Overview of Bulk Electric Power System Operations in New England

National Electric Power Company of Jordan

Amy Crowley, Corporate Communications
April 27, 2009

Agenda

- ISO New England Overview
- Operating the Bulk Power System: System Operations and Control Room Overview
- Overseeing and Administering New England's Wholesale Electricity Markets
- Planning for the Future: Addressing Regional Reliability, Economic, and Environmental Concerns
- Progress to Date
- Key Challenges

ISO New England Overview

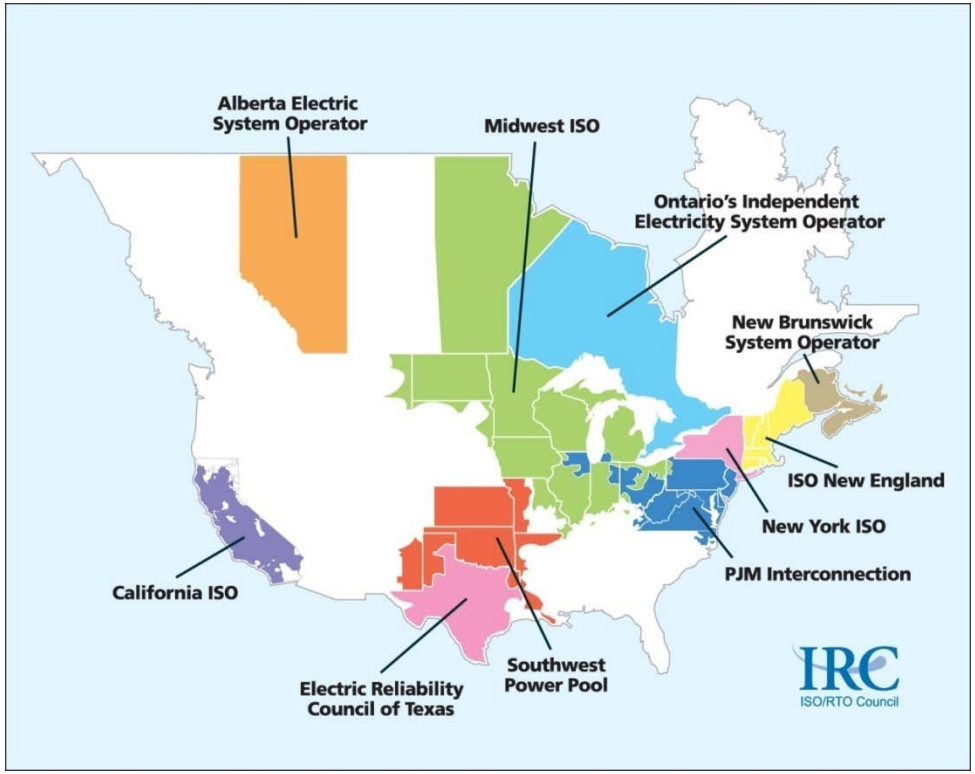
About ISO New England

- Private, not-for-profit corporation created in 1997 to oversee New England's restructured electric power system and bulk power grid
  - Independent of companies doing business in the market
  - Regulated by the Federal Energy Regulatory Commission (FERC)
- 400 employees headquartered in Western Massachusetts

Existing ISOs and RTOs in North America

- ISO is an acronym for **Independent System Operator**. Another name for an entity that dispatches bulk power grids and administers wholesale electricity markets is a **Regional Transmission Organization**

