power capability may be reduced at lower voltage

All DER shall utilize a fixed reference voltage V_{Ref}

5.4 Voltage-Active Power Control (volt-watt)

PNM requires the settings for Voltage-Active Power control to be enabled[3] for IEEE 1547-2018 Category

[2] PNM will be evaluating the effects of utilizing the Volt-VAR setting on the PNM Distribution System. Inverter Voltage control settings will have very local effects on the distribution system, and at this time, PNM does not have situational awareness specific to individual DERs to determine the effects that inverter settings can have on the relevant portion of the distribution system. PNM's modeling evaluation, to the extent it can be done with currently available data, will form the basis for possible future changes in the Volt-VAR settings in the TIIR.

[3] PNM will be evaluating the effects of utilizing the Volt-Watt setting on the PNM Distribution System. Inverter Voltage control settings will have very local effects on the distribution system, and at this time, PNM does not have situational awareness specific to individual DERs to determine the effects that inverter settings can have on the

B systems, unless otherwise specified by the Interconnection Agreement.

The Voltage-Active Power mode default setting shall be set to the IEEE 1547-2018 Category B default setting as shown in Table 3 unless otherwise specified by PNM's System Impact Study.

Table 3: Voltage-Active Power Default Setting

Voltage-Active Power Parameters	Default Setting
V_1	1.06 V_n
P_1	P_{rated}
V_2	1.1 V_n
P_2(applicable to DER that can only generate active power)	The lesser of 0.2 P_{rated} or P_{min} [a]
P'_2 (applicable to energy storage)	0[b]
Open Loop Response Times	10 s

[a] P_{min} is the minimum active power output in p.u. of the DER rating.
[b] P'_{rated} is the maximum amount of active power that can be absorbed by the DER. ESS operating in the negative real power half plane, through charging, shall follow this curve as long as available energy storage capacity permits this operation.

5.5 Active-Reactive Power Control

PNM requires the settings for Active Power-Reactive Power control to be disabled.

5.6 Constant Reactive Power Control

PNM requires the settings for Constant Reactive Power control to be disabled.

6. Response to Abnormal Conditions

PNM requires the settings for Voltage Disturbance Ride-Through and Frequency Disturbance Ride-Through to be enabled. Inverter-based DER shall be able to meet the requirements of IEEE 1547-2018 Abnormal Performance Category III for response to abnormal conditions. Tables 13 and 16 and Figures H.7 – H.9 of IEEE 1547-2018 are applicable for abnormal voltages and Tables 18 and 19 and Figure H.10 of IEEE 1547-2018 are applicable for abnormal frequencies. Synchronous machine-based DER shall be able to meet the requirements of IEEE 1547-2018 Abnormal Performance Category I for response to abnormal conditions. Tables 11 and 14 and Figure H.7 – H.9 are applicable for abnormal voltages and Tables 18 and 19 and Figure H.10 of IEEE 1547-2018 are applicable for abnormal frequencies. If exceptions apply per IEEE 1547-2018 Section 6.4.2.1 and 6.5.2.1, the voltage and frequency ride-through requirements specified in this section do not apply and DER may cease to energize the PNM Distribution System and trip without limitations.

relevant portion of the distribution system. PNM's modeling evaluation, to the extent it can be done with currently available data, will form the basis for possible future changes in the Volt-Watt settings in the TIIR.

6.1 Abnormal Voltages

6.1.1 Inverter-Based DER

For all inverter-based DER, the DER shall trip for the voltage conditions, as shown in Table 4.

Table 4: Inverter DER Voltage Abnormal Response

Shall Trip – Inverter DER		
Shall Trip Function	Default Setting	
	Clearing time(s)	Voltage (p.u.of nominal voltage)
UV1	21.0	0.88
UV2	2.0	0.50
OV1	13.0	1.10
OV2	0.16	1.20

The DER shall ride-through consecutive temporary voltage disturbances in accordance with IEEE 1547-2018 Section 6.4.2.5 requirements for Cat III DER.

6.1.2 Synchronous DER

For all synchronous machine-based DER, the DER shall trip for the voltage conditions in accordance with the IEEE 1547-2018 Table 11 default settings for Category I DER, as shown in Table 5.

Table 5: Synchronous Machine DER Abnormal Voltage Response

Shall Trip – Synchronous DER		
Shall Trip Function	Default Setting	
	Clearing time(s)	Voltage (p.u. of nominal voltage)
UV1	2.0	0.70
UV2	0.16	0.45
OV1	2.0	1.10
OV2	0.16	1.20

The DER shall ride-through consecutive temporary voltage disturbances in accordance with IEEE 1547-2018 Section 6.4.2.5 requirements for Cat I DER.

