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How Distributed Energy Resources Are Impacting the New England Power System

National Council on Electricity Policy

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KEY MESSAGES

- New England is seeing significant growth in distributed energy resources (DER), particularly solar photovoltaic (PV) resources
- As New England adds significant amounts of DERs, it is essential that they be interconnected in a way that does not adversely impact the reliability of the Bulk Electric System
- ISO New England has been actively engaged with stakeholders on the need to update state interconnection standards for DERs to ensure reliability

ISO New England (ISO) Has Two Decades of Experience Overseeing the Region's Restructured Electric Power System

- **Regulated** by the Federal Energy Regulatory Commission
- **Reliability Coordinator** and **Planning Coordinator** for New England under the North American Electric Reliability Corporation
- **Independent** of companies in the marketplace and **neutral** on technology

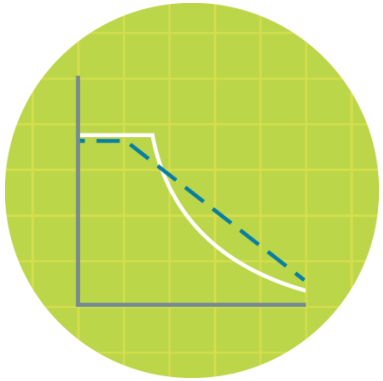
ISO New England Performs Three Critical Roles to Ensure Reliable Electricity at Competitive Prices

Grid Operation

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

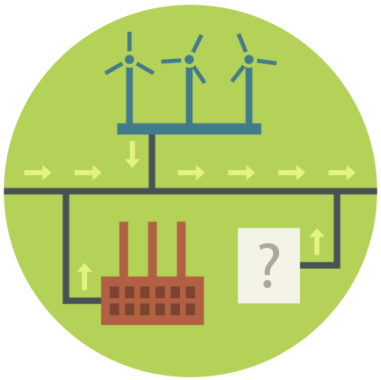
Market Administration

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



ISO New England Adheres to Mandatory Reliability Standards Set by Numerous Entities

FERC
FEDERAL ENERGY REGULATORY COMMISSION

Defines the ISO's authority, responsibilities, and the services it provides. The ISO's responsibilities are guided by rules approved or mandated by FERC.

Northeast Power Coordinating Council (NPCC)

NERC coordinates its activities with eight regional reliability councils. NPCC develops, implements, and enforces standards for the design and operation of the interconnected power systems in the Northeast.

Purpose: To ensure that the regional transmission system can reliably deliver power to consumers under a wide range of future system conditions

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

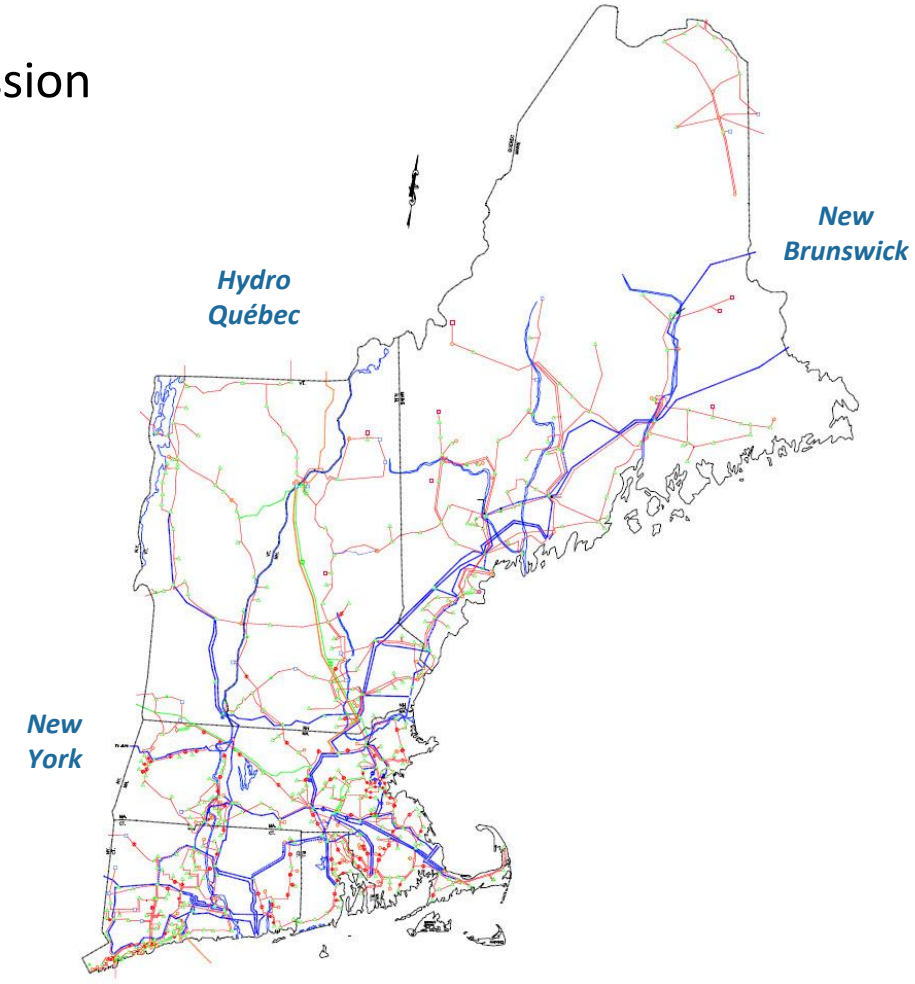
Develops and ensures compliance with mandatory standards for planning and operating power systems in North America. Can levy fines of $1,000 to $1 million per day for violations.