- There are ten ISOs and RTOs in North America

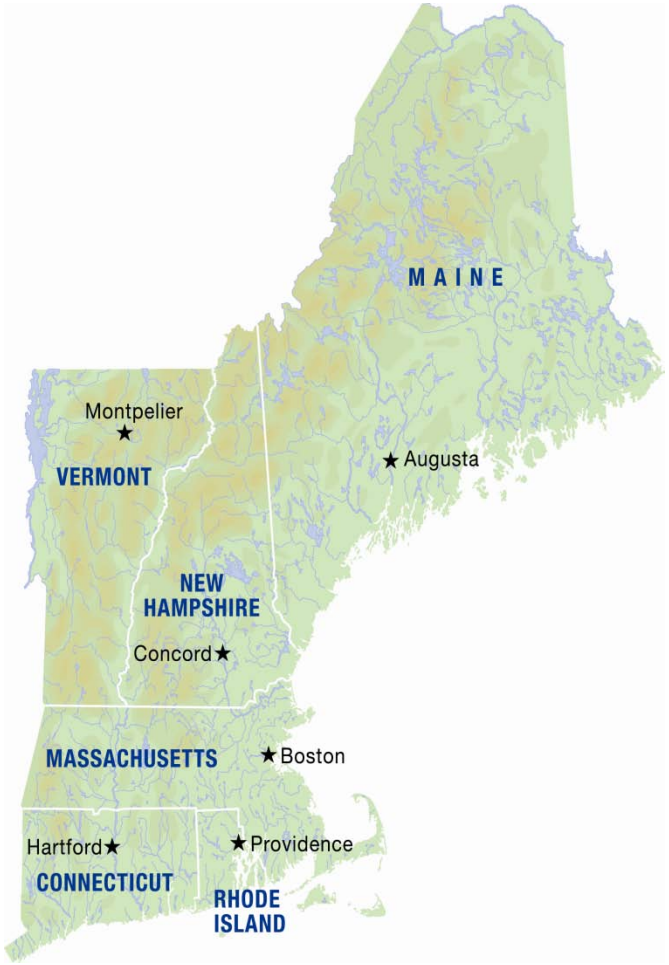


ISO New England History

1965	Northeast Blackout shuts down power to 30 million
1971	New England Power Pool (NEPOOL) created to establish a central dispatch system and enhance system reliability. Utilities and municipals own generation, transmission and distribution lines
1996	FERC initiates wholesale competition and open access to transmission lines. Independent system operators are created. NEPOOL files with FERC to establish ISO for the New England
1997	ISO-NE created to manage the regional bulk power system and new wholesale markets, and ensure open access to transmission lines
1999	ISO New England launches restructured regional wholesale power markets with one price for all of NE
2003	ISO introduces locational pricing in wholesale markets (eight prices in New England, three in MA and 900+ nodal prices for generators
2003	Northeast Blackout leaves approximately 40 million without power on August 14; New England largely unaffected
2005	ISO-NE begins operation as Regional Transmission Organization

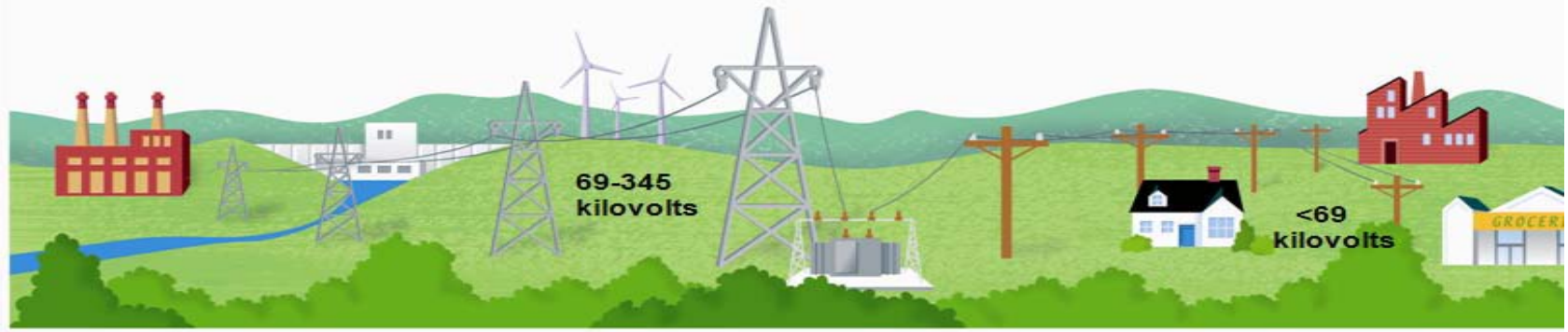
New England's Electric Power Grid at a Glance

- 6.5 million customer meters
  - Population 14 million
- 300+ generators
- 8,000+ miles of high voltage transmission lines
- 13 interconnections to three neighboring systems:
  - New York, New Brunswick, Quebec
- 32,000 megawatts (MW) of installed generating capacity
  - Includes 2,000 MW demand response
- Over 400 market participants
- System peak:
  - Summer: 28,130 MW (August 2006)
  - Winter: 22,818 MW (January 2004)



Wholesale to Retail Connection

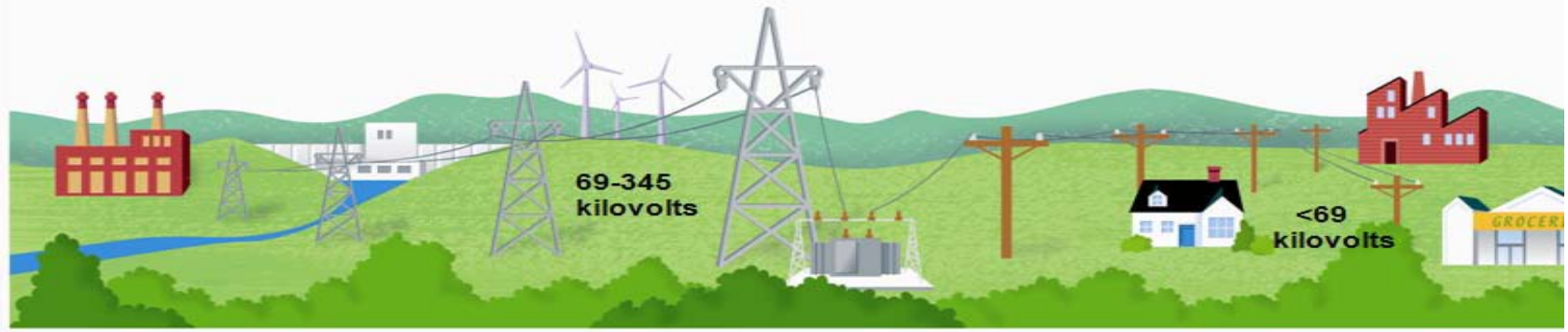
Physical



- **Bulk Power System**
  - Electricity is produced in New England by more than 350 generators
  - Region's 8,000 miles of high-voltage transmission lines move electricity to substations where it is stepped down in voltage to feed into local distribution lines
  - Federal regulation (FERC)
- **Local Distribution System**
  - Local utilities distribute the electricity to businesses and homes
  - The region's 6.5 million households and businesses create the demand for electricity, which must be produced the instant it is needed
  - State regulation (DPUC)

