Massachusetts Energy Storage Initiative

Storage Study Update

May 18, 2016

DOER Massachusetts Department of Energy Resources

MASSACHUSETTS CLEAN ENERGY CENTER

Massachusetts Energy Approach

1. Reduce and **stabilize the rising cost** of energy for consumers

2. Continue the Commonwealth's commitment to a **clean energy future**
    - GWSA GHG reductions: 25% by 2020 and 80% by 2050 (1990 baseline)

3. Ensure that we have a **safe, reliable, and resilient** energy infrastructure

Energy Storage Initiative

- Storage is a game changer that can play a part in solving our energy challenges
- $10 million Energy Storage Initiative includes a study as well as funding for demonstration projects
- Robust stakeholder engagement

"Massachusetts will continue to lead the way on clean energy, energy efficiency and the adoption of innovative technologies such as energy storage."

Governor Baker, Feb 2016, Accord for a New Energy Future Press Release

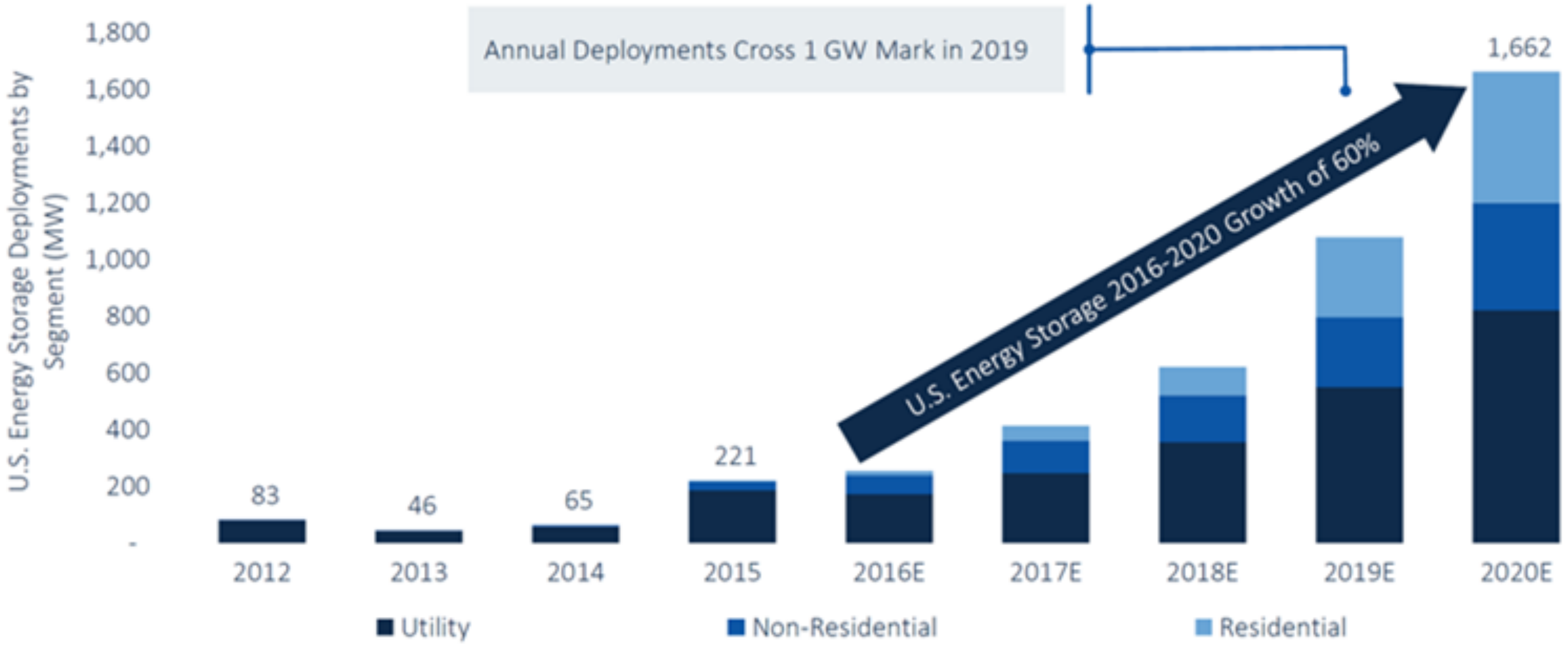
"Given the recent advances in energy storage technology and cost-effectiveness, it is hard to imagine a modern electric distribution system that does not include energy storage." Utility stakeholder perspective

Advanced Energy Storage Technologies

- **Mechanical**
  - Pumped Hydro (*Conventional Storage*)
  - CAES (Compressed Air Energy Storage)
  - Flywheel
- **Electrochemical**
  - Lead acid, Lithium Ion, Sodum Sulfur, and Sodium Nickel Chloride
  - Flow batteries - Vanadium redox, Zinc-bromine
- **Thermal**
  - Sensible - Molten salt, chilled water
  - Latent - Ice storage, Phase change materials
  - Thermochemical storage
- **Electrical**
  - Supercapacitors
  - SMES (Superconducting Magnetic Energy Storage)
- **Chemical (Hydrogen)**
  - Power-to-Power (Fuel Cells, etc)
  - Power-to-Gas

- Pumped Hydro Storage is often referred to as a “conventional” storage technology
- More recent emerging forms of energy storage such as batteries, flywheels, and new compressed air energy technologies are often referred to as “**advanced energy storage**”

Advanced Energy Storage is Growing Rapidly in the US



Source: GTMResearch, U.S. Energy Storage: 2015 Year in Review, March 9, 2016

US Market for Advanced Energy Storage technologies expected to grow by 500% in five years