ISO new england

Develops and follows procedures to meet the numerous, stringent reliability standards set by numerous entities.

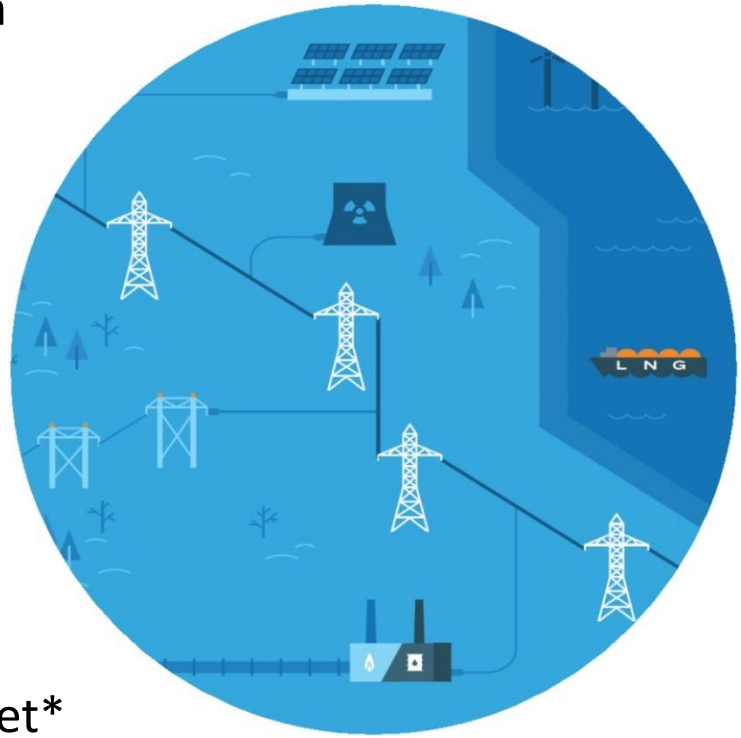
New England's Transmission Grid Is the Interstate Highway System for Electricity

- **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
- **$10.4 billion** invested to strengthen transmission system reliability since 2002; **$1.9 billion** planned
- Developers have proposed multiple transmission projects to access **non-carbon-emitting resources** inside and outside the region



Generation and Demand Resources Are Used to Meet New England's Energy Needs

- **350** dispatchable generators in the region
- **29,200 MW** of generating capacity
- **15,000 MW** of proposed generation in the ISO Queue
  - Mostly wind and natural gas
- **4,600 MW** of generation has retired or will retire in the next few years
- **400 MW** of active demand response and **2,300 MW** of energy efficiency with obligations in the Forward Capacity Market*
  - Beginning June 1, 2018, demand resources will have further opportunities in the wholesale markets



* In the Forward Capacity Market, demand-reduction resources are treated as capacity resources.

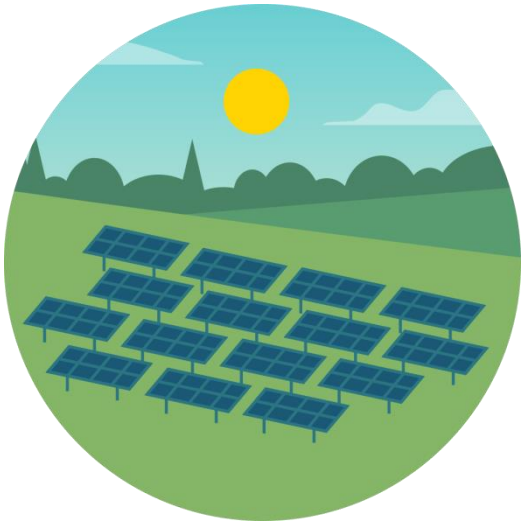
Demand Patterns Are Changing

- **7.2 million** retail electricity customers drive the demand for electricity in New England (14.8 million population)
  - Region's all-time summer peak demand: **28,130 MW** on August 2, 2006
  - Region's all-time winter peak demand: **22,818 MW** on January 15, 2004
- Energy efficiency (EE) and behind-the-meter (BTM) solar are **slowing** peak demand growth and **reducing** overall electricity use over the next ten years
  - **0.1%** annual growth rate for summer peak demand (with EE and BTM solar)
  - **-0.6%** annual growth rate for overall electricity use (with EE and BTM solar)

Note: Without energy efficiency and solar, the region's peak demand is forecasted to grow 1% annually and the region's overall electricity demand is forecasted to grow 0.9% annually. Summer peak demand is based on the "90/10" forecast for extreme summer weather.

