ISO New England Experience with IEEE Standard 1547-2018

Implementation of an interim solution

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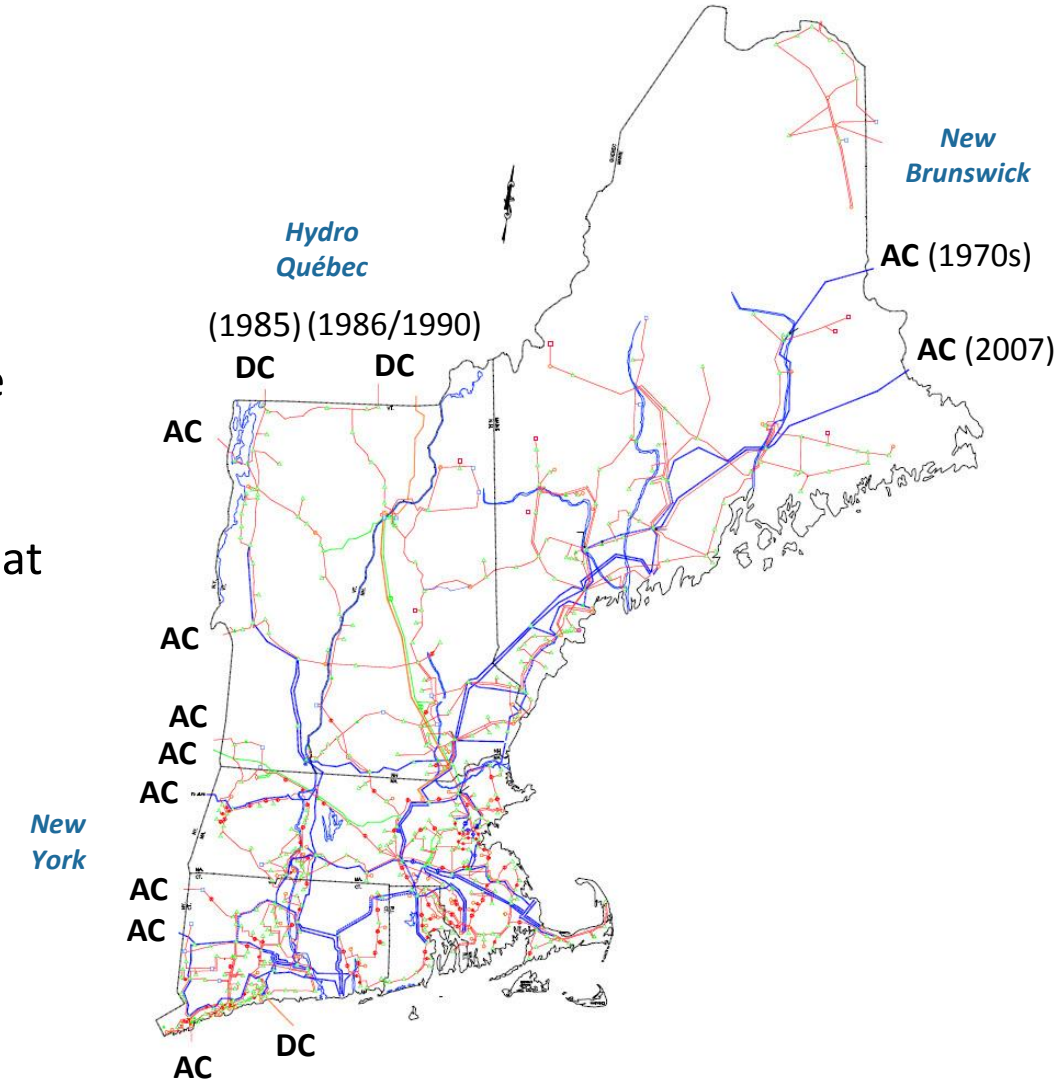
Purpose

- Describe the process ISO New England (ISO-NE) is using to implement an interim application of the revised version of IEEE 1547 for solar PV
- Discuss the contents of the Preferred Utility-Required Profile (Preferred URP) which was developed by ISO-NE with the help of Massachusetts utilities and which was titled the “ISO New England Source Requirement Document“
- Share information from the process that might be helpful to other utilities

BACKGROUND

ISO New England

- The ISO-NE region includes the six New England states: Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island and Vermont
- Region's all-time summer peak demand set on August 2, 2006 at **28,130 MW**
- New England's transmission system is tied to neighboring power systems in the U.S. and Eastern Canada:
  - New York (8 AC ties, 1 DC tie)
  - Hydro Québec (2 DC ties)
  - New Brunswick (2 AC ties)