Storage In Commodity Supply Chains

FOOD

Warehouses
Grocery stores
Freezers & refrigerators

WATER

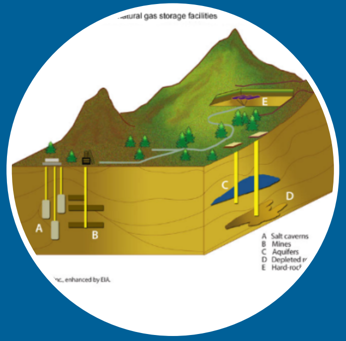
Reservoirs
Above-ground tanks
Water bottles

GASOLINE

Underground tanks
Above-ground tanks
Tank trucks
Portable fuel tanks

OIL

Above-ground tanks
Piping



NATURAL GAS

Depleted fields
Aquifers
Salt caverns
Pipelines
Above-ground tanks

ELECTRICITY

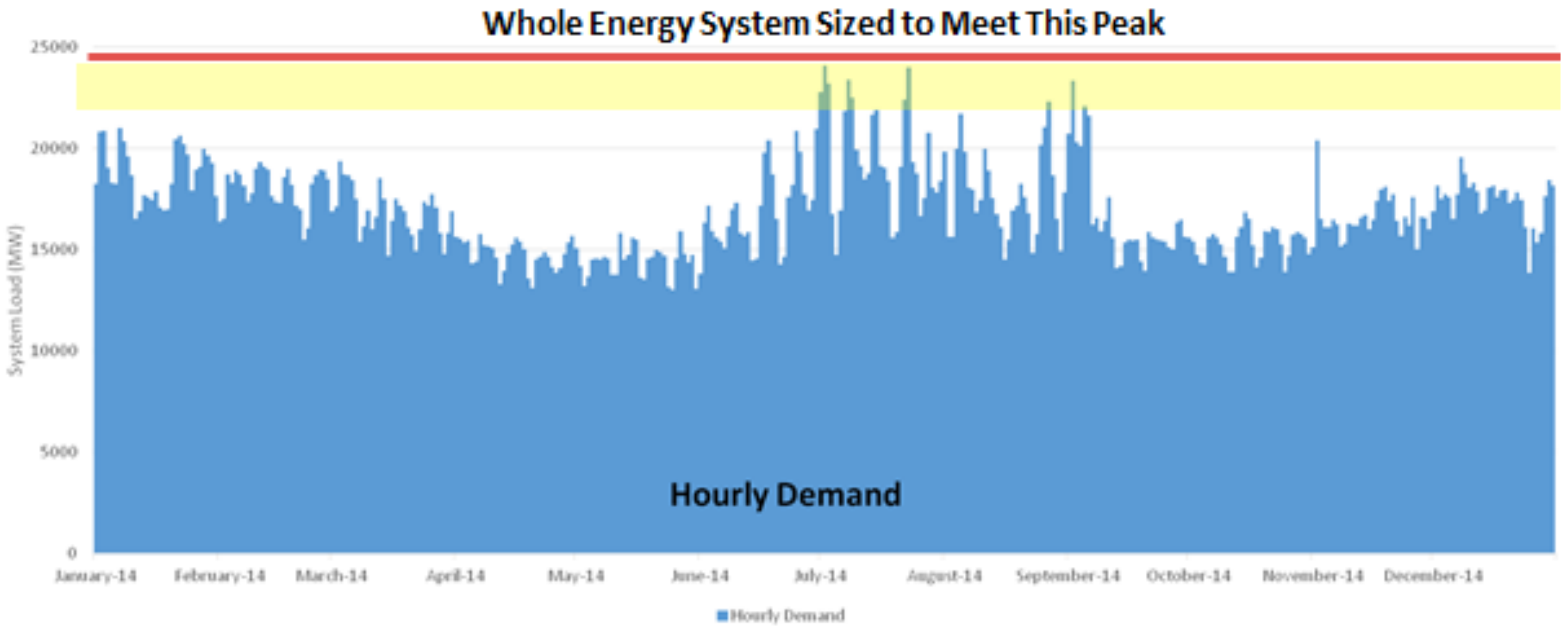
Energy Storage Technologies

Currently less than 1% of daily electricity consumption for MA

Storage capacity more than 10% of daily consumption

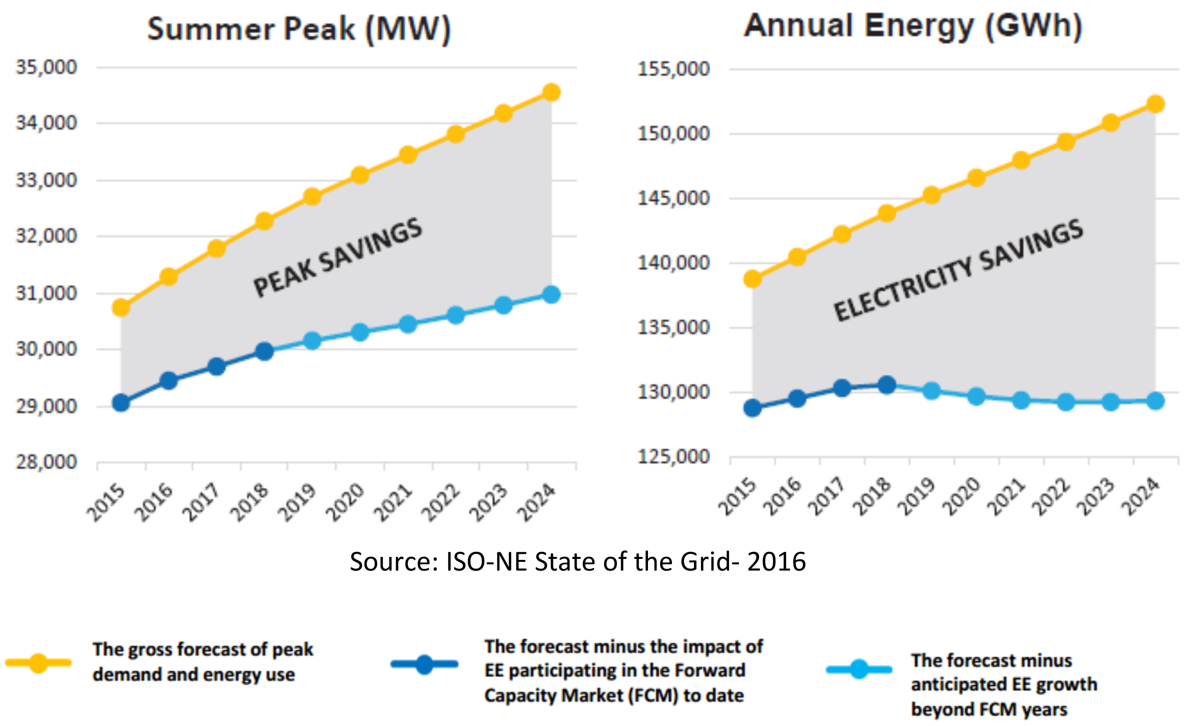
The electricity market has a fast "speed of light" supply chain and the least amount of storage. This lack of storage creates a need for additional infrastructure to maintain market reliability.