ISO New England Forecasts Growth in Distributed Generation Resources

- Since 2013, the ISO has led a regional **Distributed Generation Forecast Working Group** (DGFWG) to collect data on distributed generation (DG) policies and implementation, and to forecast long-term incremental DG growth in New England
- The DGFWG focuses on the following types of DG resources:
  - Under 5 MW
  - Connected to the distribution system
  - Not visible to the ISO directly
  - Specifically solar photovoltaic (PV) resources, the largest DG component
- The ISO forecasts strong growth in solar PV over the next 10 years

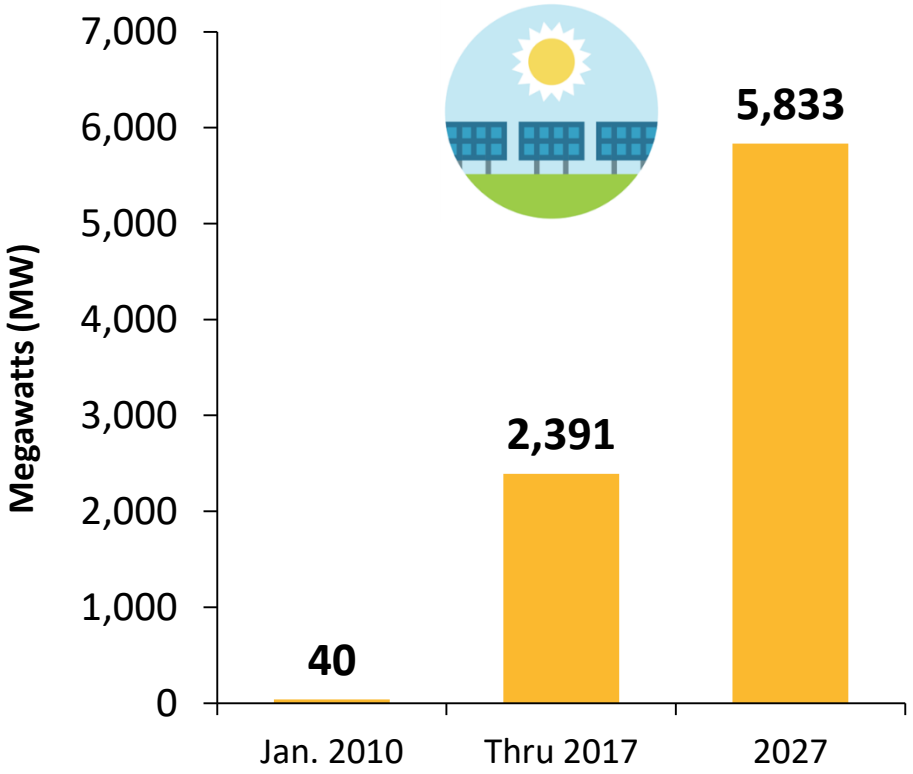


ISO New England Forecasts Strong Growth in Solar Photovoltaic (PV) Resources

December 2017 Solar PV Installed Capacity (MW_{ac})

State	Installed Capacity (MW_{ac})	No. of Installations
Connecticut	365.6	29,512
Massachusetts	1,602.3	78,047
Maine	33.5	3,598
New Hampshire	69.7	7,330
Rhode Island	62.2	4,148
Vermont	257.2	9,773
New England	**2,390.5**	**132,408**