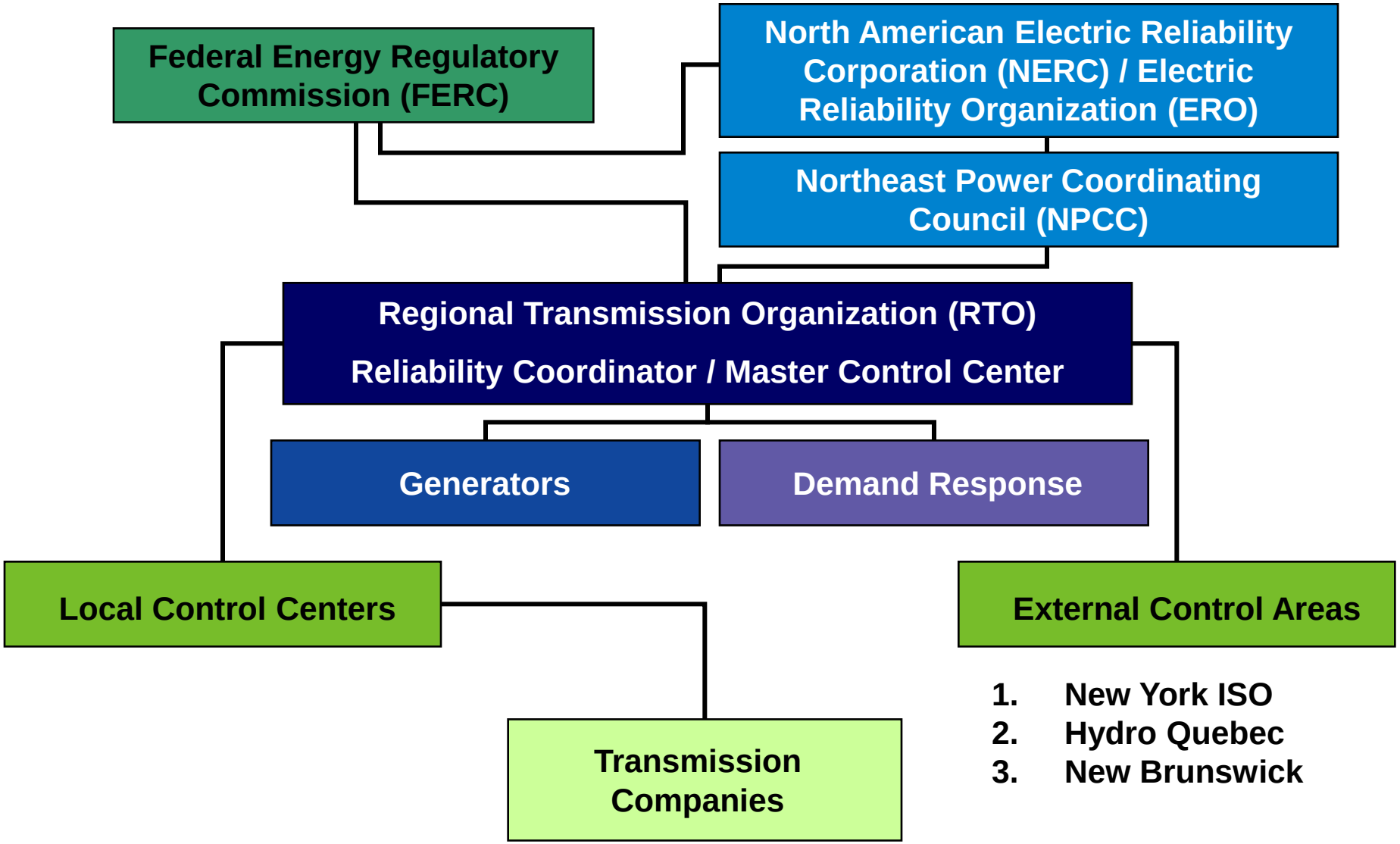
Wholesale to Retail Connection

Financial



- **Wholesale electricity**
  - Generators sell the electricity through either wholesale markets or contracts with utilities and competitive suppliers
  - Wholesale costs/prices result from the production (generation) and transmission of the product of electricity
  - Federal regulation (FERC)
- **Retail electricity**
  - Electric utilities and competitive suppliers buy electricity through markets or contracts with power producers
  - Households and businesses bills include both wholesale and retail costs of producing and delivering electricity
  - State regulation (DPUC)

