Eversource Energy
Developing the Grid of the Future

Energy and Technology Committee

February 5, 2019

Eversource Electric System

1.2 million customers in 149 Towns

4,400 square miles

98 Bulk Substations

81 Distribution Substations

1,113 Feeders
   Mostly radial supply, but sectionalized into smaller zones for automatic backup, using approximately 2,900 reclosers
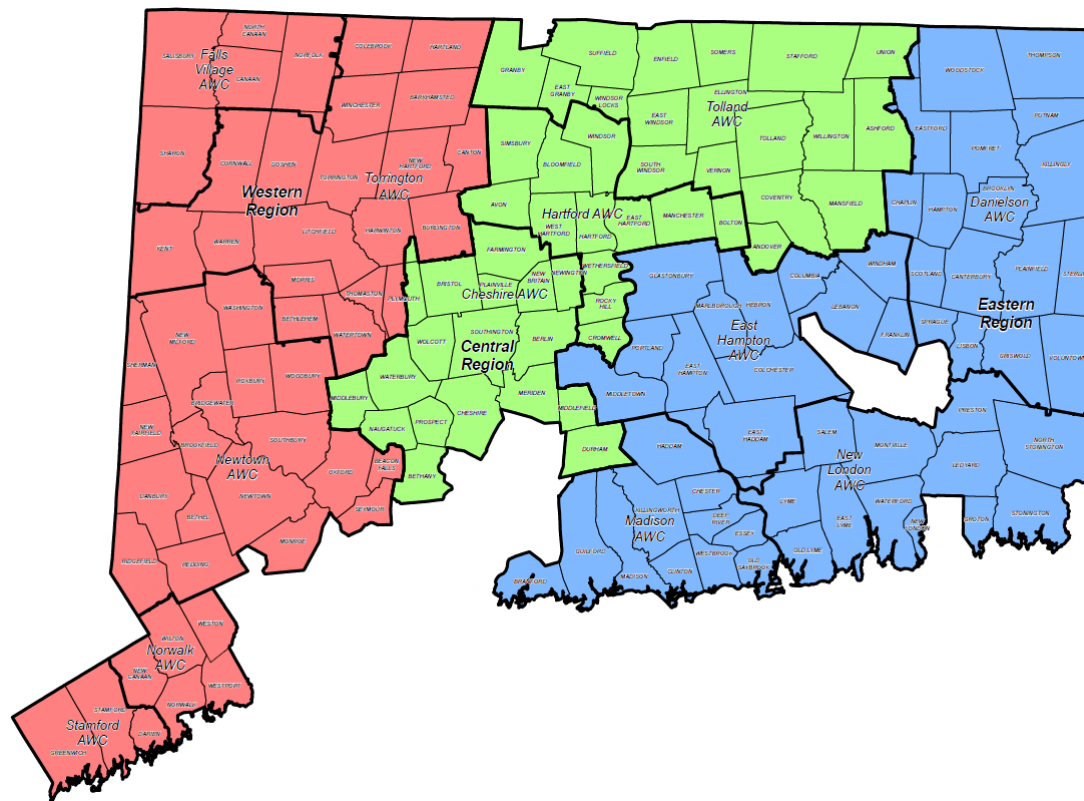
16,950 Overhead circuit miles

