Implementation of Revised IEEE Standard 1547

Presentation to ISO-TO Operations Committee

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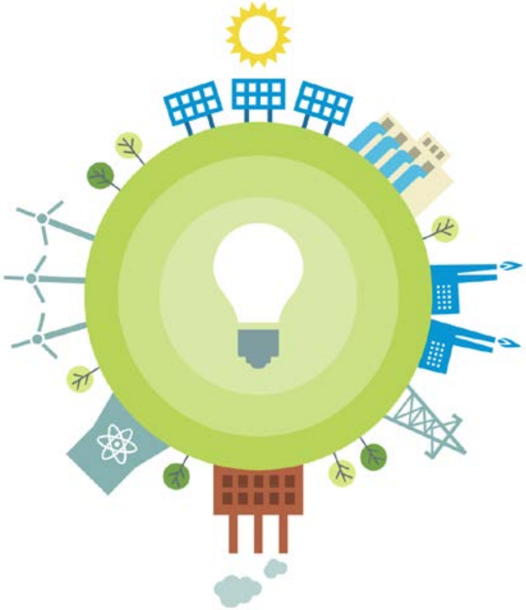
Key Points



- As New England adds significant amounts of Distributed Energy Resources (DERs), it is essential for these resources to be interconnected in a way that does not adversely impact the reliability of the Bulk Electric System (BES)
- ISO-NE identifies, in this presentation, settings in the proposed revision to IEEE Standard 1547 (*Standard for Interconnecting Distributed Resources with Electric Power Systems*) that are required to ensure this support
- Distribution engineers and planners have identified issues that need to be addressed to allow implementation of settings proposed by ISO-NE
- ISO-NE looks forward to working with the TOs to resolve any issues by the end of 2017

ISO New England Has Been Engaged

ISO-NE has initiated on-going discussions about the need for updating state interconnection requirements to include ride-through for voltage and frequency excursions

- May 16, 2012: Planning Advisory Committee (PAC) meeting
- June 20, 2013: PAC meeting
- September 30, 2013 Distributed Generation Forecast Working Group (DGFWG) meeting
- December 16, 2013: DGFWG meeting
- January 17, 2014: Comments on MA DPU 12-76-A (Grid Modernization)
- January 21, 2014: DGFWG meeting
- April 2, 2014: DGFWG meeting
- April 16, 2014: TSRG meeting
- July 11, 2014: PAC and DGFWG meeting
- May 16, 2017: TSRG Meeting

Limitations on the Loss of Source

- Planning criteria for stability analysis require limitations on the amount of sources that be lost for a contingency
- Historically, the concern has been large generators being disconnected or going unstable and tripping
- Tripping of DER for a transmission fault would add to source loss
- If total source loss exceeds the amount allowed by the planning criteria, corrective actions must be pursued possibly including placing restrictions on the operation of DER

Effect on the New England System

- In a 12/16/13 stakeholder presentation, ISO-NE described its reliability concern that New England may lose significant amounts of DER due to transmission faults*
  - This presentation shows how a fault on the transmission system can cause low voltage over a large portion of the New England system
- ISO-NE recommended the following capabilities for DER:
  - High/low frequency ride-through
  - High/low voltage ride-through
  - Default and emergency ramp rate limits
  - Reconnect by "soft start" methods
  - Voltage support
  - Communication capabilities

* See: www.iso-ne.com/static-assets/documents/committees/comm_wkgrps/othr/distributed_generation_frcst/2013mtrls/dec162013/dg_transmission_impacts.pdf.

