APRIL 25, 2018 | MIDDLEBURY, VT

ISO new england

Implementation of the Revised IEEE Standard 1547

Vermont System Planning Committee

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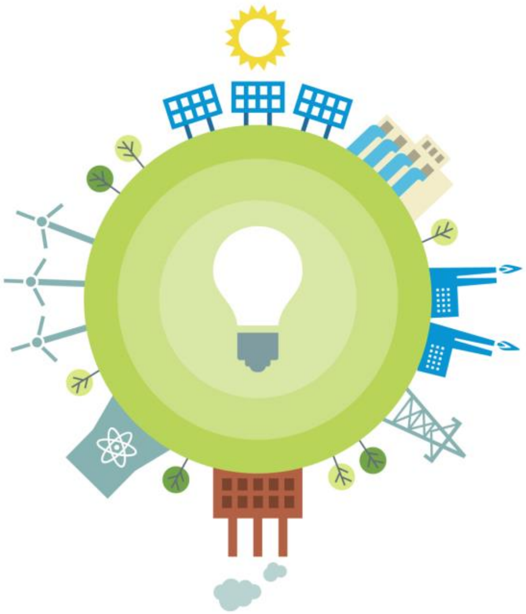
Purpose

- Provide an **update** on standards impacting interconnection of distributed energy resources (DER)
- Discuss the **need** for DER performance that supports the reliability of the Bulk Electric System
- Discuss interim steps that will **improve** DER performance

KEY POINTS OF PRESENTATION

Key Points



- As New England adds significant amounts of **Distributed Energy Resources (DER)**, 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)
- The revision to **IEEE Standard 1547** (*Standard for Interconnecting Distributed Resources with Electric Power Systems*) will not be *fully* implemented until 2020 or later
- ISO-NE identifies in this presentation **interim requirements** for performance of solar PV DER that are required to ensure this support the reliability of the Bulk Electric System

BACKGROUND

The ISO Engaged Stakeholders on DER Standards

ISO-NE continues to be involved in discussions of the need for DER to support the reliability of the Bulk Electric System

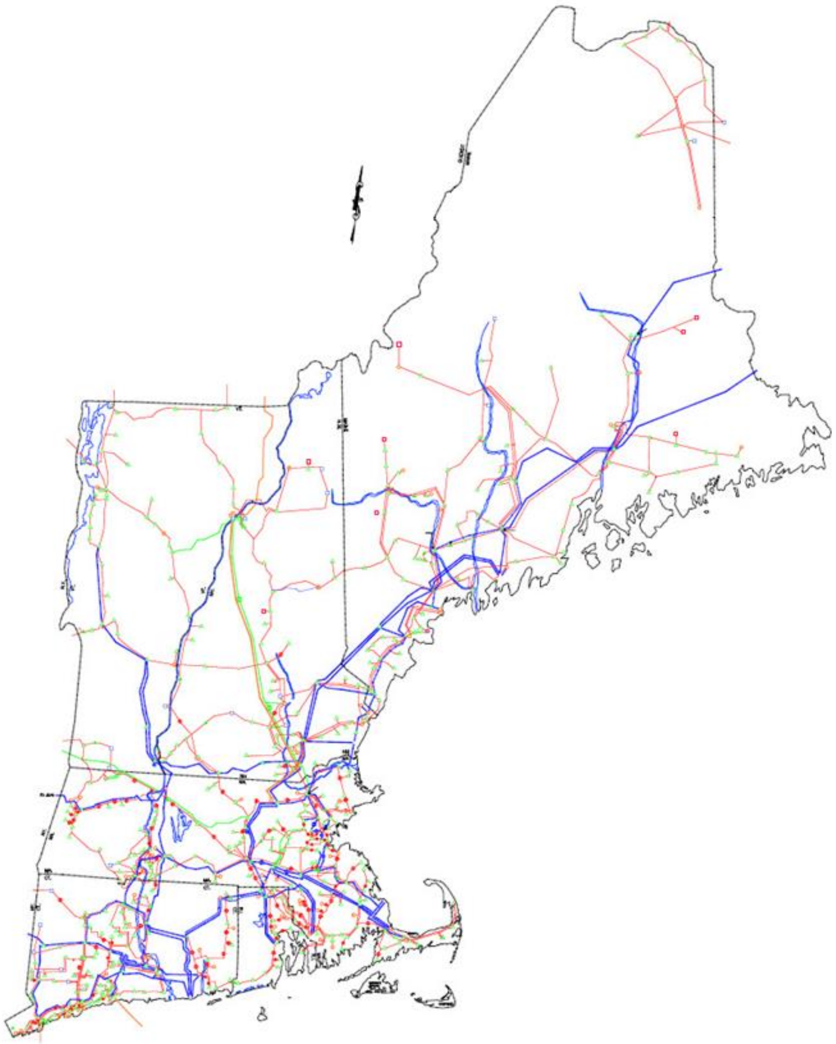
ISO-NE has initiated on-going discussions about the need for updating state interconnection requirements to include ride-through for voltage and frequency excursions