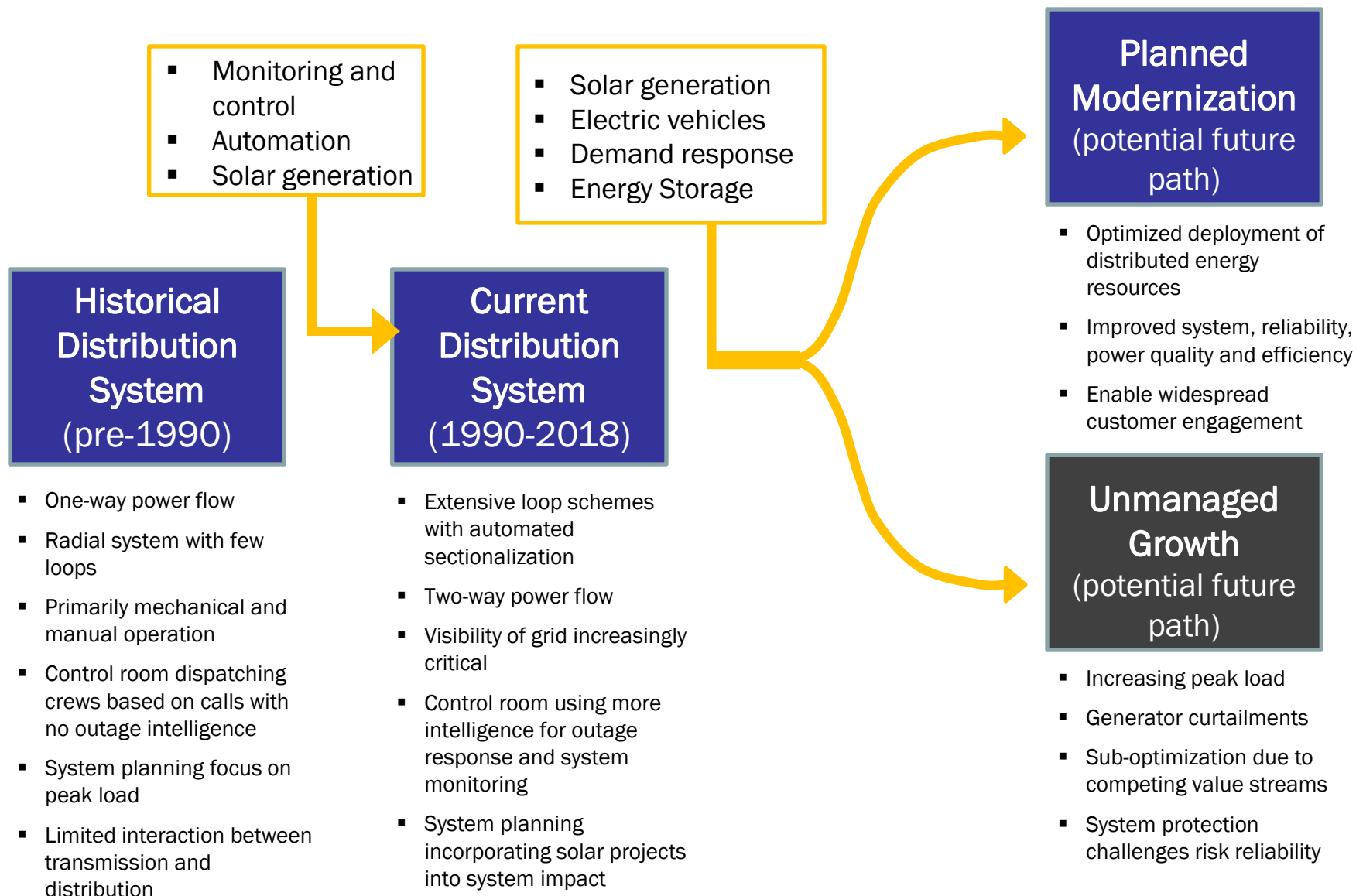6,650 Underground circuit miles

Approximately 27,000 DGs online
   Mostly solar, with a capacity of approximately 390 MW. Additional 2,800 solar generators in queue with a capacity of 608 MW
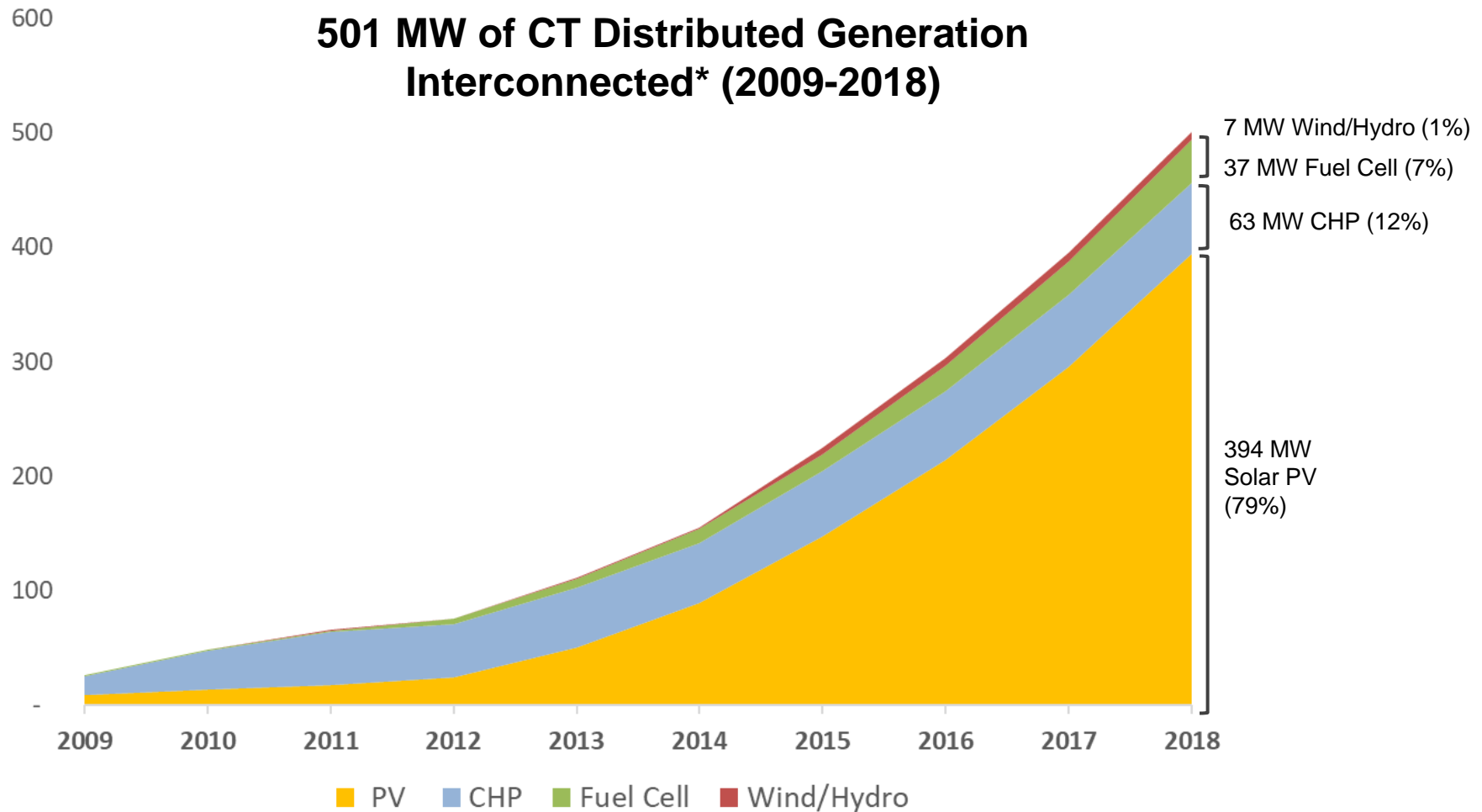
Eversource Operational Regions

Evolution of the Grid

- Monitoring and control
- Automation
- Solar generation

- Solar generation
- Electric vehicles
- Demand response
- Energy Storage

Historical Distribution System (pre-1990)

Current Distribution System (1990-2018)

Planned Modernization (potential future path)

- Optimized deployment of distributed energy resources
- Improved system, reliability, power quality and efficiency
- Enable widespread customer engagement

Unmanaged Growth (potential future path)

Historical Distribution System

- One-way power flow
- Radial system with few loops
- Primarily mechanical and manual operation
- Control room dispatching crews based on calls with no outage intelligence
- System planning focus on peak load
- Limited interaction between transmission and distribution

Current Distribution System

- Extensive loop schemes with automated sectionalization
- Two-way power flow
- Visibility of grid increasingly critical
- Control room using more intelligence for outage response and system monitoring
- System planning incorporating solar projects into system impact

Unmanaged Growth

- Increasing peak load
- Generator curtailments
- Sub-optimization due to competing value streams
- System protection challenges risk reliability

Installed Distributed Generation

501 MW of CT Distributed Generation Interconnected* (2009-2018)

- 7 MW Wind/Hydro (1%)
- 37 MW Fuel Cell (7%)
- 63 MW CHP (12%)
- 394 MW Solar PV (79%)

Legend: PV | CHP | Fuel Cell | Wind/Hydro

* Does not include emergency/peaking generators or 233 MW installed prior to 2009 (95% hydro or CHP)