New England's Industry Relationships



1. New York ISO
2. Hydro Quebec
3. New Brunswick

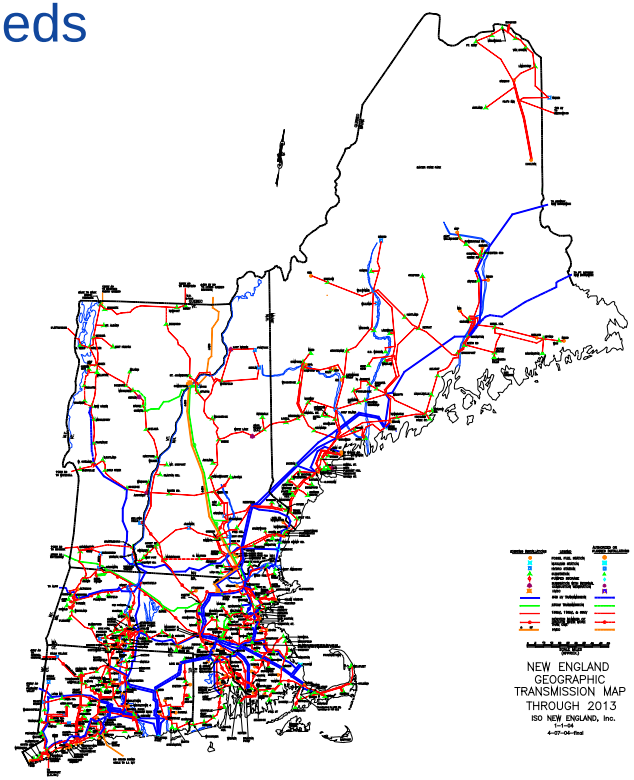
ISO New England's Role – Three Primary Areas of Responsibility

- Maintain day-to-day bulk power generation and transmission system reliability
  - "Air traffic controller"
  - Provide centrally dispatched direction for the generation and flow of electricity across the region's interstate high-voltage transmission lines
- Oversee and administer New England's wholesale electricity marketplace, through which bulk electric power is bought, sold, and traded
  - Similar to a "stock exchange" for wholesale electricity purchases and sales
- Plan and ensure the development of a reliable and efficient bulk power system to meet New England's current and future power needs

Operating the Bulk Power System: System Ops & Control Room Overview

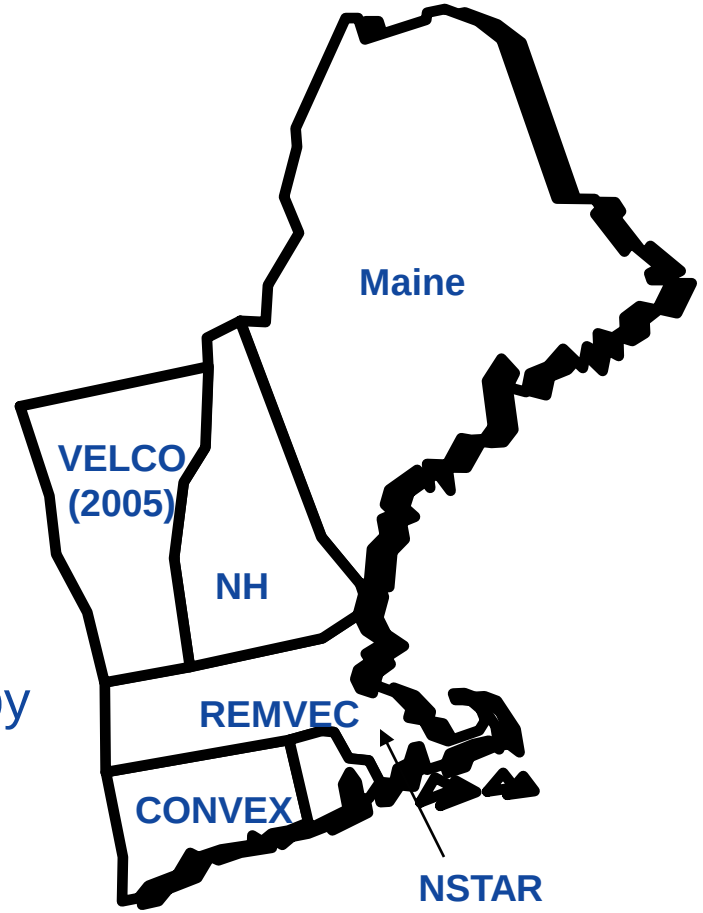
A Day-to-Day, Minute-to-Minute Operation

- Forecasts for both short and long-term needs
- Commits generating, demand response, and external purchases to meet expected load and reserve requirements
- Real-time monitoring and control of bulk power system
  - Economic dispatch of generating, demand response, and external sales/purchases to meet load and reserve requirements
  - Monitors and controls transmission system to conform with established reliability standards (thermal, voltage, stability limits, etc.).
- Coordinates and approves generating and transmission facilities' outage requests to assure reliable system operation



Central Dispatch Essential to Reliability

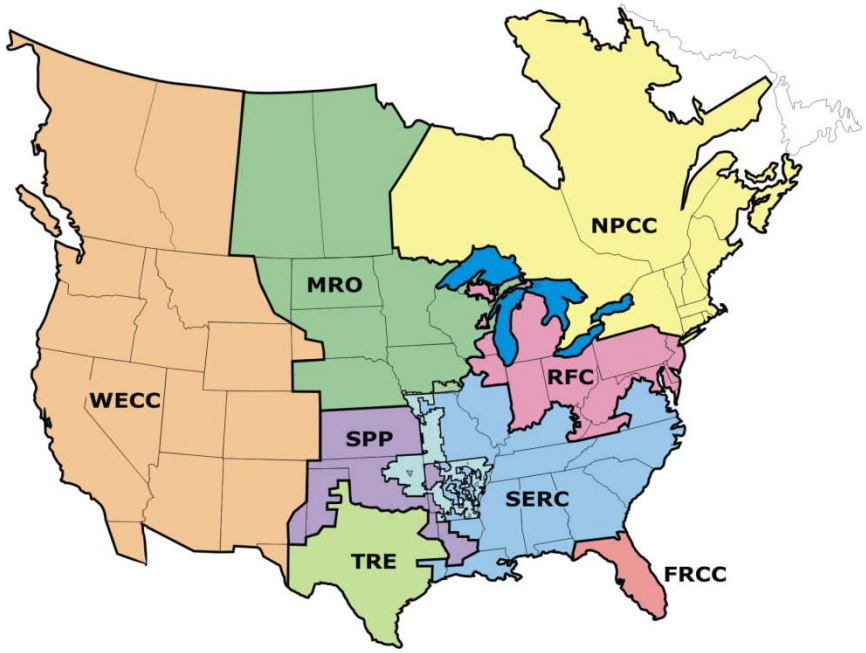
- ISO-NE operates the grid as a single system to:
  - Maintain short- and long-term reliability throughout the region
  - Operate the system in the most reliable and efficient manner
  - Minimize cost of electric production in New England
  - Adhere to national, regional, and local operating procedures and policies
- Relies on local control center operated by Transmission Owners for transmission system switching