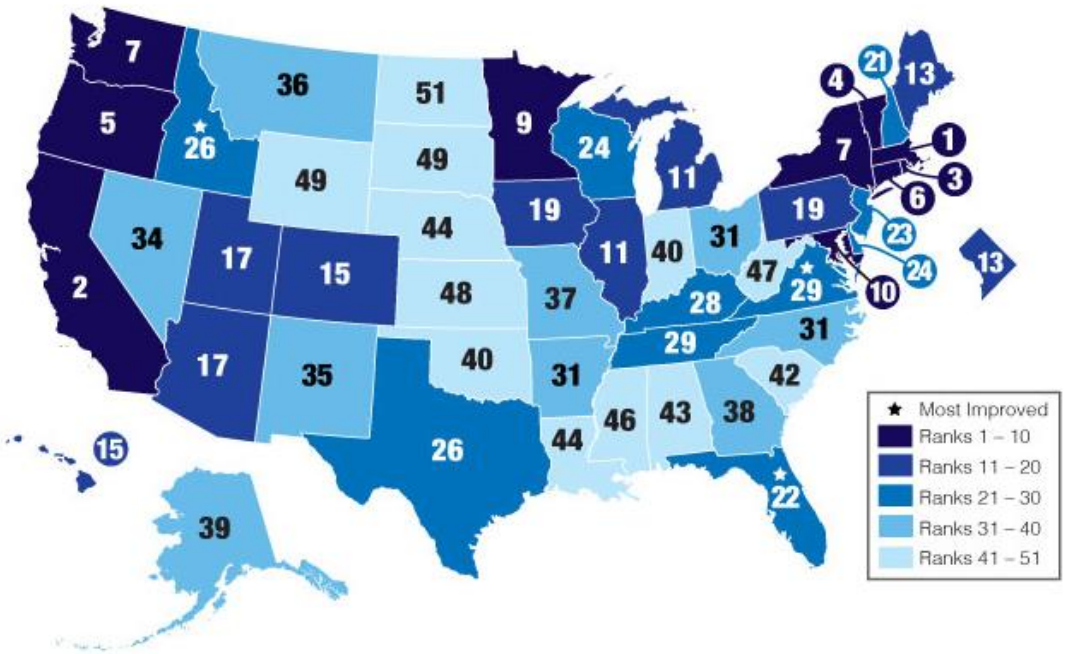
Cumulative Growth in Solar PV through 2027 (MW_{ac})



Note: The bar chart reflects the ISO's projections for nameplate capacity from PV resources participating in the region's wholesale electricity markets, as well as those connected "behind the meter." Source: Final 2018 PV Forecast (March 2018); MW values are AC nameplate.

Energy Efficiency (EE) Is a Priority for State Policymakers

2017 State Energy-Efficiency Scorecard



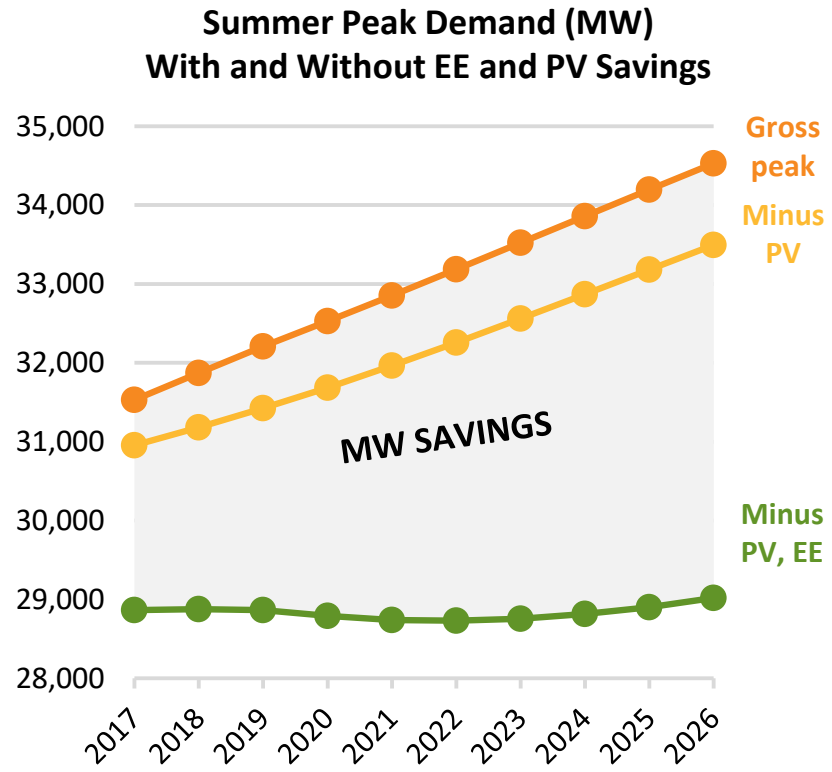
Source: American Council for an Energy-Efficient Economy