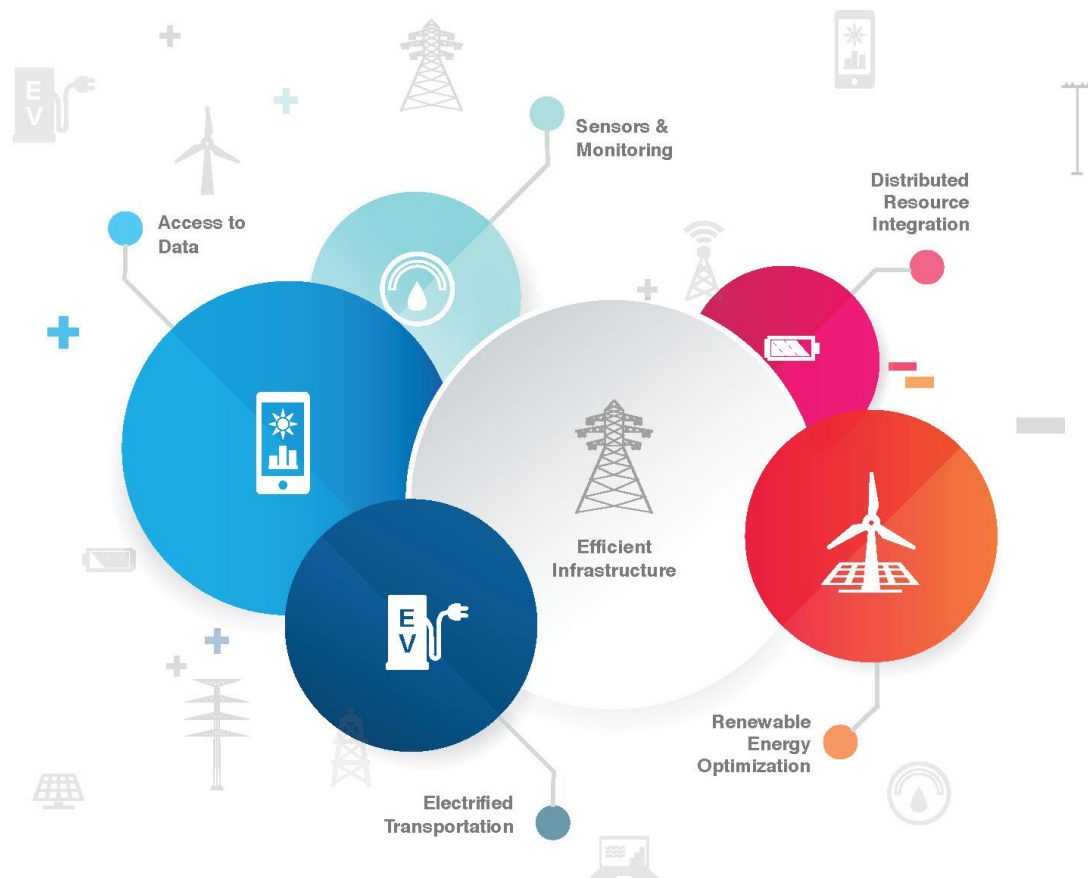# The Modern Grid Enables Seamless Integration of New Technologies

The grid of the future will help to integrate large amounts of flexible, clean energy ... from different locations ... and of varying scale
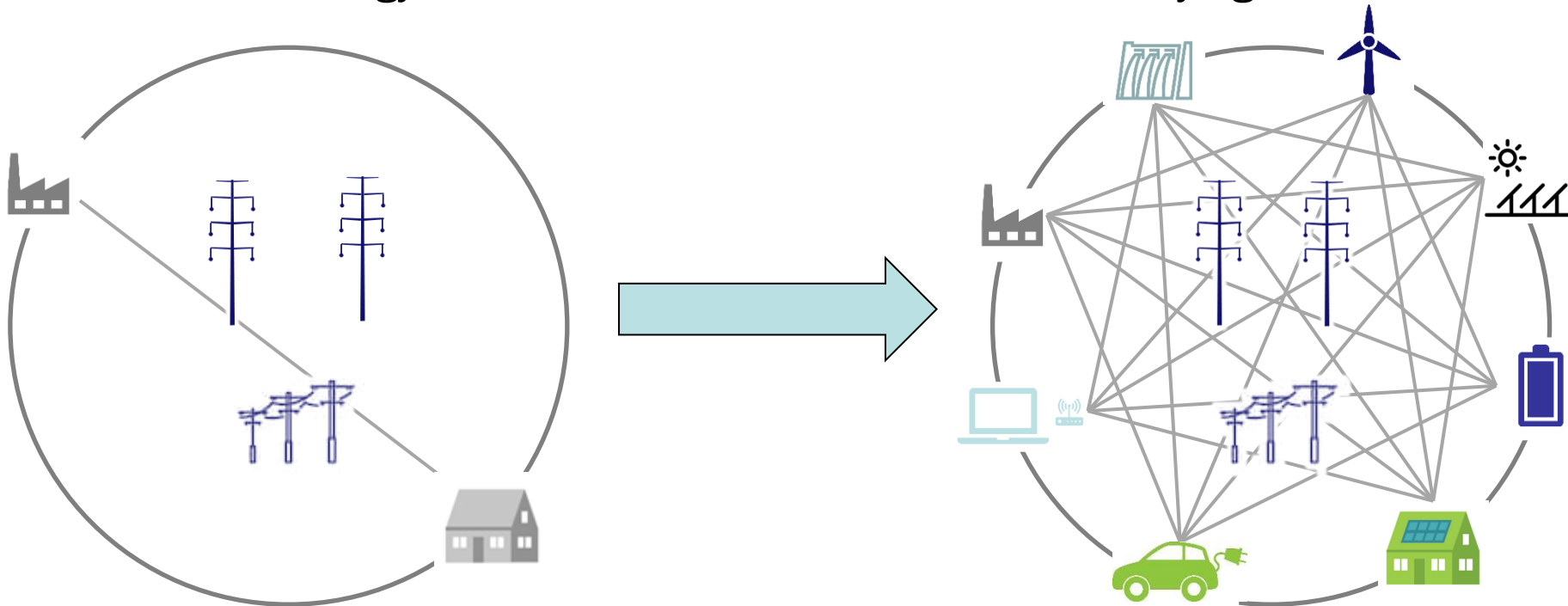
On behalf of our customers, we are positioned to lead the transition to a grid that is more interconnected, more flexible, and more optimized... in the most cost-effective way possible.