Concern at the NERC Level

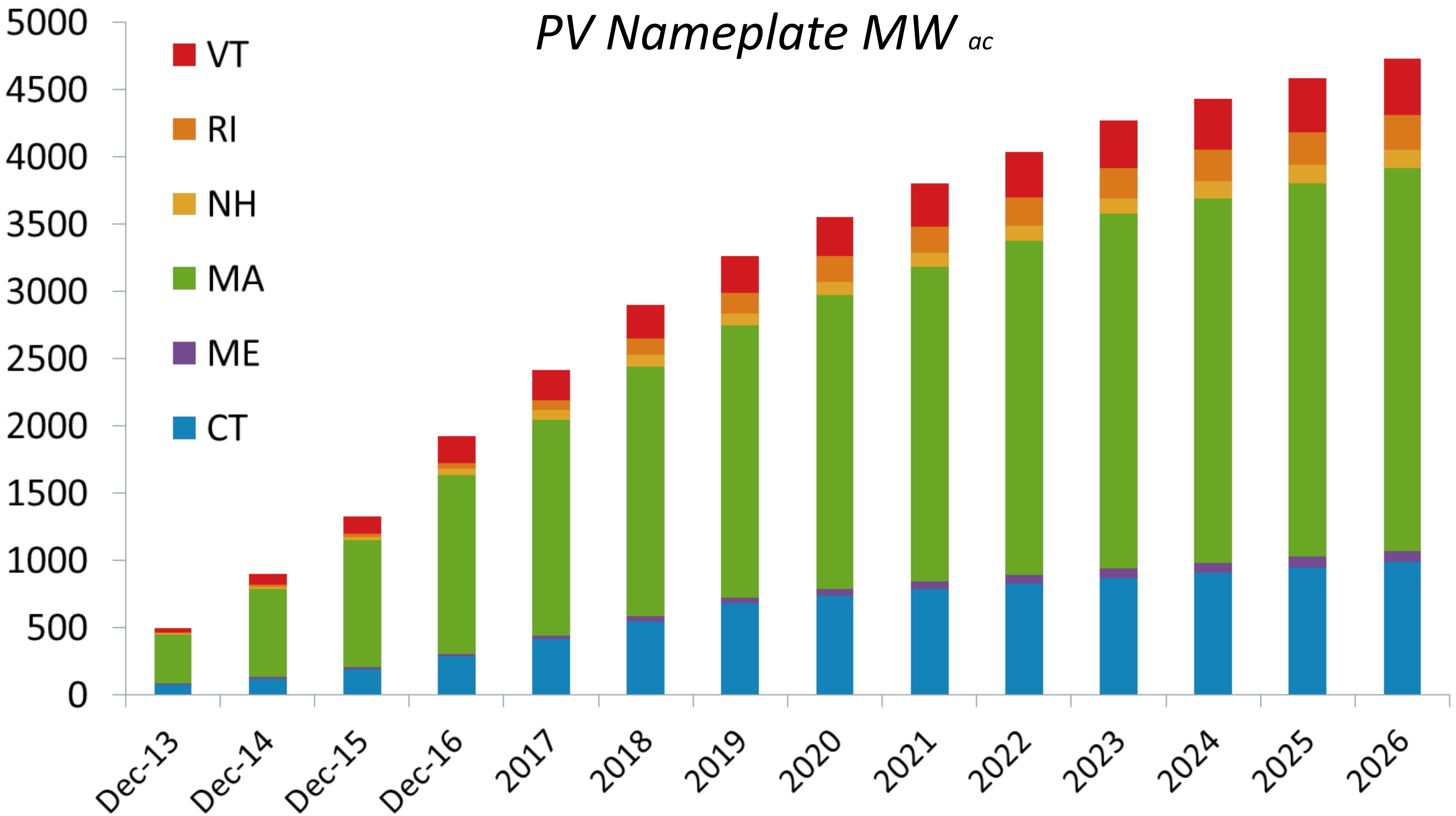
- The North American Electric Reliability Corporation (NERC) has expressed increasing concern with the impact of DERs on Bulk Electric System reliability
- In February 2017 NERC issued a report* "*Distributed Energy Resources, Connection Modeling and Reliability Considerations*"
- NERC's report supports the need for the DER capabilities identified by ISO-NE

** See: www.nerc.com/comm/other/essntlrlbltysrvcstskfrcdl/distributed_energy_resources_report.pdf*

Concern at the NERC Level, *continued*

- NERC's report also describes autonomous inverter functionalities that will be added to California's technical operating standards in Rule 21 by the end of 2017
  - Support anti-islanding to trip off under extended anomalous conditions
  - Provide ride-through of low/high voltage excursions beyond normal limits
  - Provide ride-through of low/high frequency excursions beyond normal limits
  - Provide volt/VAR control through dynamic reactive power injection through autonomous responses to local voltage measurements
  - Define default and emergency ramp rates as well as high and low limits
  - Provide reactive power by a fixed power factor
  - Reconnect by "soft-start" methods

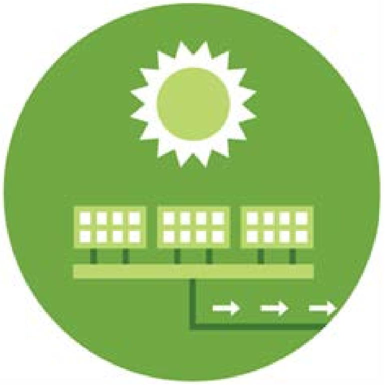
ISO Is Forecasting Continued Solar PV Growth Over the Next Decade