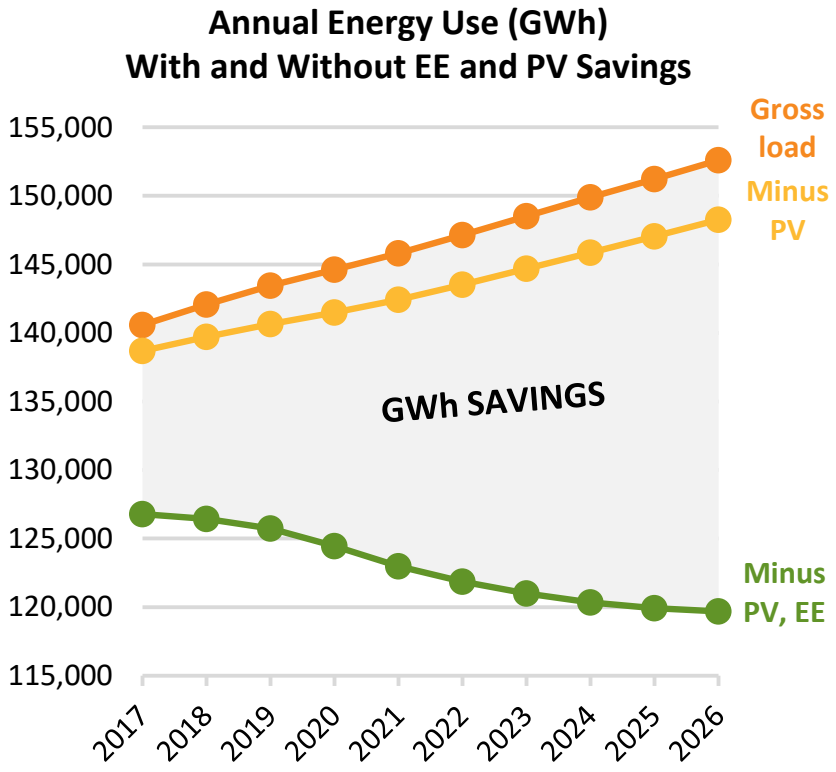
Ranking of state EE efforts by the *American Council for an Energy-Efficient Economy*:

– Massachusetts	1
– Rhode Island	3
– Vermont	4
– Connecticut	6
– Maine	13
– New Hampshire	21

- Billions spent over the past few years and more on the horizon
  - Nearly $4.5 billion invested from 2010 to 2015
- Through the **Energy-Efficiency Forecast Working Group** (EEFWG), the ISO estimates $7.2 billion to be invested in EE from 2021 to 2026

EE and Behind-the-Meter Solar Are Reducing Peak Demand Growth and Annual Energy Use



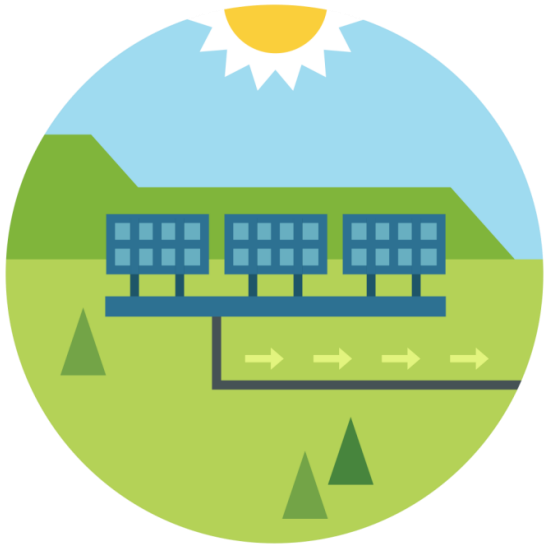


- **The gross peak and load forecast**
- **The gross peak and load forecast minus forecasted "behind-the-meter" (BTM) solar PV resources**
- **The gross peak and load forecast minus forecasted BTM solar PV, minus energy-efficiency (EE) resources in the Forward Capacity Market 2017-2020 and forecasted EE 2021-2026**

Note: Summer peak demand is based on the "90/10" forecast, which accounts for the possibility of extreme summer weather (temperatures of about 94° F).
Source: Final 2017 Solar PV Forecast (April 2017) and Final ISO New England Energy-Efficiency Forecast 2021-2026 (May 2017)

The ISO Is Leading Efforts to Account for Solar Resources Connected to the Distribution System

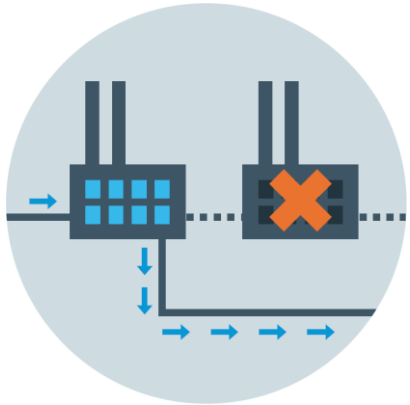
- **Forecasting Long-Term Solar Growth**
  - The ISO tracks historical solar growth and forecasts long-term solar growth working with distribution utilities and state agencies
  - The solar forecast is used in transmission planning and market needs assessments
- **Forecasting Short-Term Solar Performance**
  - The ISO creates daily forecasts of solar generation production to improve daily load forecasts and situational awareness for grid operators
- **Improving Interconnection Rules**
  - The ISO is actively engaged with industry stakeholders to strengthen interconnection standards and reduce reliability concerns



Bulk Electric System Planning Criteria

- ISO New England is required to plan for the contingency loss of resources (including DERs) 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 the 115 kV system can range from 0.1 seconds to over 0.5 seconds depending on the protective relay scheme