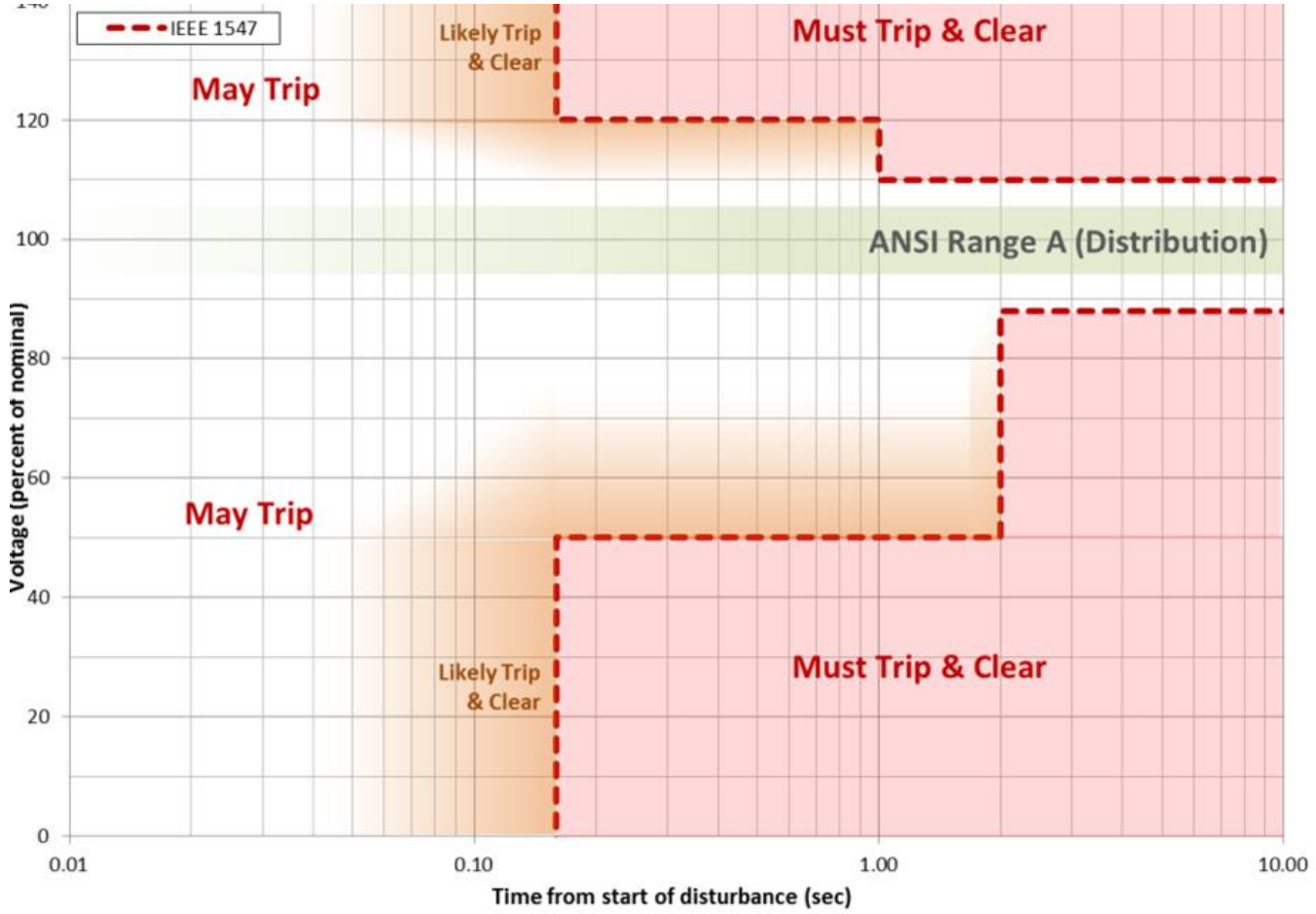


Note: AC stands for Alternating Current and DC stands for Direct Current

Planning for a Large Loss of Supply

- ISO New England plans and operates the transmission system to ensure that the loss of a large source of supply (source loss) does not adversely impact the reliability of the Eastern Interconnection
- Historically, the concern has been source loss due to large generators being disconnected or going unstable and tripping
- Tripping of large quantities of distributed energy resources (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, and this could negatively impact the benefits of state policies to encourage renewable energy
- The acceptable maximum source loss is limited by the ISO-NE interconnections to other regions, to approx. 1,200 MW for Normal Design Contingencies.