Electric Grid is Sized for Highest Hour of Demand

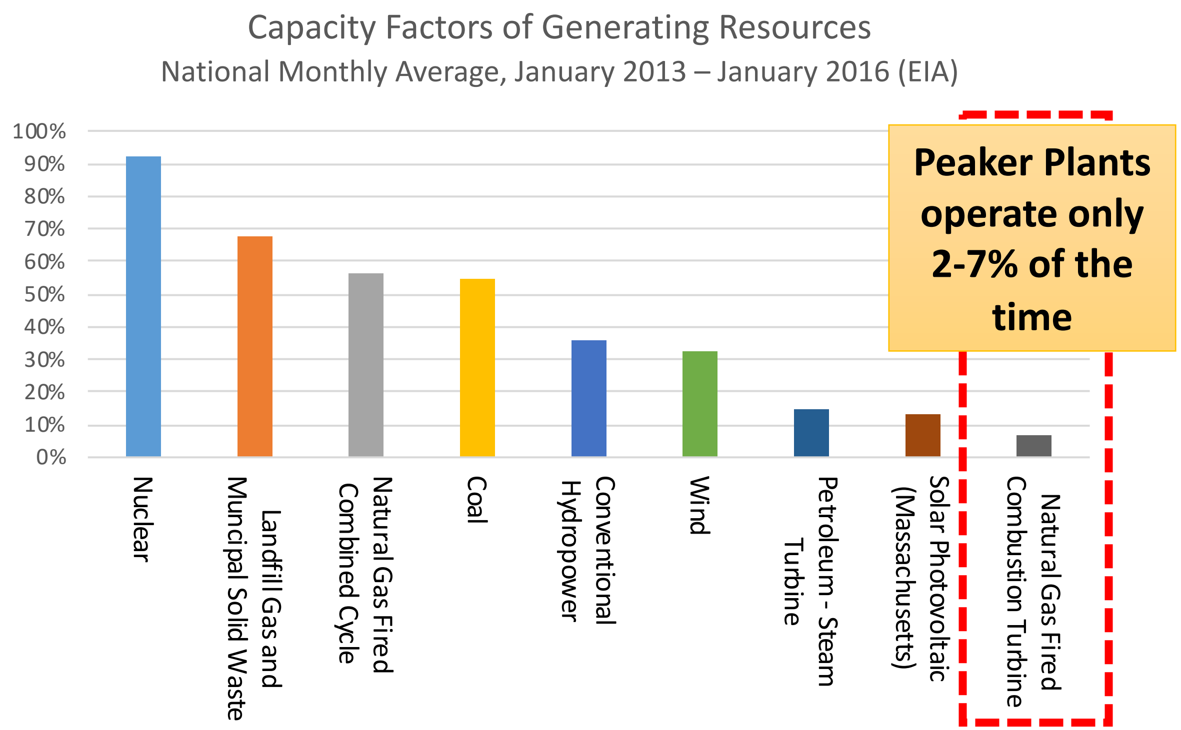


Top 1% of Hours accounts for 8% of Massachusetts Spend on Electricity
Top 10% of Hours accounts for 40% of Electricity Spend

While Energy Efficiency has Decreased Average Energy Consumption, Peak Continues to Grow (1.5% per year)