Limitations on the Loss of Source

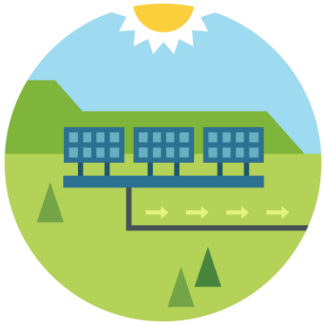


- Planning criteria require limitations on the amount of resources that can be lost in response to a **contingency**
- Historically, the concern has been large generators being disconnected or becoming unstable and tripping
- Tripping of DERs for a **transmission fault** would add to source loss
- If total source loss exceeds the amount allowed by the planning criteria, a system upgrade would be required
- Each year, the projections increase for the amount of DERs installed in New England, making DER impact on **BES reliability** a larger concern

The ISO Has Engaged Stakeholders on DER Standards

ISO New England has played an active role in discussions on the need to update state interconnection standards for DERs to protect the reliability of the BES

- The ISO has concerns that New England may lose significant amounts of DERs due to faults on the transmission system, and has recommended the following capabilities for DERs:
  - High/low frequency and voltage ride-through
  - Default and emergency ramp rate limits
  - Reconnect by "soft start" methods after disconnect
  - Voltage support
  - Communication capabilities to support other functionalities



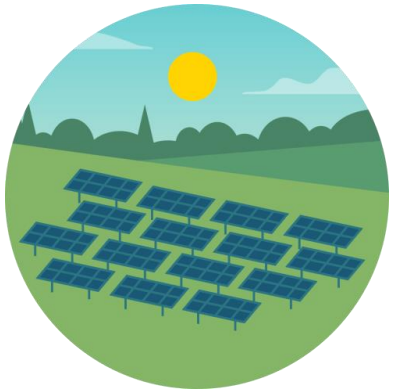
- Since 2012, the ISO has discussed these concerns with several stakeholder groups:
  - Planning Advisory Committee (PAC)
  - Distributed Generation Forecast Working Group (DGFWG)
  - Massachusetts Department of Public Utilities (Grid Modernization docket)
  - Massachusetts Technical Standards Review Group (TSRG)

The ISO Developed an Interim Solution for Obtaining Ride-Through for Voltage and Frequency Variations

- Because of the rapid growth of solar PV in New England and the protracted timeline for full implementation of revised interconnection standards for DERs (IEEE 1547), the ISO sought an **interim solution** for obtaining ride-through for voltage and frequency variations
- Working with the Massachusetts Technical Standards Review Group (TSRG), the ISO developed inverter performance requirements and an implementation plan
  - More than 60% of solar PV in New England is or will be installed in Massachusetts

ISO New England's Source Requirements Document Contains Updated Standards for Inverter-Based PV

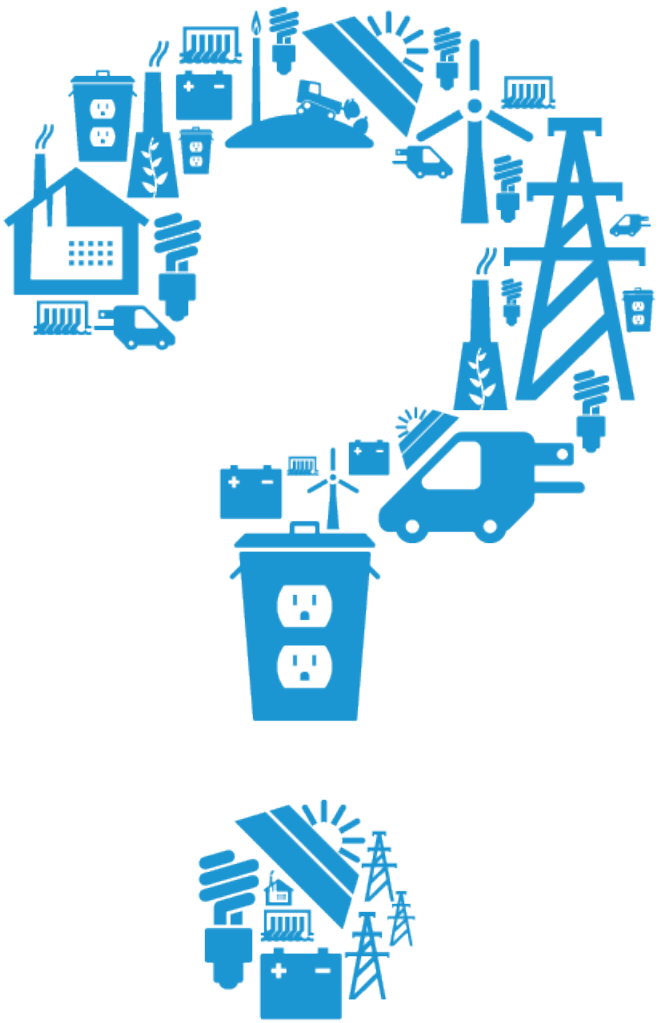
- All inverter-based solar PV projects 100 kW or less with applications submitted on or after June 1, 2018 are subject to the ISO-NE Source Requirements Document
- All inverter-based solar PV projects greater than 100 kW with applications submitted on or after March 1, 2018 are subject to the ISO-NE Source Requirements Document
- The updated standards require certain frequency and voltage trip settings (and associated voltage and frequency ride-through performance) that are consistent with the allowable ranges of the revised IEEE 1547 standards and NPCC requirements



