Impact of Distributed Energy Resources on Transmission System Reliability

National Council on Electricity Policy (NCEP)

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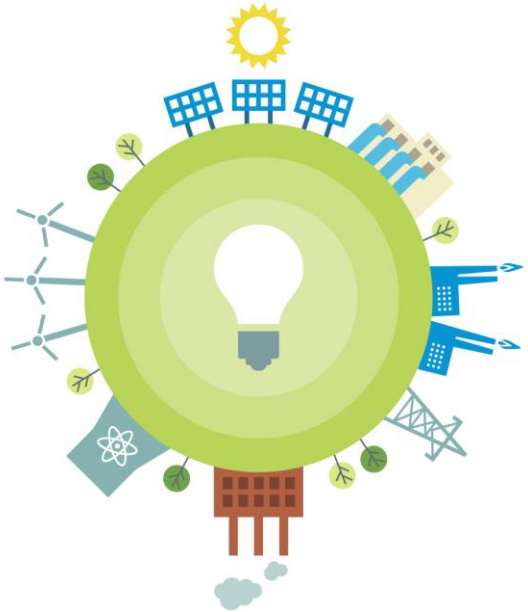
Key Points



- 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 the performance of solar PV DER that are required to ensure support of the reliability of the Bulk Electric System

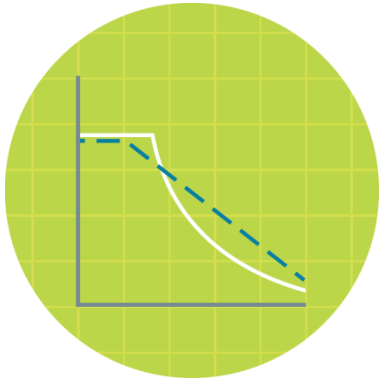
ISO New England Performs Three Critical Roles to Ensure Reliable Electricity at Competitive Prices

Grid Operation

Coordinate and direct the flow of electricity over the region's high-voltage transmission system

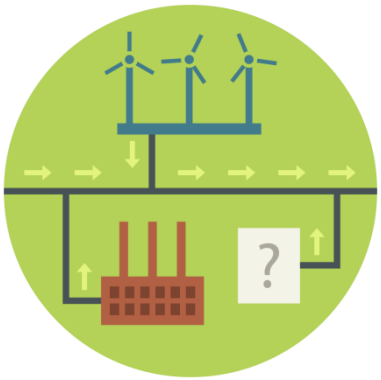
Market Administration

Design, run, and oversee the markets where wholesale electricity is bought and sold