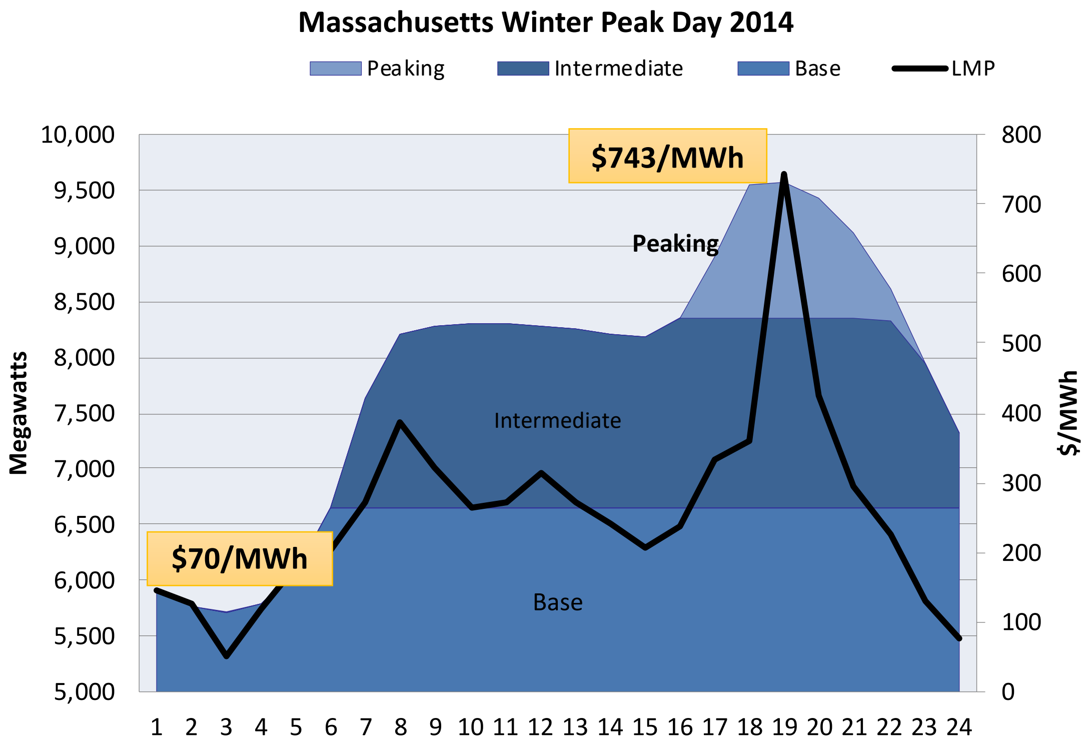


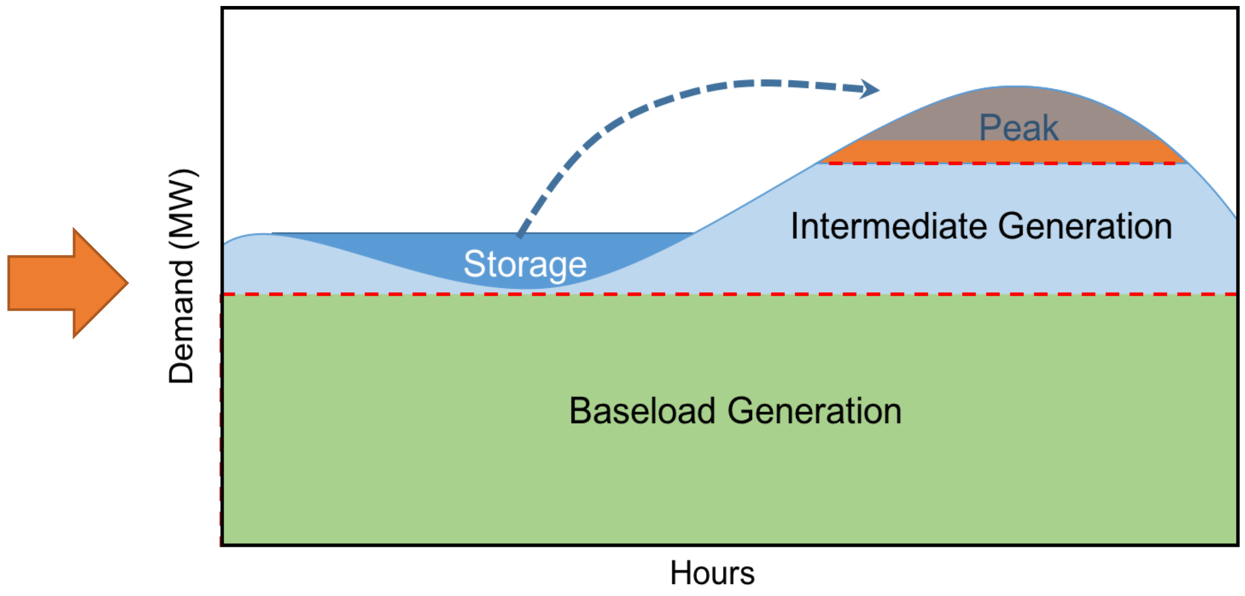
Source: ISO-NE State of the Grid- 2016



Growing peak results in inefficient use of grid assets, including generation, transmission and distribution, increasing the cost to ratepayers

Storage is “Game Changer” for Meeting Peak

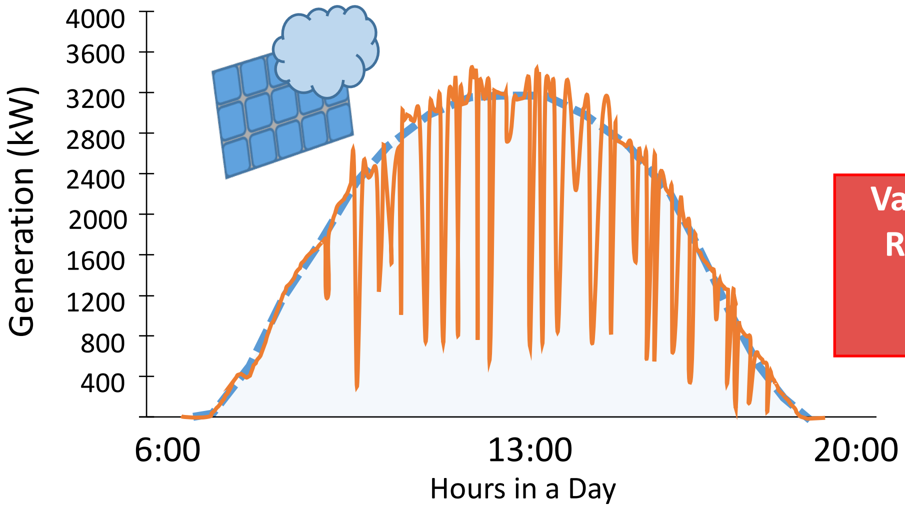




Energy storage is the only technology that can use energy generated during low cost off-peak periods to serve load during expensive peak.