Closing Thoughts…

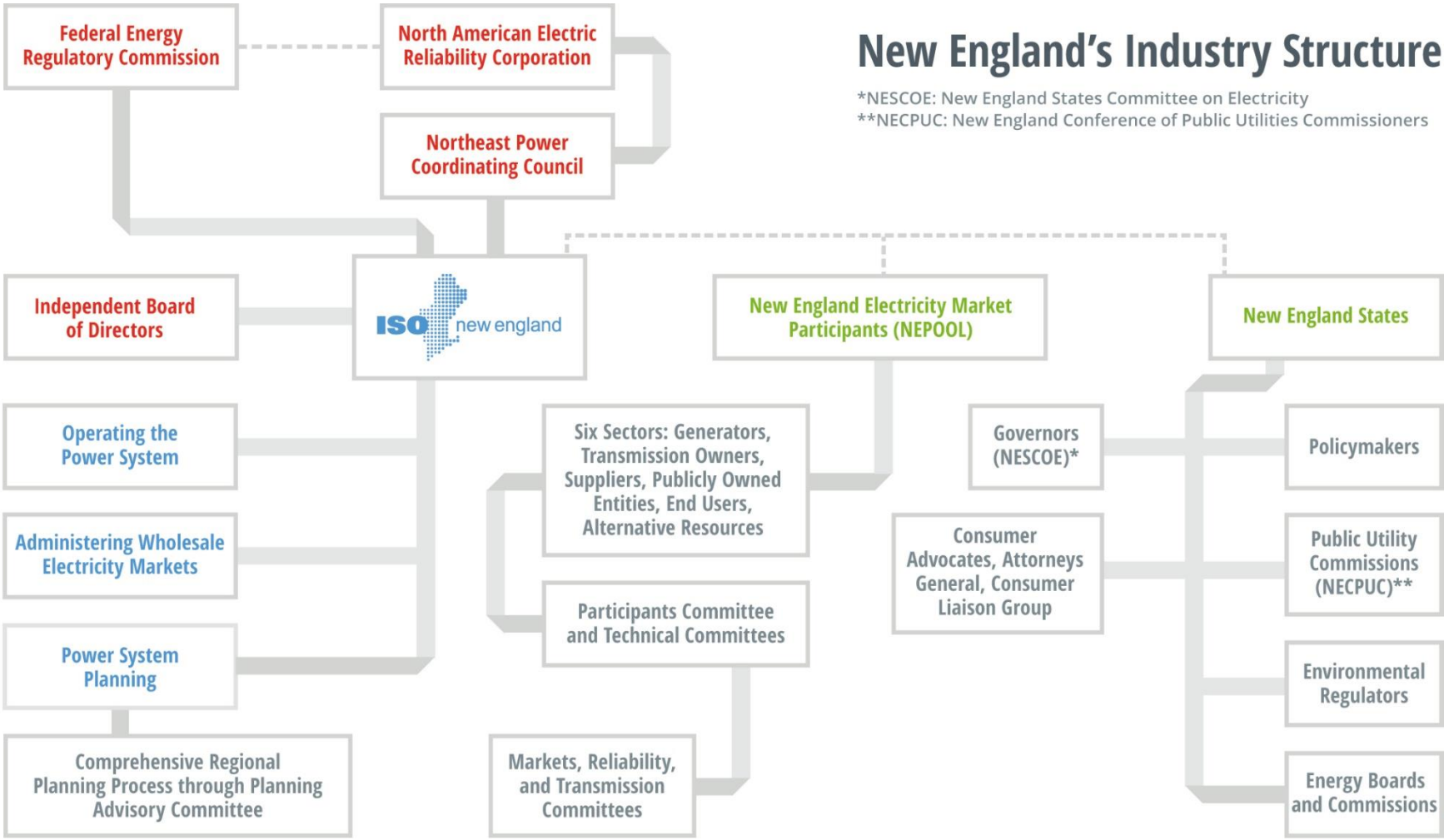
- ISO New England will continue to work with utilities and regulators in each state to implement ISO-NE SRD
  - Having one SRD for all of New England will minimize developers' costs
  - Having one SRD will simplify modeling DERs in planning studies
- ISO New England will continue to work with utilities to optimize the utilization of advanced inverter functions that will be available under the revised IEEE 1547 standards
- ISO New England will continue to forecast solar PV and incorporate solar projections into transmission planning studies