Following Reliability & Performance Standards

- Bulk power system is designed, built, and operated to reliably meet power needs in accordance with established industry criteria
- Since the passage of the 2005 Federal Energy Policy Act, reliability standards are mandatory and non-compliance is subject to penalty
  - North American Electric Reliability Corporation(NERC) establishes reliability and performance standards
  - ISO-NE is a member of the Northeast Power Coordinating Council (NPCC)

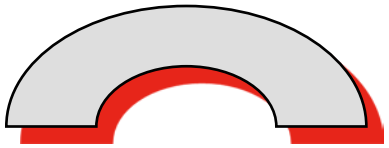
NERC Regions



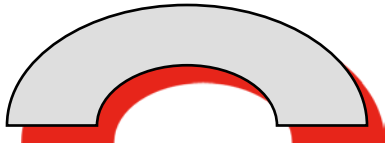
ISO New England's Control Room

- State-of-the-art control room opened in 2007
- Centerpiece is the 12 ft. x 47 ft. dynamic display board
- Allows wide-area dynamic view of neighboring operating areas in the Northeast
- Dynamic visualization tools for monitoring the health of the power system

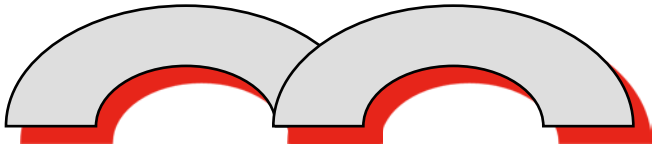
Control Room Configuration



Generation

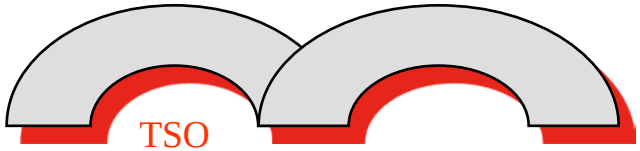


Loader



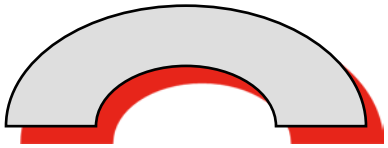
Transmission
(Security + Spare)

Control Room Manager

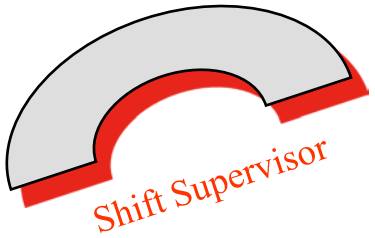


TSO
Administrator

Forecaster



Senior



Shift Supervisor

Restoration Room

Control Room Team

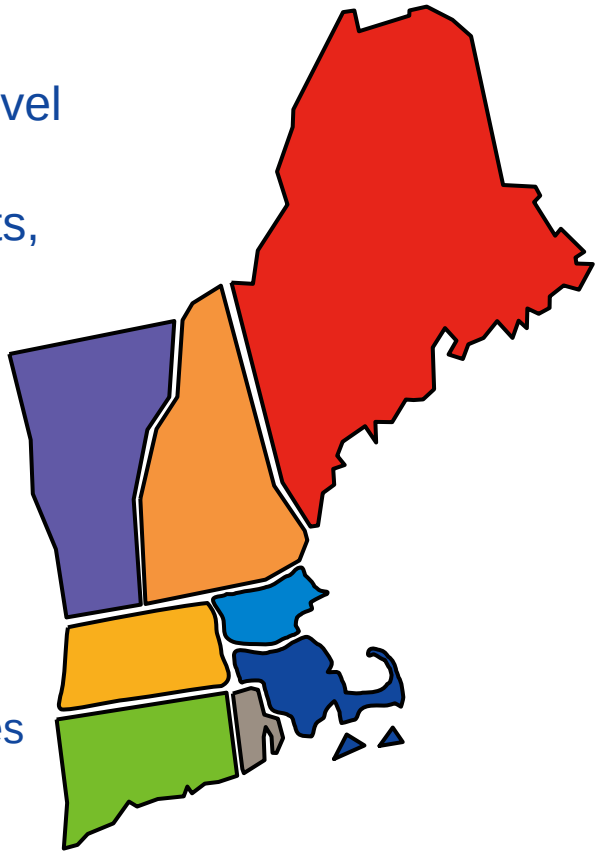
30 operators and 6 forecasters

- Shift supervisor
  - Responsible for overseeing operations
- Security operator
  - Responsible for transmission security
- Loading operator
  - Responsible for unit dispatch, balancing demand with generation
- Generation coordinator
  - Responsible for communicating with generators
- Senior operator
  - Responsible for overseeing external contracts with other control areas
- Forecaster
  - Responsible for forecasting load