Integration Technologies

- Energy storage

- Distribution visibility, control and management systems

- Distributed energy resource management systems

- Active voltage control

- Advanced metering

- Hosting capacity analysis

- Electric vehicle infrastructure

Access to Data

Sensors & Monitoring

Distributed Resource Integration

Efficient Infrastructure

Electrified Transportation

Renewable Energy Optimization

Source: Environmental Defense Fund

Enabling Customer Benefit

The modern grid will be characterized by advanced functionality to enable customer participation and benefit
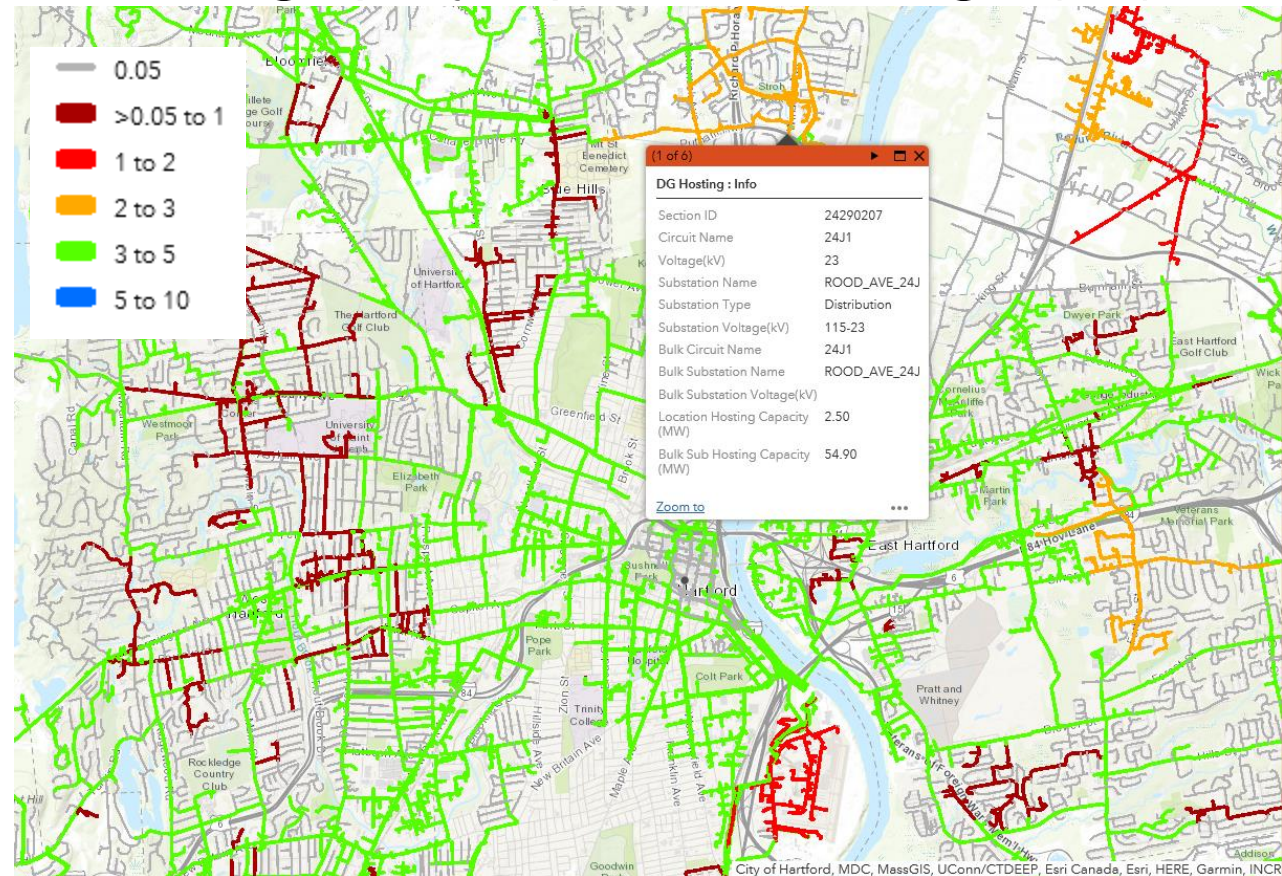
- Visibility
  - Monitor and control real-time grid operations, from the substation to the grid edge

- Automation
  - Operate field devices to improve reliability, support peak load reduction and improve power quality

- Modeling & Forecasting
  - Manage and analyze large volumes of data, ensuring it results in actionable information
  - Deploy advanced forecasting tools to predict the impact of solar energy and electric vehicles on the system

- Distribution Network Operations Platform
  - Optimize the use of all resources to achieve lowest cost clean energy solutions
  - Capture locational benefits of distributed energy resources, including energy storage and electric vehicle charging behavior

EVERSOURCE
ENERGY

ENABLE

VISIBILITY

OPTIMIZATION
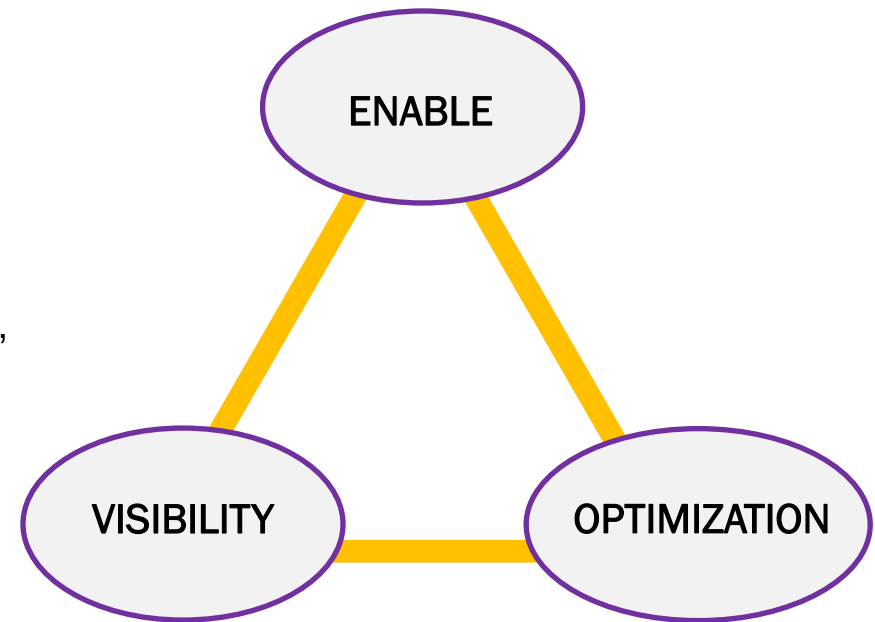
Hosting Capacity Maps

- Maps show customers where it is likely to be easier to locate medium and larger scale solar facilities