DER could trip before the 1547-2003 trip requirement



Source: Draft NERC IVGTF Task 1-7 report

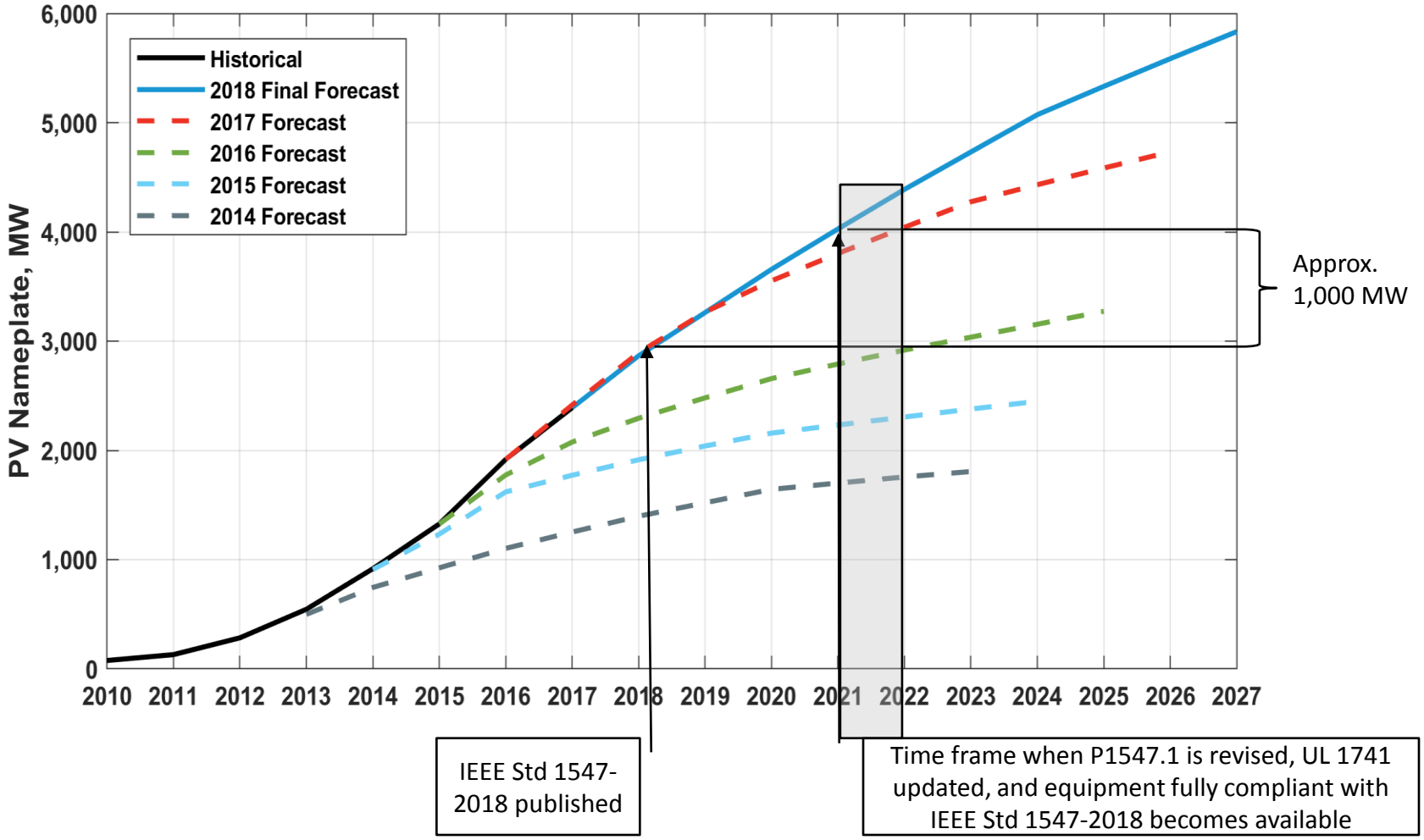
INTERIM SOLUTION

Interim Solution

- Because of the rapid growth of solar PV in New England and because the timeline for full implementation of the revision to IEEE 1547 is 2020 or later, 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 in the interim
- 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

ISO-NE PV Growth: Reported Historical vs. Forecast

ISO Updates the Forecast Annually to Capture Policy Changes



Interim Solution

- The TSRG is an existing group tasked with addressing distribution interconnection issues
- The TSRG includes representatives from utilities, developers, manufacturers and Massachusetts regulators
- Over 60% of solar PV in New England is/will be installed in Massachusetts
- The TSRG includes representatives from Eversource, which also has subsidiaries in Connecticut and New Hampshire
- The TSRG includes representatives from National Grid, which also has a subsidiary in Rhode Island
- The TSRG includes representatives from Unitil, which also serves customers in New Hampshire