- 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: MA Technical Standard Review Group (TSRG) meeting
- July 11, 2014: PAC and DGFWG meeting
- May 16, 2017:TSRG meeting
- February 14, 2018 PAC meeting

Bulk Electric System Planning Criteria

- ISO-NE is **required** to plan for the contingency loss of resources (including DER) for conditions included in planning criteria mandated by NERC and NPCC
- **Planning criteria** require that the transmission system remain secure for a permanent three-phase fault with normal fault clearing
  - Normal clearing of a three-phase fault on the 345 kV system is approximately 0.1 seconds
  - Normal clearing of a three-phase fault on a the 115 kV system can range from 0.1 seconds to over 0.5 seconds depending on the protective relay scheme

Bulk Electric System Planning Criteria, *continued*



- **Planning criteria** also require analysis of a three-phase fault with delayed clearing
  - Delayed clearing of a three-phase fault on the 345 kV system is approximately 0.1-0.2 seconds
  - Delayed clearing of a three-phase fault on a the 115 kV system can range from 0.3 seconds to over a second depending on the protective relay scheme

Limitations on the Loss of Source

- Planning criteria 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, a system upgrade would be required

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

**** Source:*** *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

***** Source:** 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 **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

The ISO Is Forecasting Significant Solar Growth

- The following four slides are from the *Final 2018 PV Forecast*
- Each year the projections increase for the amount of DER in New England thus making DER impact on the BES reliability a larger concern

Source: ISO New England Final 2018 PV Forecast:
https://www.iso-ne.com/static-assets/documents/2018/03/a03-2018-pv-forecast.pdf

Final 2018 PV Forecast

Nameplate Capacity, MW_{ac}

States	Annual Total MW (AC nameplate rating)											Totals
	Thru 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
CT	365.6	88.6	86.8	89.8	80.6	72.9	53.7	52.2	50.6	49.0	47.4	**1,037.3**
MA	1602.3	**296.7**	228.0	228.0	215.3	215.3	215.3	215.3	135.1	130.9	126.7	**3,608.9**
ME	33.5	10.2	10.2	10.2	9.6	9.6	9.6	9.6	9.6	9.6	9.6	**131.4**
NH	69.7	13.8	13.8	13.8	13.1	13.1	13.1	13.1	13.1	13.1	13.1	**202.7**
RI	62.2	34.5	34.5	31.4	29.6	29.6	29.6	29.6	29.6	29.6	29.6	**370.2**
VT	257.2	**31.5**	22.5	22.5	21.3	21.3	21.3	21.3	21.3	21.3	21.3	**482.5**
Regional - Annual (MW)	**2390.5**	**475.3**	**395.8**	**395.8**	**369.5**	**361.9**	**342.7**	**341.1**	**259.3**	**253.5**	**247.7**	**5,832.9**
Regional - Cumulative (MW)	**2390.5**	**2865.8**	**3261.6**	**3657.4**	**4026.9**	**4388.8**	**4731.4**	**5072.5**	**5331.8**	**5585.3**	**5832.9**	**5,832.9**