- Information is expected to improve the interconnection experience for customers

- Future enhancements are under development that will provide more granular information for decision making

Hosting capacity map for the Hartford region (MW)

Legend:
- 0.05
- >0.05 to 1
- 1 to 2
- 2 to 3
- 3 to 5
- 5 to 10

DG Hosting : Info

Section ID	24290207
Circuit Name	24J1
Voltage(kV)	23
Substation Name	ROOD_AVE_24J
Substation Type	Distribution
Substation Voltage(kV)	115-23
Bulk Circuit Name	24J1
Bulk Substation Name	ROOD_AVE_24J
Bulk Substation Voltage(kV)	
Location Hosting Capacity (MW)	2.50
Bulk Sub Hosting Capacity (MW)	54.90

Zoom to

City of Hartford, MDC, MassGIS, UConn/CTDEEP, Esri Canada, Esri, HERE, Garmin, INCR

Energy Storage

- Energy storage is a grid asset used for optimization

- Multiple use cases provide grid benefit

    - Peak shaving

    - Reliability and support for microgrid applications

    - Power grid infrastructure alternatives

    - Renewable integration with voltage smoothing technology and mitigation of impacts associated with reverse power flow

    - Wholesale market services

- Capturing the full benefit of energy storage as a grid asset depends on responding to real-time system conditions

Energy Storage Applications
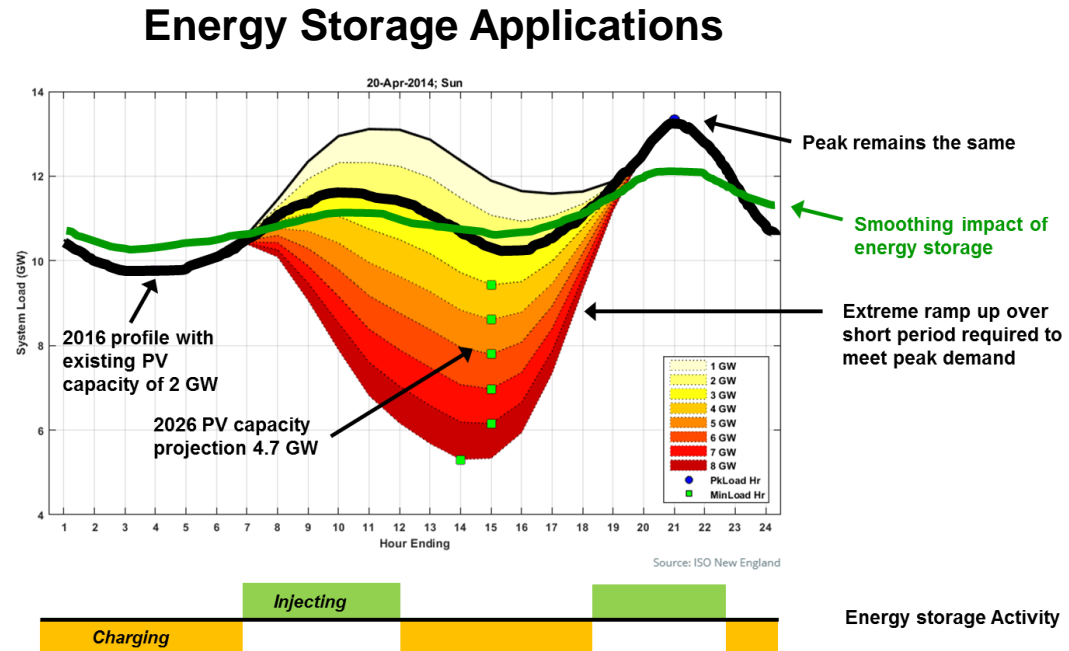
Higher Expectations for Reliability and Resilience

Our health, safety and economic well-being are increasingly tied to a reliable and flexible grid which ensures that *power is always available when and where it is needed*.

**The grid is the backbone of even higher reliability and resilience**

2019 Resiliency Program

- **Smart Switches:** Deploy devices to automatically reduce the number of customers affected by an outage event

- **Islanded Substations:** Provide robust back-up supply options at the grid edge

- **Right-of-Way Relocation:** Harden critical backbone supply infrastructure, replacing obsolete equipment

- **Pole Integrity Program:** Replace over 1,000 older distribution poles to new resiliency design standards

- **Flood Mitigation:** Complete Resiliency program to raise and replace substation equipment to ensure compliance with 100-year flood protection standards

- **Substation Security:** Add cameras and state-of-the art fencing to key substations to protect against physical attacks

Storm Damage Prediction Modeling

- Collaboration with University of Connecticut uses detailed Eversource facility data, historical storm outage records and high resolution weather forecasts to better predict expected damage, by town