Source: Final PV Forecast (April 2017); * Note: MW values are AC nameplate

Final 2017 PV Forecast

Nameplate Capacity, MW_{ac}



States	Cumulative Total MW (AC nameplate rating)										
	Thru 2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
CT	281.5	414.3	547.1	679.9	738.9	783.6	827.1	869.3	910.2	949.8	988.2
MA	1324.8	1598.7	1858.9	2023.3	2183.3	2338.9	2490.0	2636.7	2707.8	2776.7	2843.3
ME	22.1	29.0	35.8	42.7	48.8	54.6	60.4	66.3	72.1	77.9	83.7
NH	54.3	72.4	84.4	91.8	99.1	106.1	112.9	119.5	125.9	132.2	138.2
RI	36.8	78.1	119.5	154.8	186.6	201.8	213.1	224.1	235.0	245.6	255.9
VT	198.4	223.4	248.4	273.4	295.9	317.1	338.4	359.6	380.9	402.1	423.4
Regional - Cumulative (MW)	**1918.0**	**2415.9**	**2894.1**	**3265.9**	**3552.5**	**3802.1**	**4041.9**	**4275.5**	**4431.8**	**4584.2**	**4732.7**

Source: Final PV Forecast (April 2017); * Note: MW values are AC nameplate

IEEE 1547 Categories For Response to Abnormal Conditions

- IEEE 1547 is technology neutral and thus does not establish performance requirements for specific DER technologies
- Instead it defines three categories related to the response of DER to abnormal conditions that have different performance requirements
- IEEE 1547 suggests that "Authorities Governing Interconnection Requirements" define the performance requirement (the category) for each type of DER and provides guidance on how to do this in Annex B
- A significant factor in determining performance requirements is the level of penetration of the DER technology
- DER technology that has a high level of penetration will have the largest impact on reliability and should have the highest performance requirements

IEEE 1547 Category I

- Category I is based on minimal bulk electric system reliability needs and is reasonably attainable by all DER technologies that are in common usage today
- The disturbance ride-through requirements for Category I are derived from the German standard for medium voltage synchronous generators and is one of the most widely applied standards in Europe
- Many synchronous generator manufacturers are currently designing products to meet the requirements of this standard

IEEE 1547 Category II

- Category II covers all BES reliability needs and is coordinated with existing reliability standards to avoid widespread DER tripping for disturbances for which the bulk system generators are expected to remain connected
- It is based on NERC Standard PRC-024 (generator frequency and voltage protective relay settings), with additional allowance for the fact that voltage levels in distribution systems may have delayed recovery after disturbances due to load effects, and is harmonized with NERC Standard PRC-006 (under frequency load shedding standard) with regard to frequency ride-through requirements

IEEE 1547 Category III

- Category III provides the highest disturbance ride-through capabilities, intended to address integration issues such as power quality and system overloads caused by DER tripping in local Area EPS having very high levels of DER penetration
- This category also provides increased bulk power system security by further reducing the potential loss of DER during bulk system events
- These requirements are based on the California Rule 21 Smart Inverter requirements

ISO-NE Recommendation: IEEE 1547 Categories

- ISO-NE recommends that new DERs that are synchronous generators be required to meet the performance requirements of Category I since this category is based on a synchronous generator standard
- ISO-NE recommends that inverter type DERs be required to meet the performance requirements of Category III
  - Inverter-based generation designed for California will meet Category III requirements and a UL standard exists to certify these inverters
  - Inverter type DER has the largest penetration and thus the largest potential impact on BES reliability

Voltage Ride-Through Settings

- ISO-NE will require the following voltage ride-through settings:

Voltage range (% of Nominal)	Minimum Ride-through Time in seconds
V > 120	N/A
110 < V ≤ 120	12 seconds *
5 ≤ V < 88	3+ seconds **
50 ≤ V < 70	1 second ***
V < 50	1 second *

Notes

* *This is the minimum setting for Category III DER*

** *This is the minimum setting for Category II DER and is below the minimum setting for a Category III DER*

*** *This is below the minimum setting for Category III, a longer ride-through time would be desirable*

Frequency Ride-Through Settings

- IEEE 1547 establishes the same ride-through requirements for frequency variations for DER in Categories I, II and III
- ISO-NE supports these frequency ride-through minimum settings because they coordinate with NPCC requirements

Frequency range (Hz)	Operating Mode	Minimum time(s) (design criteria)
$f > 62.0$	N/A	N/A
$60.6 < f \leq 62.0$	Mandatory Operation	299
$58.5 \leq f \leq 60.6$	Continuous Operation	Infinite
$57.0 \leq f < 58.5$	Mandatory Operation	299
$f < 57.0$	N/A	N/A

Next Steps

- ISO-NE requested that the MA TSRG identify any issues that need to be resolved prior to distribution company implementation of ISO-NE's proposed settings
- The MA TSRG has established a group to work to resolve any issues identified (first meeting June 13)
- ISO-NE will continue to work with state regulators to urge the adoption of interconnection standards that achieve the objectives of IEEE 1547

January 2018

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7	8	9	10	11	12	13
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