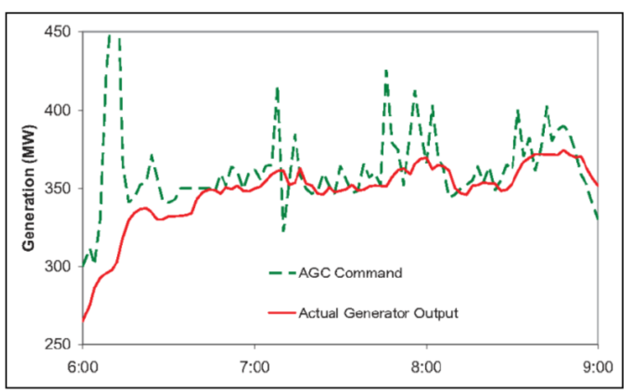
Increased Renewables Requires Grid Flexibility to Manage Intermittency

Typical Solar Output

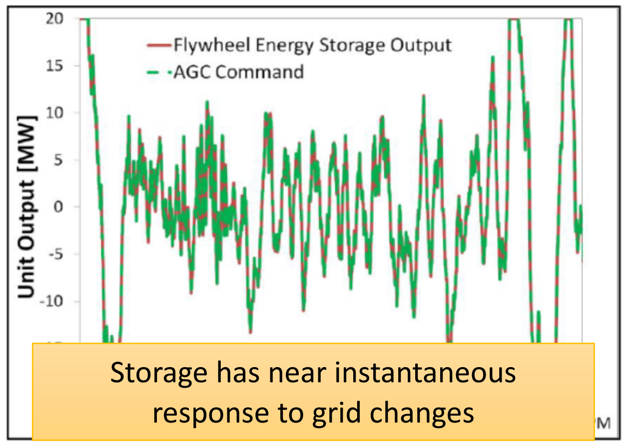


Renewable resources, such as solar, can have variable generation

Variable Output Generators Requires Fast and Flexible Resources to Maintain Balance and Reliability