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 Preferred Utility-Required Profile and an implementation plan for Massachusetts
  - A summary follows

Interim Solution-Voltage Trip Settings

Shall Trip – IEEE Std 1547-2018 (2nd ed.) Category II					
Shall Trip Function	Required Settings		Comparison to IEEE Std 1547-2018 (2nd ed.) default settings and ranges of allowable settings for Category II		
	Voltage (p.u. of nominal voltage)	Clearing Time(s)	Voltage	Clearing Time(s)	Within ranges of allowable settings?
OV2	1.20	0.16	Identical	Identical	Yes
OV1	1.10	2.0	Identical	Identical	Yes
UV1	0.88	2.0	Higher (default is 0.70 p.u.)	Much shorter (default is 10 s)	Yes
UV2	0.50	1.1	Slightly higher (default is 0.45 p.u.)	Much longer (default is 0.16 s)	Yes

Conflicts with NERC PRC-024-2 but is within limits of IEEE Std 1547.

Interim Solution Voltage Ride-through Capability and Additional Operational Requirements

Voltage Range (p.u.)	Operating Mode/ Response	Minimum Ride-through Time(s) (design criteria)	Maximum Response Time(s) (design criteria)	Comparison to IEEE Std 1547-2018 (2nd ed.) for Category II
V > 1.20	Cease to Energize	N/A	0.16	Identical
1.175 < V ≤ 1.20	Permissive Operation	0.2	N/A	Identical
1.15 < V ≤ 1.175	Permissive Operation	0.5	N/A	Identical
1.10 < V ≤ 1.15	Permissive Operation	1	N/A	Identical
0.88 ≤ V ≤ 1.10	Continuous Operation	infinite	N/A	Identical
0.65 ≤ V < 0.88	Mandatory Operation	Linear slope of 8.7 s/1 p.u. voltage starting at 3 s @ 0.65 p.u.: $T_{VRT} = 3\text{ s} + \frac{8.7\text{ s}}{1\text{ p.u.}}(V - 0.65\text{ p.u.})$	N/A	Identical
0.45 ≤ V < 0.65	Permissive Operation [a,b]	0.32	N/A	See footnotes a & b
0.30 ≤ V < 0.45	Permissive Operation [b]	0.16	N/A	See footnote b
V < 0.30	Cease to Energize	N/A	0.16	Identical

The following additional operational requirements shall apply for all inverters:

a. **In the Permissive Operation region above 0.5 p.u., inverters shall ride-through in Mandatory Operation mode, and**

b. **In the Permissive Operation region below 0.5 p.u., inverters shall ride-through in Momentary Cessation mode with a maximum response time of 0.083 seconds.**

Interim Solution-Frequency Trip Settings

Shall Trip Function	Required Settings		Comparison to IEEE Std 1547-2018 (2nd ed.) default settings and ranges of allowable settings for Category I, Category II, and Category III		
	Frequency (Hz)	Clearing Time(s)	Frequency	Clearing Time(s)	Within ranges of allowable settings?
OF2	62.0	0.16	Identical	Identical	Yes
OF1	61.2	300.0	Identical	Identical	Yes
UF1	58.5	300.0	Identical	Identical	Yes
UF2	56.5	0.16	Identical	Identical	Yes

Interim Solution-Frequency Ride-through Capability

Frequency Range (Hz)	Operating Mode	Minimum Time(s) (design criteria)	Comparison to IEEE Std 1547-2018 (2nd ed.) for Category II
f > 62.0	No ride-through requirements apply to this range		Identical
61.2 < f ≤ 61.8	Mandatory Operation	299	Identical
58.8 ≤ f ≤ 61.2	Continuous Operation	Infinite	Identical
57.0 ≤ f < 58.8	Mandatory Operation	299	Identical
f < 57.0	No ride-through requirements apply to this range		Identical

Interim Solution-Grid Support Utility Interactive Inverter Functions Status

Function	Default Activation State
SPF, Specified Power Factor	OFF
Q(V), Volt-VAr Function with Watt or VAr Priority	OFF
SS, Soft-Start Ramp Rate	ON Default value : 2% of maximum current output per second
FW, Frequency-Watt Function	OFF

Interim Solution-Timeline

State	ISO-NE SRD Implementation Schedule
Connecticut	All solar PV projects with applications submitted on or after June 1, 2018
Maine	All solar PV projects with applications submitted on or after September 1, 2018
Massachusetts	Solar PV projects greater than 100KW with applications submitted on or after March 1, 2018 Solar PV projects 100kW or less with applications submitted on or after June 1, 2018
New Hampshire	All solar PV projects with applications submitted on or after June 1, 2018
Rhode Island	Solar PV projects greater than 100KW with applications submitted on or after March 1, 2018 Solar PV projects 100kW or less with applications submitted on or after June 1, 2018
Vermont	Implementation timeline currently* under development
Municipals & Co-ops	Implementation timeline currently* under development