Overseeing and Administering New England's Wholesale Electricity Markets

Buying and Selling Wholesale Electricity

- ISO-NE acts as an electronic auction house for buying and selling electricity at the wholesale level
- New England's first wholesale electricity markets, launched in 1999, were built upon historic "tight power pool" operating infrastructure with uniform pricing for region
- Since 2003, Energy Market features Locational Marginal Pricing (LMP)
  - 900+ nodes or points on the system at which prices are calculated; generation is priced nodally
  - Nodes prices are averaged into eight pricing zones. Load pays zonal price for wholesale electricity.
  - Prices are made up of energy, congestion, and losses

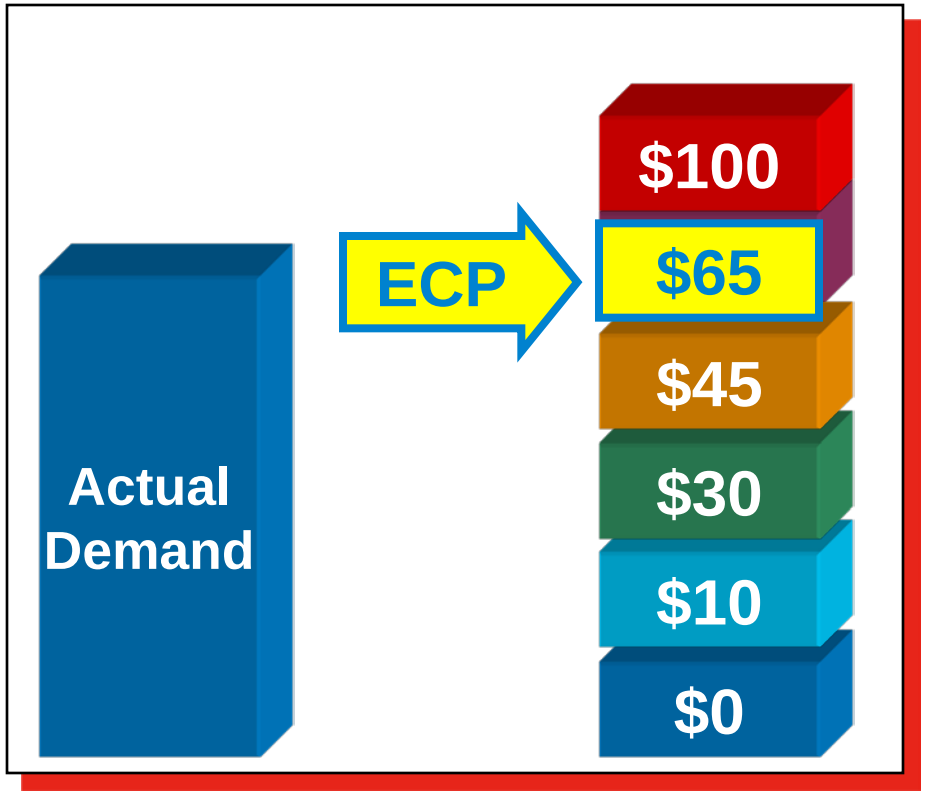


Since 2003

"LMP"

Dispatching Resources

- ISO-NE selects least expensive resources (generators) to meet minute-to-minute power needs of the region, accounting for transmission constraints and potential outages (Schedule Constrained Economic Dispatch)
- ISO New England operates electricity markets with uniform clearing prices
  - Sellers have incentive to bid operating costs, which drives efficiencies and lowers the cost of power for the entire region



Maintaining Adequate Supply of Power

- Ample electricity supplies are essential for truly competitive markets.
- Electricity cannot be stored; therefore, sufficient generation capacity is needed for the estimated peak demand plus a reserve margin for contingencies.
- Generators are dispatched in the order of lowest to highest offer (Economic Dispatch). Thus, in general, when demand is high, wholesale prices are high and vice versa.
- Transmission constraints limit the transfer of energy and result in high prices.

Wholesale Electricity Markets Administered by ISO-NE

Physical & Reliability	Market Tools
Electricity – Day-to-day power	Electric Energy Market – Day-Ahead Energy Market & Real-Time Energy Market
Reliability − Reserve Power −Frequency	Ancillary Services Market − Forward Reserve Market (FRM) − Regulation
Assure long-term power	Capacity Market − Forward Capacity Market for both supply- and demand-side resources
Congestion Management	Financial Transmission Rights
Reduce Peaking Demand	Demand Response Program

Demand-Response Program

- Demand-Response Program compensates electricity users for reducing use when market prices are high or when reliability is a risk.
- Objectives
  - Contributes to system reliability
  - Lessens the need to build expensive new infrastructure
  - Stabilizes wholesale prices during peak periods
  - Limits market power by wholesale electricity suppliers
  - Helps achieve environmental goals
  - Encourages consumers to be more responsive to price: Ideally, prices would never get too high because use would be curtailed when price was more than customers wanted to pay.
  - Improves linkages between wholesale and retail markets