Notes:

(1) Forecast values include FCM Resources, non-FCM Energy Only Generators, and behind-the-meter PV resources
(2) The forecast values are net of the effects of discount factors applied to reflect a degree of uncertainty in the policy-based forecast
(3) All values represent end-of-year installed capacities
(4) Forecast does not include forward-looking PV projects > 5MW in nameplate capacity

Final 2018 PV Forecast

Cumulative Nameplate, MW_{ac}

States	Cumulative Total MW (AC nameplate rating)										
	Thru 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
CT	365.6	454.3	541.0	630.9	711.5	784.4	838.2	890.3	940.9	989.9	1037.3
MA	1602.3	1898.9	2126.9	2354.9	2570.3	2785.6	3000.9	3216.3	3351.4	3482.3	3608.9
ME	33.5	43.6	53.8	64.0	73.6	83.3	92.9	102.5	112.1	121.8	131.4
NH	69.7	83.5	97.4	111.2	124.3	137.3	150.4	163.5	176.5	189.6	202.7
RI	62.2	96.7	131.2	162.6	192.3	221.9	251.6	281.2	310.9	340.5	370.2
VT	257.2	288.7	311.2	333.7	355.0	376.2	397.5	418.7	440.0	461.2	482.5
Regional - Cumulative (MW)	**2390.5**	**2865.8**	**3261.6**	**3657.4**	**4026.9**	**4388.8**	**4731.4**	**5072.5**	**5331.8**	**5585.3**	**5832.9**

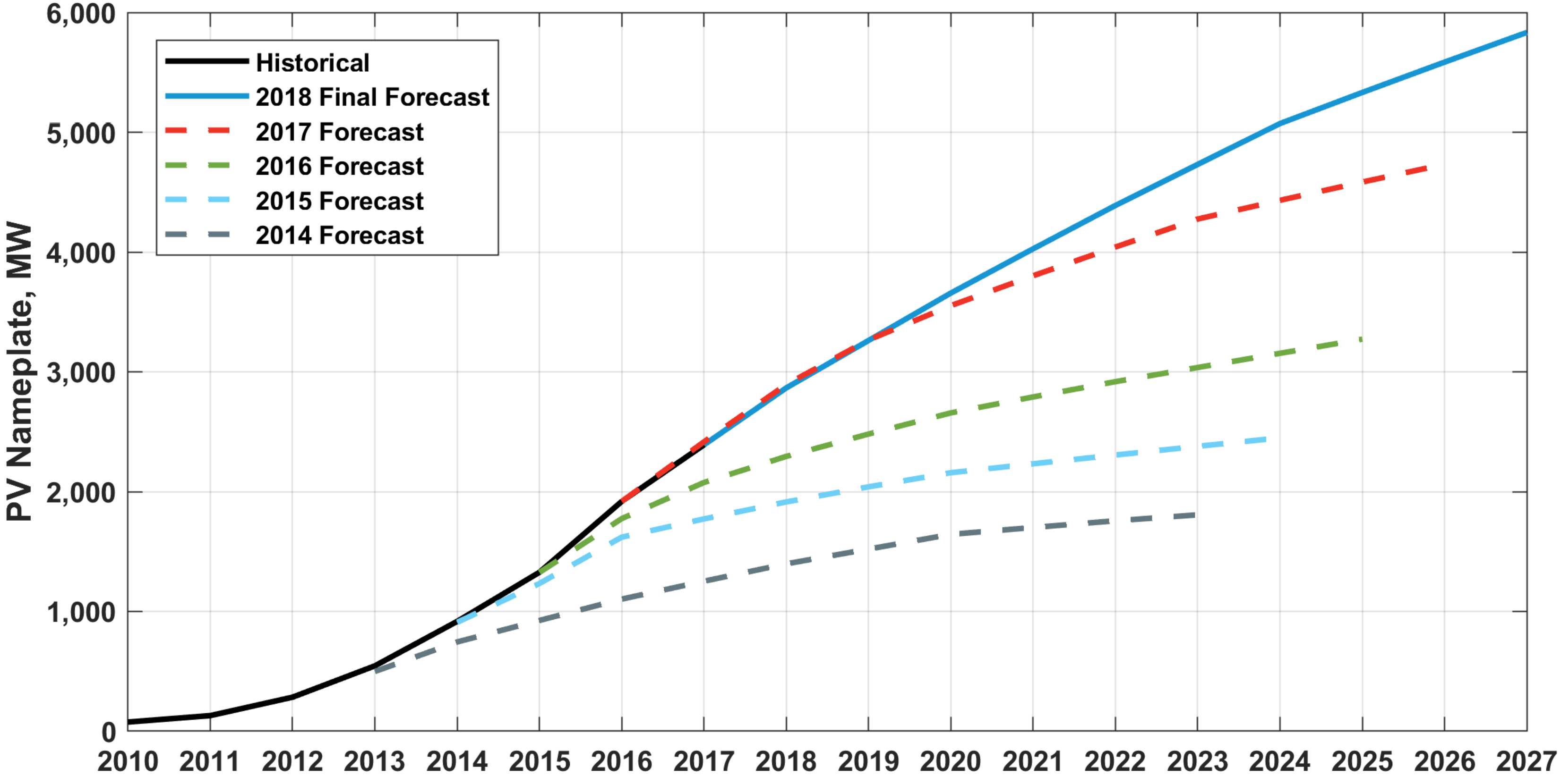
Notes:

(1) Forecast values include FCM Resources, non-FCM Energy Only Generators, and behind-the-meter PV resources

(2) The forecast reflects discount factors to account for uncertainty in meeting state policy goals

(3) All values represent end-of-year installed capacities

PV Growth: Reported Historical vs. Forecast



Discount Factors Used in Final 2018 PV Forecast

Policy-Based

Forecast	Final 2018
2018	10%
2019	10%
2020	10%
2021	15%
2022	15%
2023	15%
2024	15%
2025	15%
2026	15%
2027	15%

Post-Policy

Forecast	Final 2018
2018	35.0%
2019	36.7%
2020	38.3%
2021	40.0%
2022	41.7%
2023	43.3%
2024	45.0%
2025	46.7%
2026	48.3%
2027	50.0%

STATUS OF IEEE 1547 AND UL 1741

IEEE 1547

- **IEEE 1547,** IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems, was originally issued in 2003 (1547-2003)
- **In 2013,** Amendment 1 was approved (IEEE 1547a) to allow ranges of settings for tripping distributed resources for abnormal voltage and frequency. Amendment 1 also allowed settings to regulate voltage with the agreement of the interconnecting utility.
- In December 2013, IEEE started the process to do a **complete revision** to IEEE 1547
- **In 2017**, the revised IEEE 1547 was balloted and approved
- The standard was then updated to address comments from the balloters, was re-balloted and approved **by a greater margin**

IEEE 1547, ***continued***

- The approved revision to 1547 underwent final editing at IEEE and was published in early April 2018
- Before DER can be certified as meeting the revised 1547, the testing standard 1547.1 must be revised
- Work on 1547.1 is on-going and will optimistically be completed by the end of 2018
- Once 1547.1 is approved, UL 1741 will need to be updated to agree with the revised 1547.1
- Once UL 1741 is updated and approved, it will take a year or longer for all inverter manufacturers to have their inverters tested and certified
- Thus it will be 2020 or possibly later before utilities will able use the revised IEEE 1547

UL 1741

- **UL 1741** is the UL Standard for Safety for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
  - The second edition was dated January 28, 2010
  - UL 1741 was revised as of September 7, 2016 to incorporate the new supplement SA
- **UL 1741 SA** defines the requirements for "Grid Support Utility Interactive Inverters"
- These inverters have the capabilities required by California Rule 21 (see slide 12) and that meet ISO-NE needs
- As of September 9, 2017 inverter-based generation in California is required to be certified as meeting UL 1741 SA