- Enables better planning for adequate line crews

- Supports more proactive communication and planning with town officials

- Better planning minimizes the overall duration of power outages
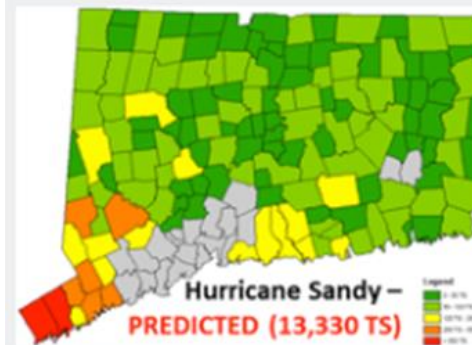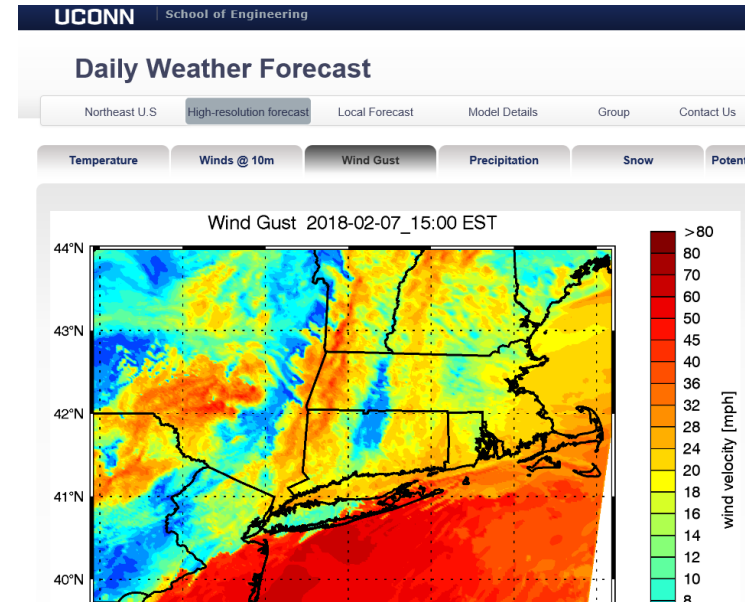
Predicted outages from Hurricane Sandy (2012) in Eversource CT service territory
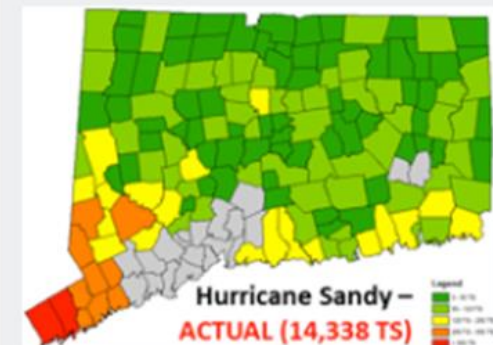
Actual outages from Hurricane Sandy (2012) in Eversource CT service territory

The Modern Grid's Value Proposition

Facilitate delivery of cost effective clean energy

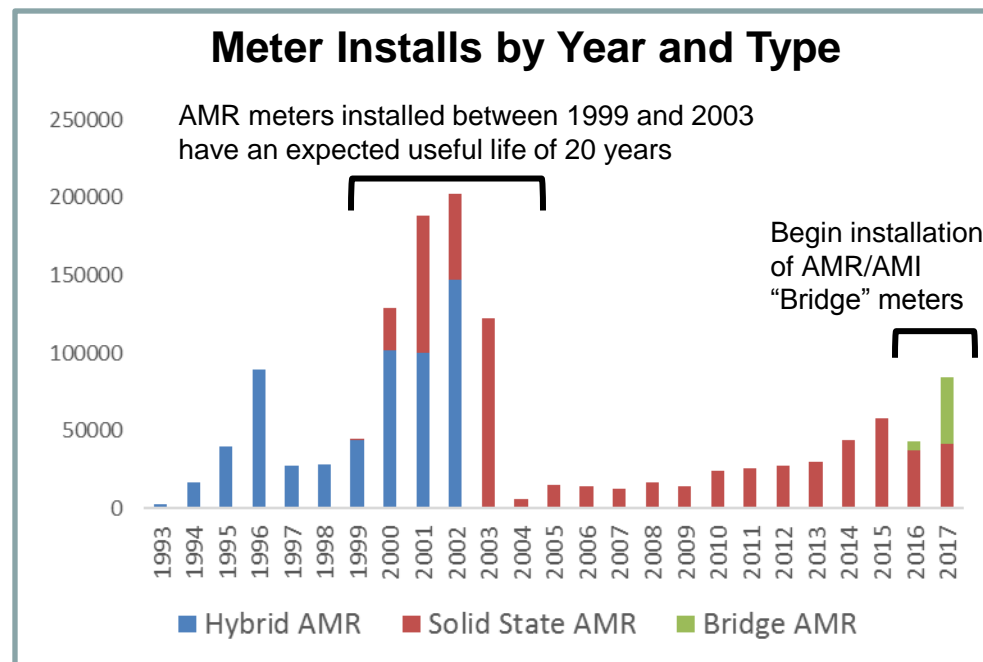Ensure high reliability and resilience

Optimize use of resources

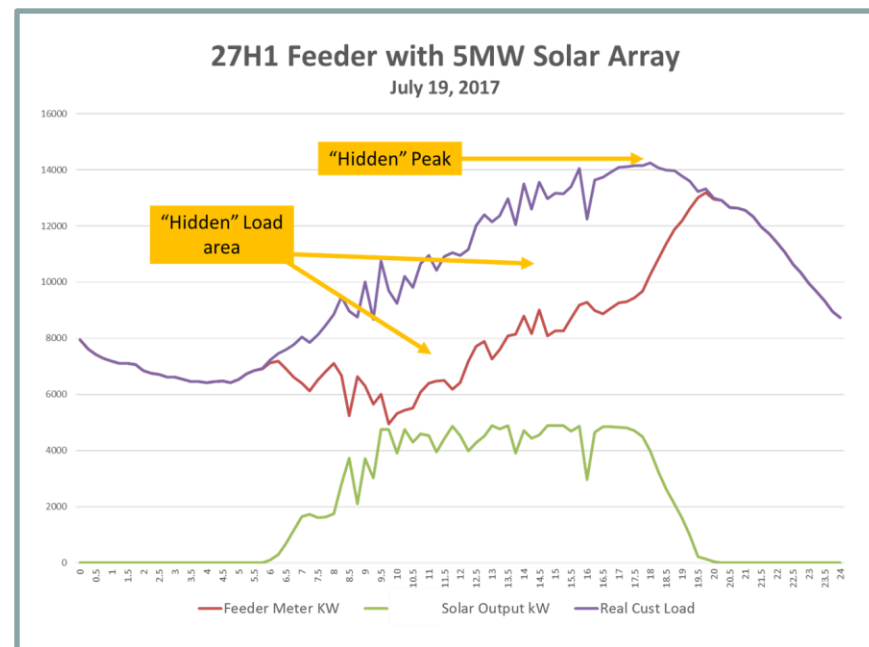

Enable customer choices

APPENDIX

Grid Edge Visibility

- Existing drive-by AMR system collects monthly energy usage

- Residential customer access to detailed information on their usage, including usage during peak times, is limited by current metering technologies