* As of September 13, 2018

Interim-Solution-Next Steps

- ISO-NE is working with utilities and regulators in Vermont to implement the ISO-NE SRD
  - Having one SRD for all of New England will minimize developer costs
  - Having one SDR will simplify modeling DER in planning studies
- ISO-NE is working with Municipal Utilities and Co-ops to implement the ISO-NE SRD on their systems
- ISO-NE will work with utilities to optimize the utilization of advanced inverter functions that will be available under the revised IEEE 1547
- ISO-NE will work with utilities and regulators to specify the IEEE 1547 category that will be assigned to each type of DER

LESSONS LEARNED

ISO-NE has benefited engaging stakeholders on DER standards

ISO-NE has initiated on-going discussions with stakeholders 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

Lessons Learned

- The revised 1547 Annex B recommends that level of penetration be considered in determining the required performance category
  - Solar PV has a high level of penetration in New England
  - Battery storage is increasing recently
- Some state regulations require compliance with 1547-2003 as updated, choosing trip settings within 1547a ranges may eliminate the need to revise state regulations
- The Energy Policy Act of 2005 requires electric utilities to provide interconnection services “based on standards developed by the Institute of Electrical and Electronics Engineers: IEEE Standard 1547 for Interconnecting Distributed Resources with Electric Power Systems, as they may be amended from time to time.”
  - Public Law 109–58, August 8, 2005

Lessons Learned

- Distribution utilities are currently requiring DERs to comply with NPCC frequency trip requirements and thus were not concerned with ISO-NE frequency tripping and ride-through proposed requirements
- Distribution utilities expressed concerns on the impact of high voltages (near 120%) on their and customer equipment
- Distribution utilities requested two-second tripping for 110% voltage to provide back-up protection for SLG faults on distribution circuits
- Distribution utilities accepted a 1.1 second clearing time for voltages 0.5 per unit and below as long as inverters ceased to energize ("Momentary Cessation")
  - Category II can be combined with Momentary Cessation!
- Distribution utilities decided not to implement voltage regulation at this time

Lessons Learned

- Manufacturers requested that ISO-NE develop a source requirement document
- Manufacturers require time to develop a methodology (software) to implement ISO-NE settings in one step
- Developers noted that electricians typically install smaller solar PV projects and are not typically trained to change settings in the field
- Developers noted that ride-through capability may be different for some inverter-based technologies such as fuel cells and combined heat and power that utilizes a synchronous generator connecter through an inverter

Lessons Learned

- ISO-NE choose IEEE 1547 Category II so that trip settings would be within the range of acceptable settings
- Procedures need to be developed to track DER with difference performance capabilities to enable accurate representation in planning studies
- The voltage trip settings will result in the following values for DER ride-through performance that may be used by transmission planners in system studies
  - NERC Reliability Guideline on DER Modeling (Sep 2017)
  - EPRI White Paper on New Aggregated DER (der a) Model (May 2018)

Voltage range (p.u.)	Operating Mode / Response	Range of ride-through time (s) (min – max)
V > 1.20	Cease to Energize	N/A
1.175 < V ≤ 1.20	Permissive Operation	0.2 – 2.0
1.15 < V ≤ 1.175	Permissive Operation	0.50 – 2.0
1.10 < V ≤ 1.15	Permissive Operation	1.00 – 2.0
0.88 ≤ V ≤ 1.10	Continuous Operation	Infinite
0.65 ≤ V < 0.88	Mandatory Operation	1.84 – 2.0
0.50 ≤ V < 0.65	Mandatory Operation	0.32 – 2.0
V < 0.50	Momentary Cessation (with a maximum response time of 0.083 seconds)	0.16 – 1.1

Lessons Learned

- ISO-NE rejected a proposal to exempt “smaller” solar PV from ride-through requirements based on the kW installed as of 2016

New England			
Size Class	Site Count	ACKW	% ACKW
<10kW	87,993	493,701.67	26%
10kW-<20kW	14,471	171,101.46	9%
20kW-<100kW	3,639	133,472.31	7%
100kW-500kW	1,263	291,619.29	15%
>500kW-<1000kW	165	124,246.58	6%
1000kW-<5000kW	315	623,729.13	33%
>=5000kW	13	80,087.30	4%
Total	107,859	1,917,957.74	100%

Questions