INTERIM SOLUTION

Interim Solution

- Because of the **rapid growth** of solar PV in New England and the timeline for full implementation of the revision to IEEE 1547, ISO-NE sought out an **interim solution** for obtaining ride-through for voltage and frequency variations
- Inverters meeting the requirements of UL 1741 SA have the capabilities required by ISO-NE
- Choosing performance requirements for these inverters required the **input** from distribution engineers, solar PV developers and inverter manufacturers
- ISO-NE worked with the **Massachusetts Technical Standards Review Group (TSRG)** to get input from these entities

About the Massachusetts Technical Standards Review Group (TSRG)

- The **Technical Standards Review Group**:
  - Is an **existing group** tasked with addressing distribution interconnection issues
  - Includes **representatives** from utilities, developers, manufacturers and Massachusetts regulators
  - Includes representatives from **Eversource**, which also has subsidiaries in Connecticut and New Hampshire
  - Includes representatives from **National Grid**, which also has a subsidiary in Rhode Island
- Over 60% of solar PV in New England is/will be installed in **Massachusetts**

Interim Solution

- Development of inverter performance requirements and an implementation plan required addressing **multiple issues**
  - Transmission reliability
  - Distribution protection
  - Retaining maximum trip time
  - Anti-islanding protection
  - Conformance with the revised IEEE 1547
  - Allowing time for manufacturers to develop software to implement ISO-NE settings
- Balancing these and other issues ISO-NE and the TSRG developed a **Source Requirements Document** and an implementation plan
  - A summary follows

Interim Solution (developed with the MA TSRG)

- The Inverter Source Requirements Document of ISO-NE (ISO-NE SRD) contains additional details on the application of “Grid Support Utility Interactive Inverters”
  - It is available from the ISO and is also posted with the February 14 2018 PAC meeting’s materials
  - A Source Requirements Document can be used by to certify that equipment meets a specific set of requirements
  - The ISO-NE SRD can be used with the existing UL 1741 SA

Interim Solution (developed with the MA TSRG), *continued*

- All inverter-based solar PV projects **100kW or less** with applications submitted on or **after June 1, 2018** are subject to the ISO-NE Source Requirements Document
- All inverter-based solar PV projects **greater than 100KW** with applications submitted on or after **March 1, 2018** are subject to the ISO-NE Source Requirements Document
- Inverter-based solar PV projects with applications submitted prior to the above dates **are encouraged to comply** with the ISO-NE Source Requirement Documents with the approval of the interconnecting utility

Interim Solution (developed with the MA TSRG), *continued*

- ISO-NE will require the following **frequency trip settings** which are consistent with the allowable ranges of the revised 1547 and with NPCC requirements:

Shall trip function	Default Settings (b)	
	Frequency (Hz)	Clearing Time(s)
OF2	62	0.16
OF1	61.2	300
UF1	58.5	300
UF2	56.5	0.16

Interim Solution (developed with the MA TSRG), *continued*

- ISO-NE will require the following voltage trip settings which are consistent with the allowable ranges in Category II of the revised 1547:

Shall Trip		
Shall Trip Function (OV = Overvoltage UV = Undervoltage)		
	Voltage (per unit of nominal voltage)	Clearing time(s)
OV2	1.20	0.16
OV1	1.10	2.0
UV1	0.88	2.0
UV2	0.50	1.1

NEXT STEPS

Next Steps

- ISO-NE will work with utilities and regulators **in each state** to implement the ISO-NE SRD
  - Having one SRD for all of New England will minimize developer's costs
  - Having one SDR will simplify modeling DER in planning studies
- ISO-NE will work with utilities to optimize the utilization of **advanced inverter functions** that will be available under the revised IEEE 1547 and update its SRD as needed
- ISO-NE will work with **Municipal Utilities and Co-ops** to implement the ISO-NE SRD on their systems

Questions