Questions



APPENDIX

Numerous Entities Including an Independent Board Provide Oversight of and Input on ISO's Responsibilities



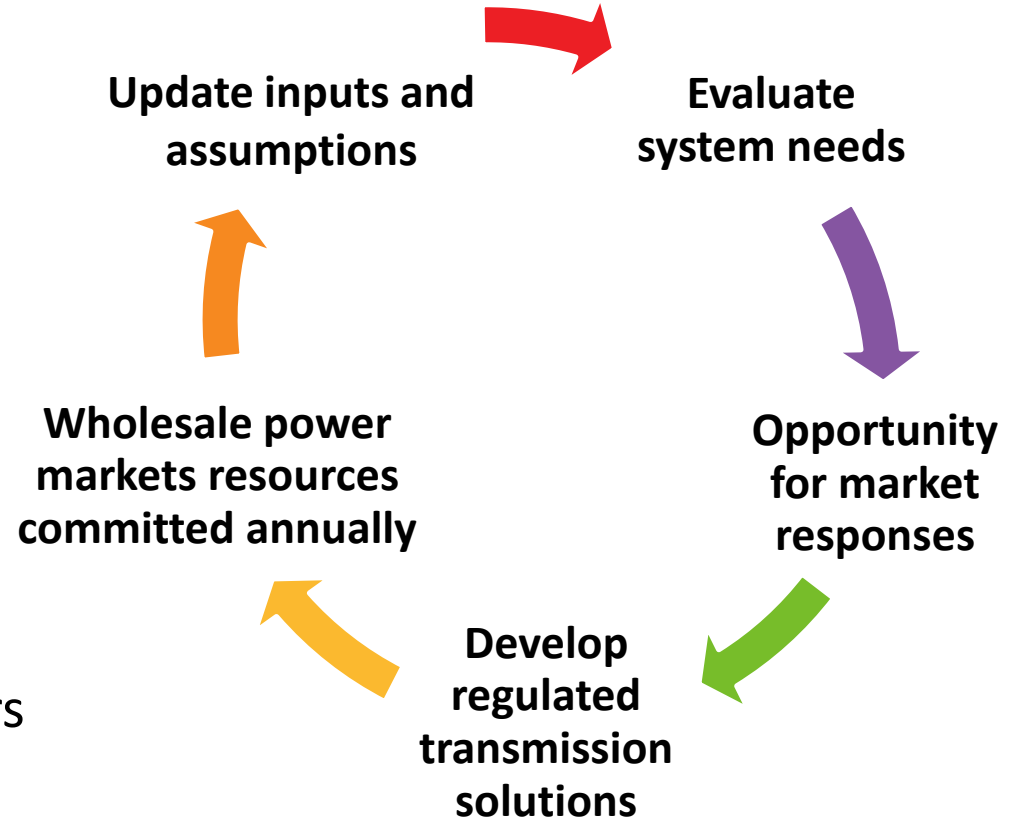
Hierarchy of Organizations That Set Reliability Criteria

- **North American Electric Reliability Corporation (NERC)**
  - International – United States (US) and Canada
  - Transmission planning criteria contained in Transmission System Planning Performance Requirements (TPL-001-04)
  - Covers the Bulk Electric System (BES)
- **Northeast Power Coordinating Council (NPCC)**
  - International/Regional – New York, New England and eastern Canada
  - Transmission planning criteria contained in Regional Reliability Reference Directory # 1 (Directory 1)
  - Covers the Bulk Power System (BPS)
- **ISO New England**
  - Regional – New England
  - Transmission planning criteria contained in Planning Procedure 3 (PP-3)
  - Covers the Bulk Power System (functionally covers Pool Transmission Facilities (PTF))
- **The ISO New England transmission planning process has been successful at identifying needed transmission to address this set of reliability criteria**
  - $10 billion in new transmission investment over the past 15 years
  - Addressed significant reliability concerns and eliminated most congestion and uplift charges in the energy market, eliminated costly Reliability-Must-Run Contracts

New England's Power System Planning Process

Continuous and adaptive feedback loop

- Open and transparent **ten-year** planning process reflects:
  - Updated inputs and assumptions
  - Evaluation of system needs
  - Opportunity for market responses
  - Development of regulated transmission solutions
- Provide information to marketplace and stakeholders
- Coordinate with neighboring planning areas



ISO-NE Source Requirements Document: Frequency Trip Settings

- ISO-NE will require the following frequency trip settings which are consistent with the allowable ranges of the revised IEEE 1547 standards and 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

ISO-NE Source Requirements Document: Voltage Trip Settings

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

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

For More Information…

- Subscribe to the ***ISO Newswire***
  - *ISO Newswire* is your source for regular news about ISO New England and the wholesale electricity industry within the six-state region
- Log on to **ISO Express**
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