Slow-ramping Generator

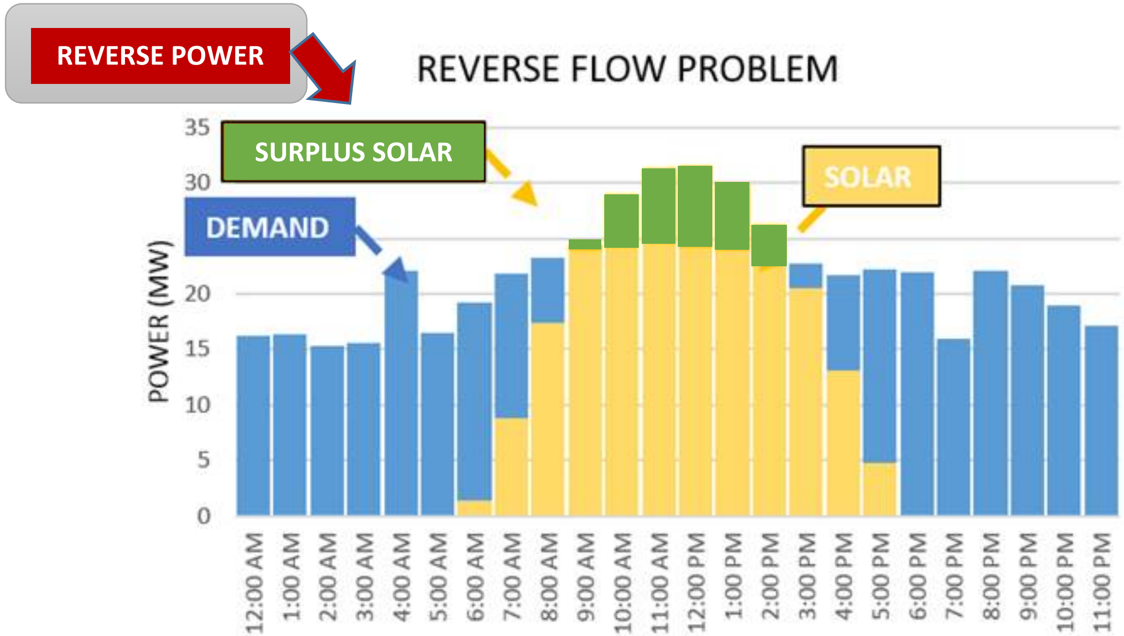


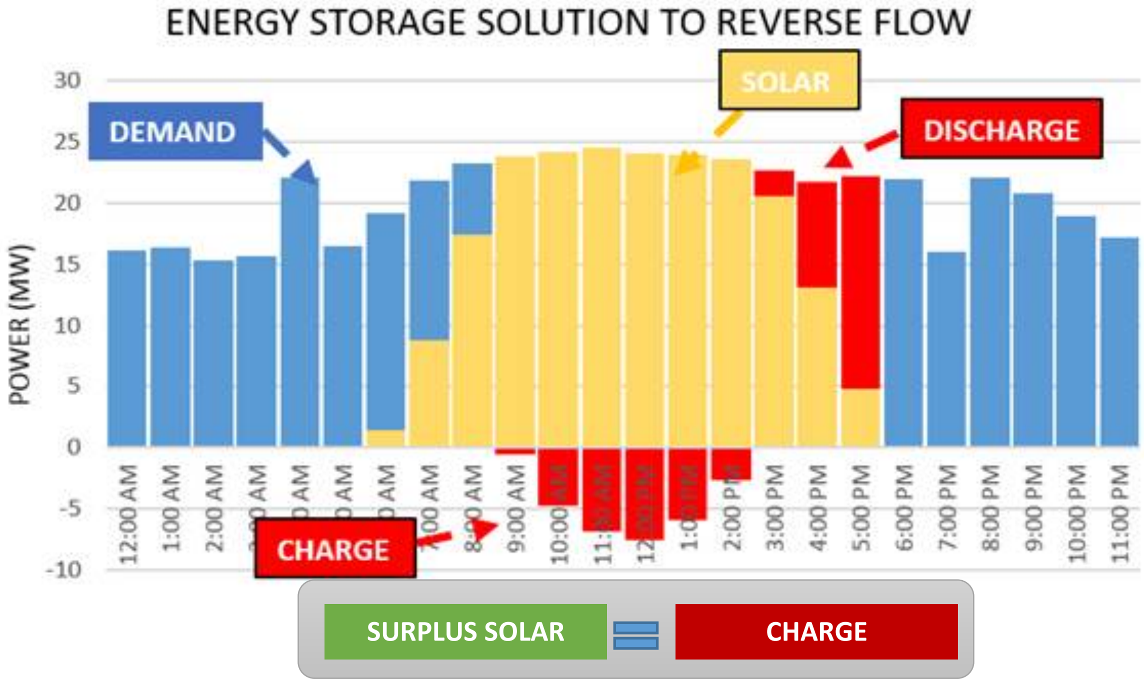
Fast-responding Energy Storage

According to ISO-NE "State of the Grid – 2016" fast and flexible resources will be needed to balance intermittent resources' variable output. Storage can provide this flexibility.

Amount of Distributed Generation has Skyrocketed

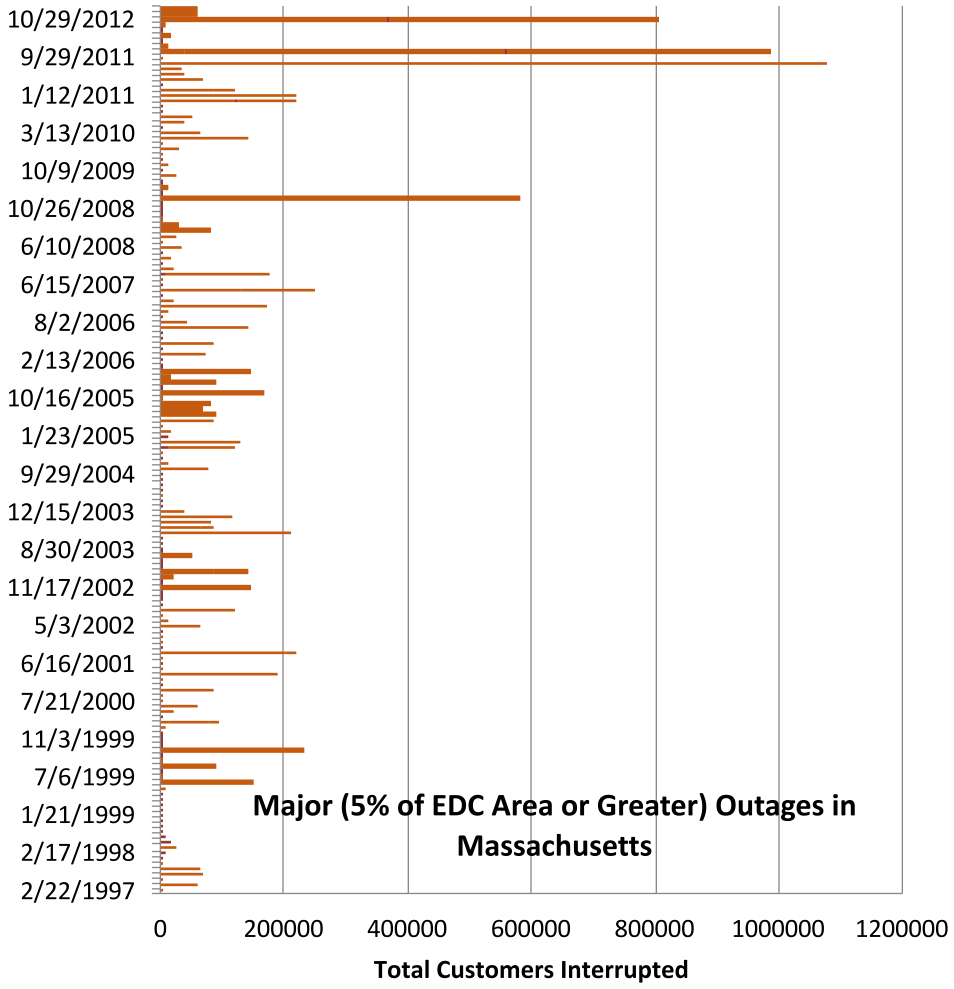
- There are over 40,000 distributed solar projects in Massachusetts
- Distributed generation is growing at rate of 400 installed projects per week





As distributed generation increases, utilities are challenged to manage reverse power flow at substations. Distributed storage can manage and optimize power flows.