6.2 Abnormal Frequency

6.2.1 Inverter-Based DER

Inverter-based DER shall trip for abnormal frequency conditions in accordance with the IEEE 1547-2018 Table 18 default recommended settings for DER of abnormal operating performance Category III, as shown in Table 6.

Table 6: Abnormal Frequency Response

Shall Trip Function	Shall Trip – Inverter DER	
	Clearing time (s)	Frequency (Hz)
UF1	300.0*	58.5
UF2	0.16	56.5
OF1	300.0	61.2
OF2	0.16	62.0

*PNM may need to adjust this time to coordinate with typical regional under frequency load-shedding programs and expected frequency restoration time.

All inverter-based DER shall comply with the rate of change of frequency (ROCOF) ride-through performance requirements per IEEE 1547-2018 Section 6.5.2.5.

All inverter-based DER shall comply with the voltage phase angle changes ride-through requirements per IEEE 1547-2018 Section 6.5.2.6.

Per IEEE 1547-2018 Table 22, inverter-based DER shall operate with a frequency droop during both low and high-frequency conditions. Inverter-based DER shall comply with the frequency droop operating parameters per IEEE 1547-2018 Table 24 default settings, as shown in Table 7.

Table 7: Inverter-Based DER Frequency Droop Operating Parameters

Parameter	Default Setting
db_{OF}, db_{UF} (Hz)	0.036
k_{OF}, k_{UF}	0.05
$T_{response}$ (s)	5

6.2.2 Synchronous DER

Synchronous machine-based DER shall trip for abnormal frequency conditions in accordance with the IEEE 1547-2018 Table 18 default recommended settings for DER of abnormal operating performance Category I, as shown in Table 8.

Table 8: Abnormal Frequency Response

Shall Trip Function	Shall Trip - Synchronous DER	
	Clearing time(s)	Frequency(Hz)
UF1	300.0*	58.5
UF2	0.16	56.5
OF1	300.0	61.2
OF2	0.16	62.0

*PNM may need to adjust this time to coordinate with typical regional under frequency loadshedding programs and expected frequency restoration time.

All synchronous machine-based DER shall comply with the rate of change of frequency (ROCOF) ride-through performance requirements per IEEE 1547-2018 Section 6.5.2.5.

All synchronous machine-based DER shall comply with the voltage phase angle changes ride-through requirements per IEEE 1547-2018 Section 6.5.2.6.

Per IEEE 1547-2018 Table 22, synchronous machine-based DER ***may*** operate with a frequency droop during both low-frequency conditions and ***shall*** operate with a frequency droop during high-frequency conditions.

6.3 Dynamic Voltage Support

Dynamic Voltage Support shall be disabled.

6.4 Communication Protocols and Ports Requirements

According to Section 10 of IEEE 1547-2018, the following is applicable to communications interoperability functions. The application of these requirements will be determined by PNM.

- A DER shall have provisions for a local DER interface capable of communicating (local DER communication interface) to support the information exchange requirements specified in the IEEE 1547 – 2018 standard for all applicable functions that are supported in the DER.
- Under mutual agreement between PNM and the DER operator, additional communication capabilities are allowed.
- The decision to use the local DER communication interface or to deploy a communication system shall be determined by PNM.
- Emergency and standby DER are exempt as specified from the interoperability requirements specified in the IEEE 1547 – 2018 standard.

According to Table 9, the DER shall support at least one of the following protocols specified below. The protocol to be utilized may be allowed under mutual agreement between PNM and the DER operator. Additional physical layers may be supported along with those specified in the Table 9 below.

Table 9: List of Eligible Communication Protocols

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

7. Operations

a. Enter Service Parameters

PNM requires the setting for Enter Service and Enter Service Ramp Rate to be enabled. The DER shall delay entry into service by an intentional minimum delay of 300 seconds. The requirements for PNM's Distribution System steady state voltage and frequency are the default ranges specified in Table 4 of IEEE 1547-2018, unless otherwise specified by Operating and Maintenance Requirements. This entry into service requirement shall also apply for return to service after a DER trips. Table 10 below shows the default settings for the applicable voltage and frequency values that a DER must meet before entering service and energizing service to the distribution feeder.

Table 10: Enter Service Criteria

DER Enter Service Criteria		
Voltage Within Range	Minimum Value	≥0.917 p.u.
	Maximum Value	≤1.05 p.u.
Frequency Within Range	Minimum Value	≥59.5 Hz
	Maximum Value	≤60.1 Hz

The DER shall parallel and synchronize with PNM in accordance with IEEE 1547-2018 Section 4.10.4.

b. Ramp Rates

After the minimum delay of the enter service requirements for service entry has elapsed, DERs shall ramp the active power output with a linear ramp of 300 seconds. PNM is intentionally not permitting "Exception 1" to the Performance During Entering Service criteria because of many local EPS areas within the service territory that have in aggregate more than 500 kVA of connected individual DER units.