New Forward Capacity Market

- ISO-NE identifies the need for capacity three years into the future and conducts annual auctions to procure supply and demand resources
  - Auction 1 held in February 2008 for need in June 2010
  - Auction 2 to be held in December 2008 for need in June 2011
  - Auction 3 to be held in October 2009 for need in 2012
- New and existing resources compete in the auction
  - Prices are set by new resources (existing resources are price-takers in the auction)
- All resources need to qualify to participate in the auction
  - Show-of-interest and qualification applications required
- ISO files with FERC resources qualified and selected in the auction

FCM Eligible Resources

- **Supply Resources**
  - Traditional Generation
    - Oil, Coal, Natural Gas
  - Intermittent/Renewable Generation
    - Hydro, Wind, Solar
- **Demand Resources**
  - Installed measures that result in additional and verifiable reductions in end-use demand
    - Energy Efficiency, Load Management, Distributed Generation
  - Demand-resource types
    - On-Peak, Seasonal Peak, Critical Peak, Real-Time Demand Response, and Real-Time Emergency Generation

Planning for the Future: Addressing Regional Reliability, Economic, and Environmental Concerns

System Planning for the Six States

- Planning ensures the development of a reliable and efficient bulk power system to meet New England's current and future power needs
- Mandatory reliability standards reinforce importance of planning
- Collaborative planning process works in conjunction with the markets to provide transparency to the industry about what kinds of investments are needed and opportunities for market solutions (e.g. generation, demand-side measures, and transmission)
  - A plan to identify system needs and solutions
  - Clear market price signals where investment is needed most
  - Regulatory certainty and support to promote investment

Regional System Planning Process

- Planning process culminates in Regional System Plan (RSP) published annually
- Process is open and ongoing
  - States, transmission owners, market participants and other stakeholders provide input to the RSP through the Planning Advisory Committee
  - PAC meets approximately 15 times during the year
  - PAC reviews and comments on study assumptions and results and drafts of the RSP