Major Outages From Storm Events are More Common

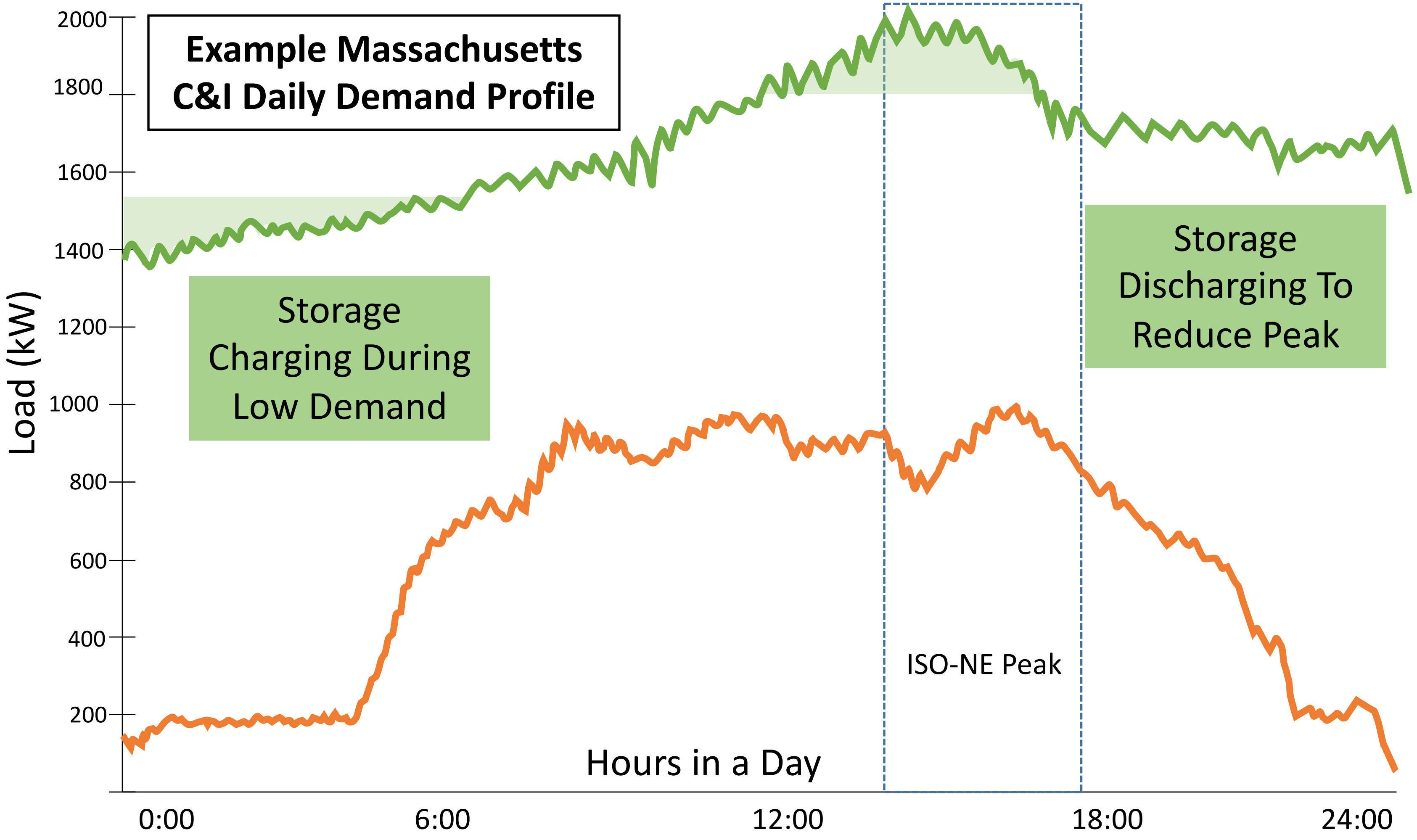


2/8/2013	February Nor'easter ("Nemo")
10/29/2012	Hurricane Sandy
10/29/2011	2011 Halloween Nor'easter
8/28/2011	Hurricane Irene
1/12/2011	January 2011 Blizzard
12/26/2010	December 2010 Blizzard
12/11/2008	2008 December Ice Storm
4/15/2007	April 15 Rain Storm
6/30/2001	June 30 Wind Storm
9/16/1999	Hurricane Floyd

- Although total weather days have decreased, the number of customer outages have increased due to an increase in severe storm events
- Major storm events **increase costs for the utilities** to maintain resiliency

Storage, especially when integrated with microgrids, can increase resiliency in storm events

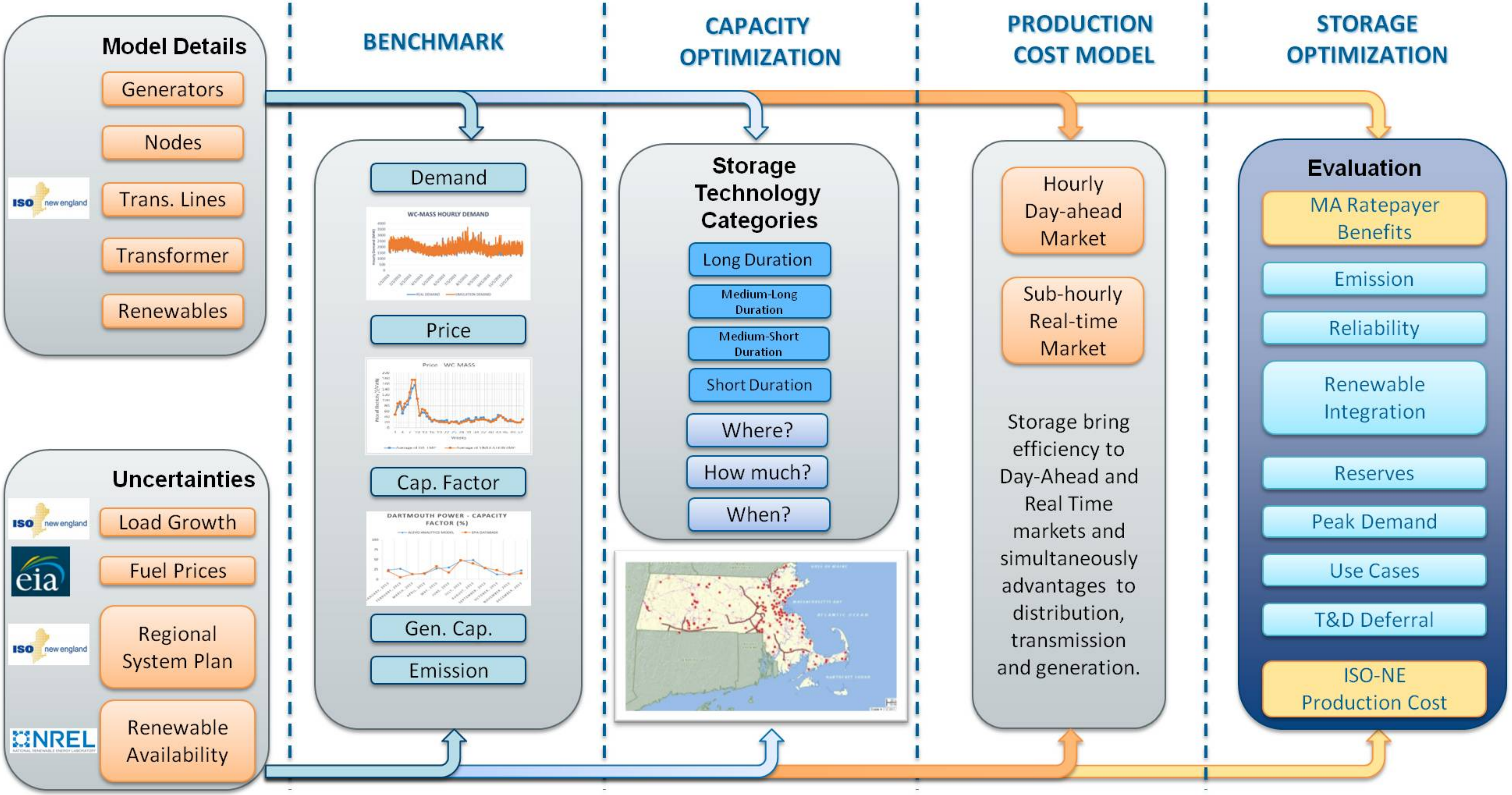
High Electricity Costs Impact Massachusetts Businesses