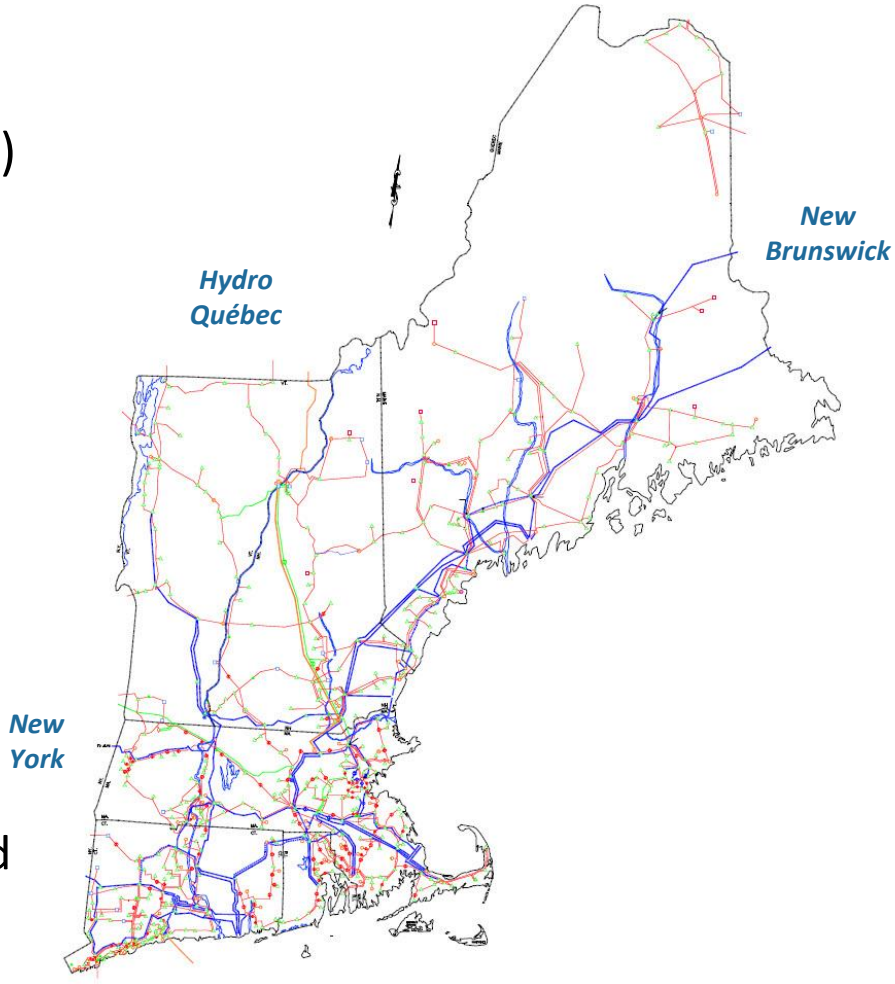
Power System Planning

Study, analyze, and plan to make sure New England's electricity needs will be met over the next 10 years



New England's Transmission Grid Is the Interstate Highway System for Electricity

- **9,000 miles** of high-voltage transmission lines (115 kV and above)
- **13 transmission interconnections** to power systems in New York and Eastern Canada
- **17%** of region's energy needs met by imports in 2017
- **$10 billion** invested to strengthen transmission system reliability since 2002; **$2.3 billion** planned
- Region's all-time summer peak demand set on August 2, 2006 at **28,130 MW**



BACKGROUND

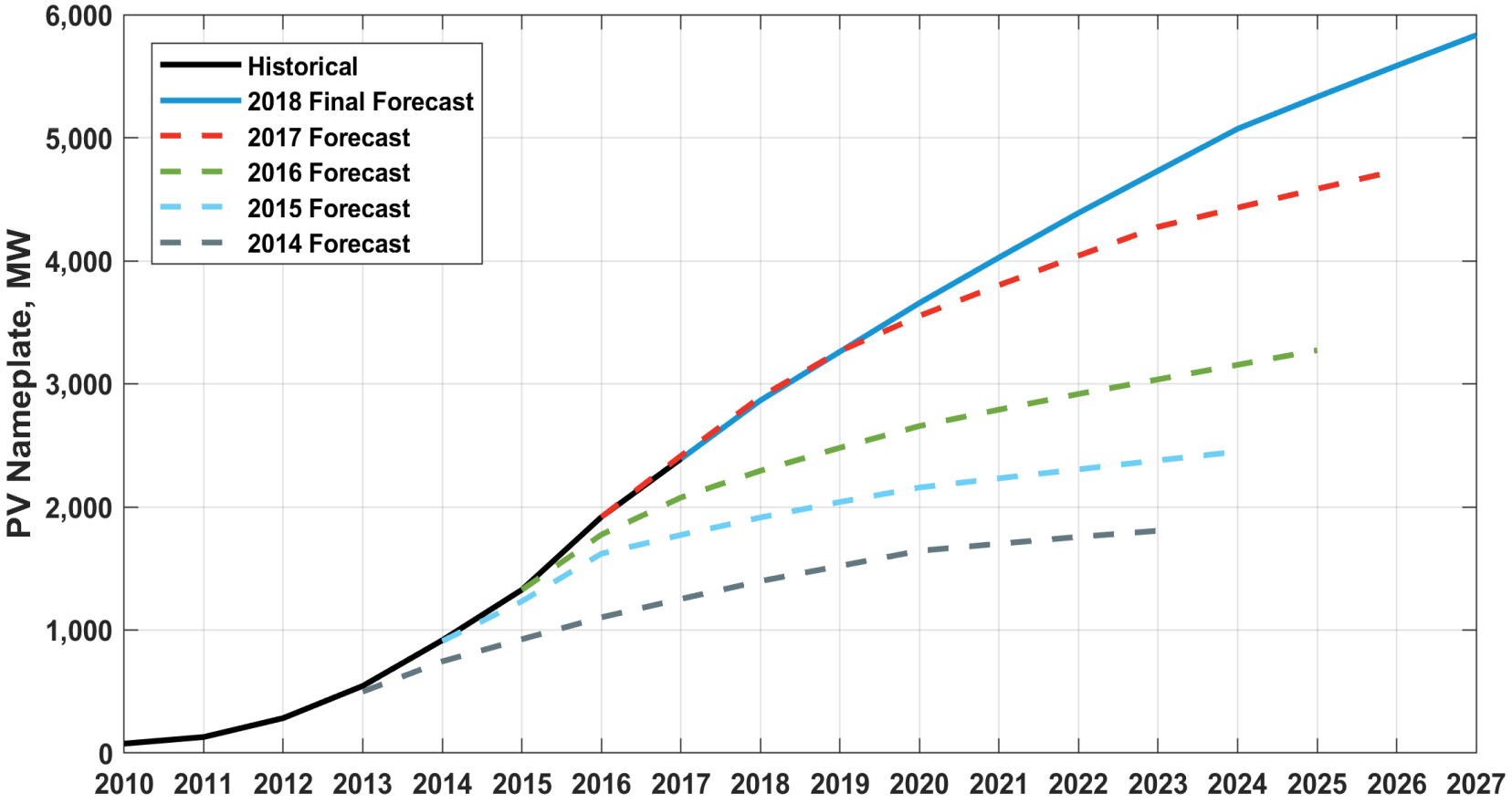
The Growth of Distributed Energy Resources in New England