- Limited incentives for electric vehicle off-peak charging or energy storage peak shaving behavior in customer bill (based on current rates)

Meter Installs by Year and Type

AMR meters installed between 1999 and 2003 have an expected useful life of 20 years

Begin installation of AMR/AMI "Bridge" meters

(Chart y-axis values: 0, 50000, 100000, 150000, 200000, 250000)
(Chart x-axis years: 1993–2017)

■ Hybrid AMR   ■ Solid State AMR   ■ Bridge AMR

- Challenging to access data required to analyze the impact of roof-top solar facilities that are masking load

- Extensive process required to analyze customer voltage complaints

- Outage response depends on customer call patterns
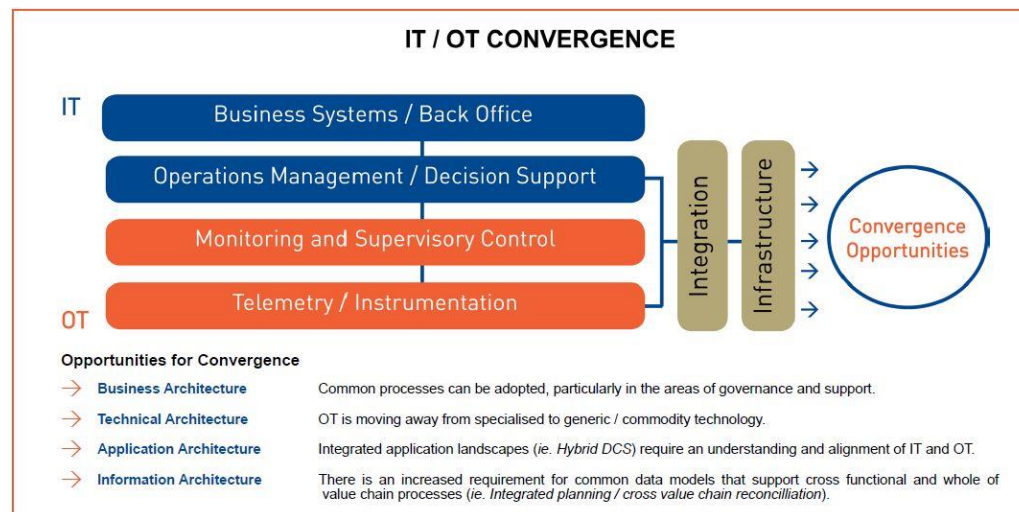
Current Forecasting Capability

- Most sophisticated forecasting analytics capability at the transmission area level using econometric data

- Limited insight into future penetration of DER and electric vehicles at the feeder level

- Difficulty forecasting impact of DG in "masking" peak load

- Focus is mainly on peak load conditions – no assessment of forecasted DG impacts at light load

27H1 Feeder with 5MW Solar Array
July 19, 2017

"Hidden" Peak

"Hidden" Load area

— Feeder Meter KW   — Solar Output kW   — Real Cust Load

Cyber Security

- **Grid Modernization requires OT operations to change to today's IT Operations to ensure**

  - *Ability to IDENTIFY assets
  - Define how to PROTECT
  - Monitor to DETECT threats
  - RESPOND to alerts
  - RECOVER from an event

IT / OT CONVERGENCE

IT
- Business Systems / Back Office
- Operations Management / Decision Support
- Monitoring and Supervisory Control
OT
- Telemetry / Instrumentation

Integration | Infrastructure → Convergence Opportunities

Opportunities for Convergence

→	**Business Architecture**	Common processes can be adopted, particularly in the areas of governance and support.
→	**Technical Architecture**	OT is moving away from specialised to generic / commodity technology.
→	**Application Architecture**	Integrated application landscapes (ie. *Hybrid DCS*) require an understanding and alignment of IT and OT.
→	**Information Architecture**	There is an increased requirement for common data models that support cross functional and whole of value chain processes (ie. *Integrated planning / cross value chain reconcilliation*).

- **The transition to an IP based networked system introduces more threat opportunities**

  - IT Controls are required to protect these systems
    - Authentication
    - Vulnerability management
    - Anomaly detection
    - Change management

- Eversource will integrate IT Security best practices into the design and implementation of GRID Modernization

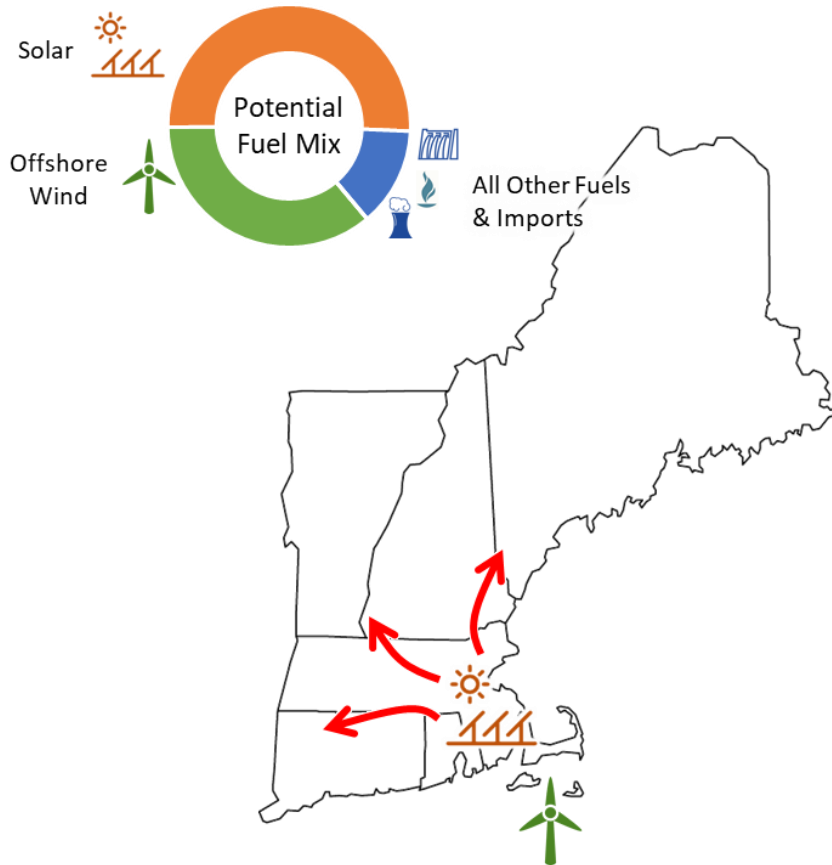 * NIST Cyber Framework, Identify, Protect, Detect, Respond, Recover