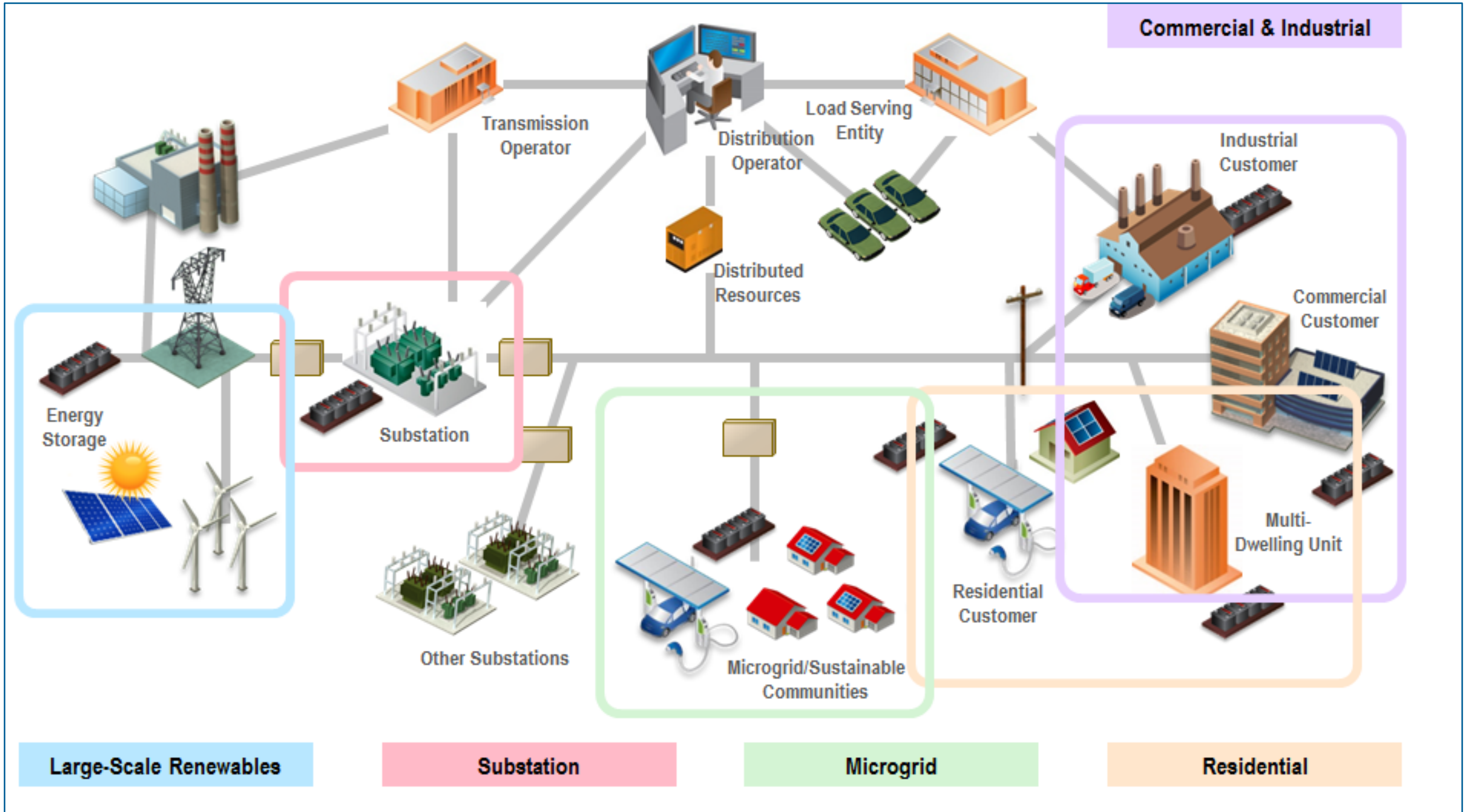
- Massachusetts has one of the highest electricity rates in the nation
- Commercial electricity customers pay utility demand charges based on customer's peak hour

Massachusetts businesses, especially those with high electricity use, could use storage to better manage their peak and reduce electricity costs

Advanced Storage Optimization Model



Storage Use Cases



Energy Storage has potential applications across the entire electricity value chain

Source: 2015 Electric Power Research Institute

Next Steps

- Storage Study is in it's final stages – expect release in the coming weeks

- Following the release of the study, DOER and MassCEC will issue an RFP for demonstration projects