The ISO Is Forecasting Significant Solar Growth

- Each year, the projections increase for the amount of DER in New England, thus making DER impact on the BES reliability a larger concern

Significant PV Growth: Reported Historical vs. Forecast

ISO Updates the Forecast Annually to Capture Policy Changes



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

Bulk Electric System Planning Criteria

- Planning criteria require that the transmission system remain secure for faults with normal or delayed fault clearing
  - Normal clearing of a three-phase fault on the 345 kV system takes approximately 0.1 seconds and delayed clearing of a single phase fault on the 345 kV system takes approximately 0.1-0.2 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 and delayed clearing of a single phase fault on a the 115 kV system can range from 0.3 seconds to over a second depending on the protective relay scheme
- 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*
  - The ISO's analysis showed that a fault on the transmission system can cause low voltage over a large portion of the New England system

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

Bulk Electric System Planning Criteria, *continued*

- 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
- 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 transmission system upgrade would be required**, and this could negatively impact the benefits of policies to encourage renewable energy

STATUS OF IEEE 1547 AND UL 1741

IEEE 1547 Standard Update

- **IEEE 1547,** the IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems, was originally issued in 2003 (1547-2003)
- **In 2014,** 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 undertake 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 Implementation Timeline

- 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 is optimistically expected to 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 potentially 2020, and likely later, before utilities will be fully 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 requirements for "Grid Support Utility Interactive Inverters"
  - These inverters have the capabilities required by California Rule 21
  - 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

Interim Solution*, continued*

- The development of inverter performance requirements and an associated implementation plan was required to address 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 Requirement Document (SRD)** and an implementation plan
  - An SRD can be used by UL for the certification of equipment
  - The ISO-NE SRD is based on the UL 1741 SA

Interim Solution: SRD 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

May be updated to agree with NERC PRC-024-2 but is currently within limits of IEEE Std 1547.

Interim Solution: SRD 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-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

NEXT STEPS

Next Steps

- ISO-NE is working with utilities and regulators in New England to implement the ISO-NE SRD
  - Having one SRD for all of New England will minimize developers' costs
  - Having one SRD will simplify the modeling of DER in planning
- 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, and update its SRD as needed

Questions