The Modern Grid Provides Access to Clean Energy Resources

Access to clean energy sources – small or large, local or remote – will be limited and more costly without a flexible and reliable transmission and distribution network
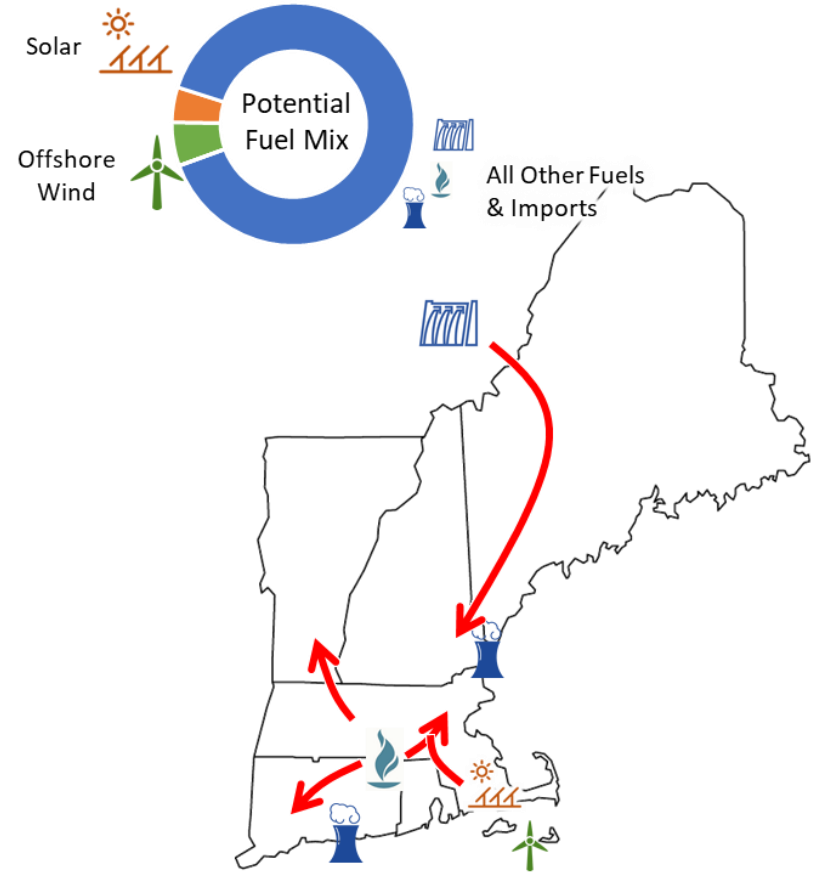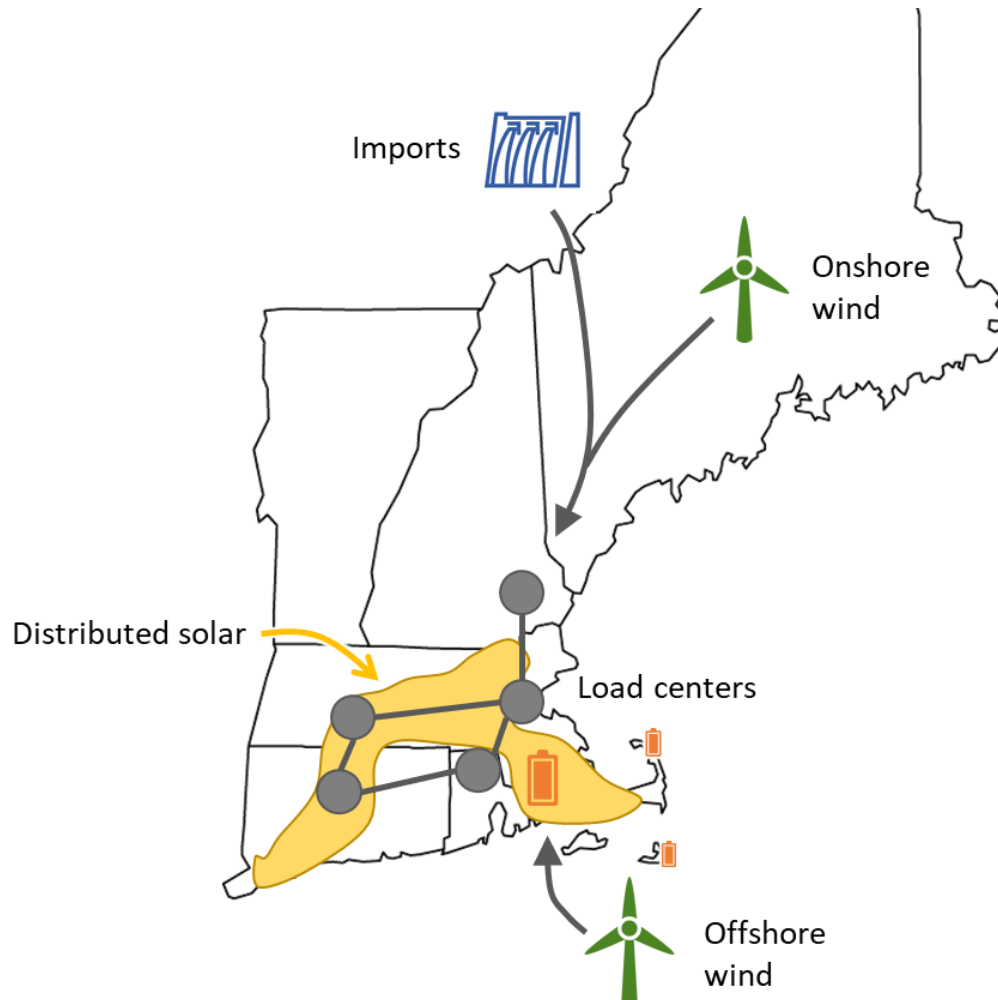
Transmission Allows Optimization Across Different Resources

Hypothetical 2030 dispatches based on ISO-NE CELT forecast and state offshore wind goals