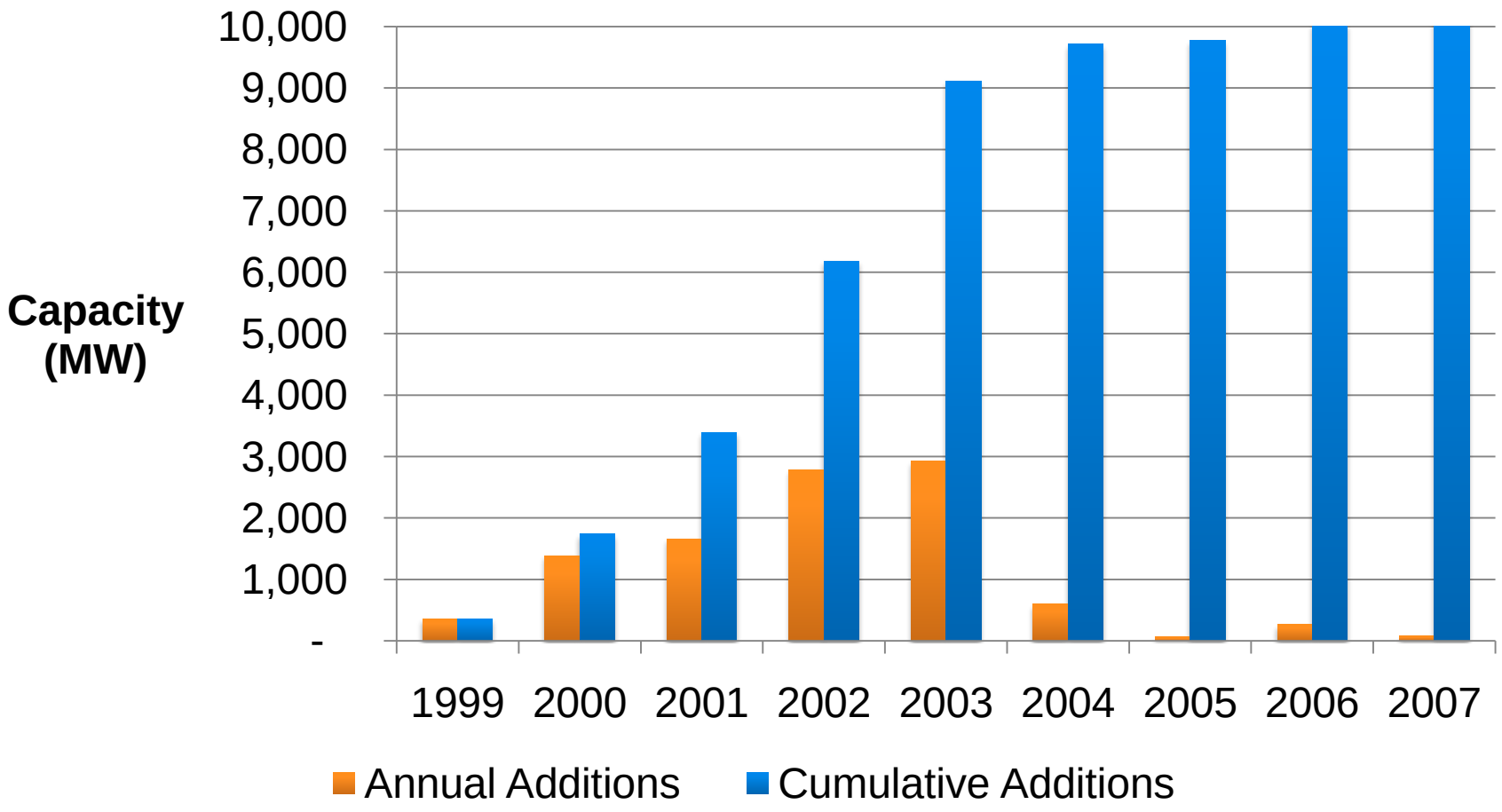
Progress to Date

Electricity System Is More Reliable, Efficient, and Environmentally Friendly

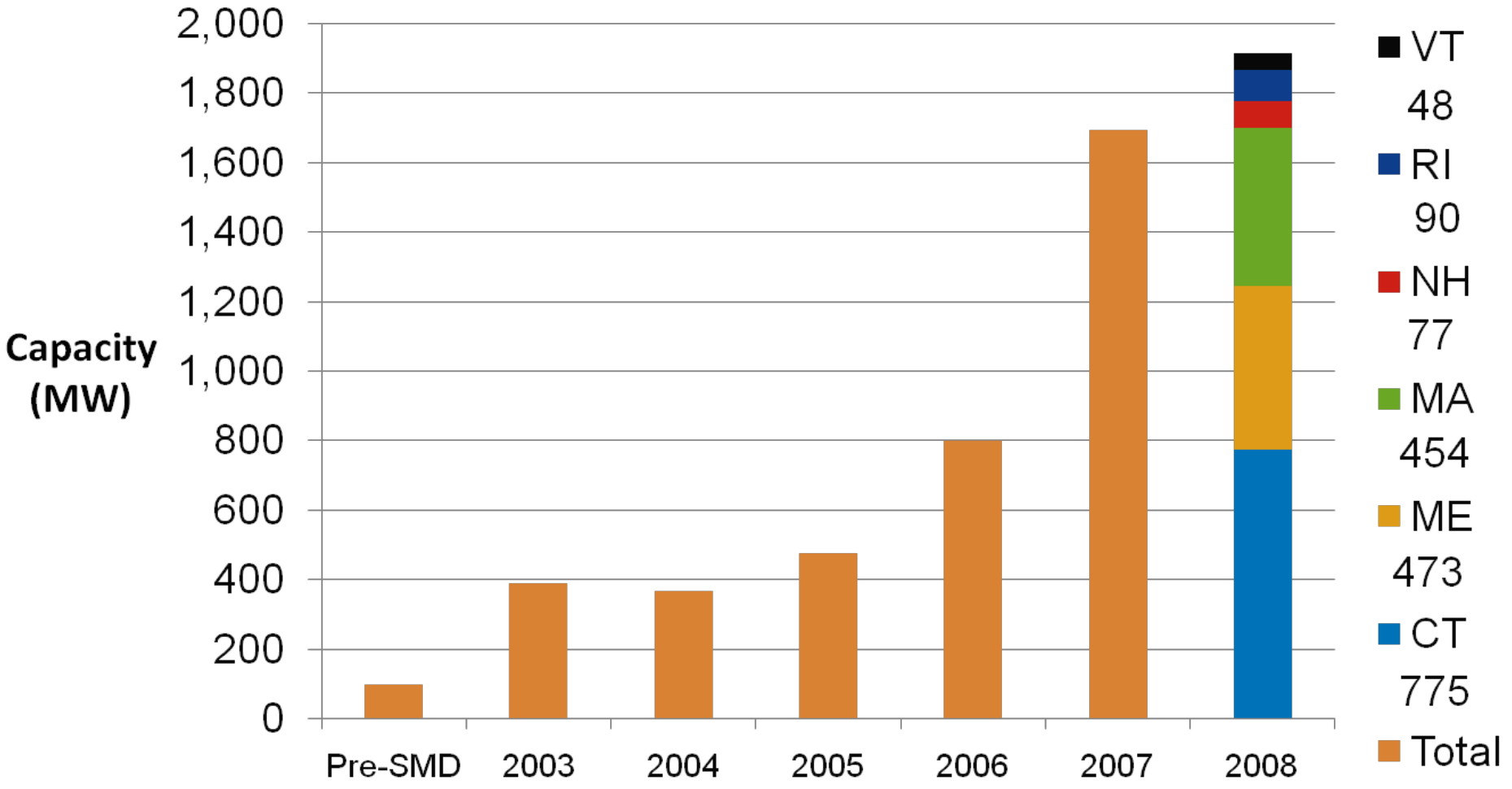
- Regional planning process, combined with the incentives created by the competitive wholesale markets, has led to significant progress towards meeting system needs identified over the past decade
- Lights stayed on during record breaking consumer demand
- Approximately 10,000 megawatts of new generation added to the grid between since 1999, totaling $10 billion in private investment
- Consumers shielded from investment risk
- Improved generator availability; development of new technologies
- Cleaner plants have resulted in environmental benefits; FCM attracting even more clean supply, including renewable resources
- Growth of demand-side participation; FCM attracting even greater levels of demand resources, energy efficiency, and conservation

New Generation in the Past Decade

10,000 MW added since 1999

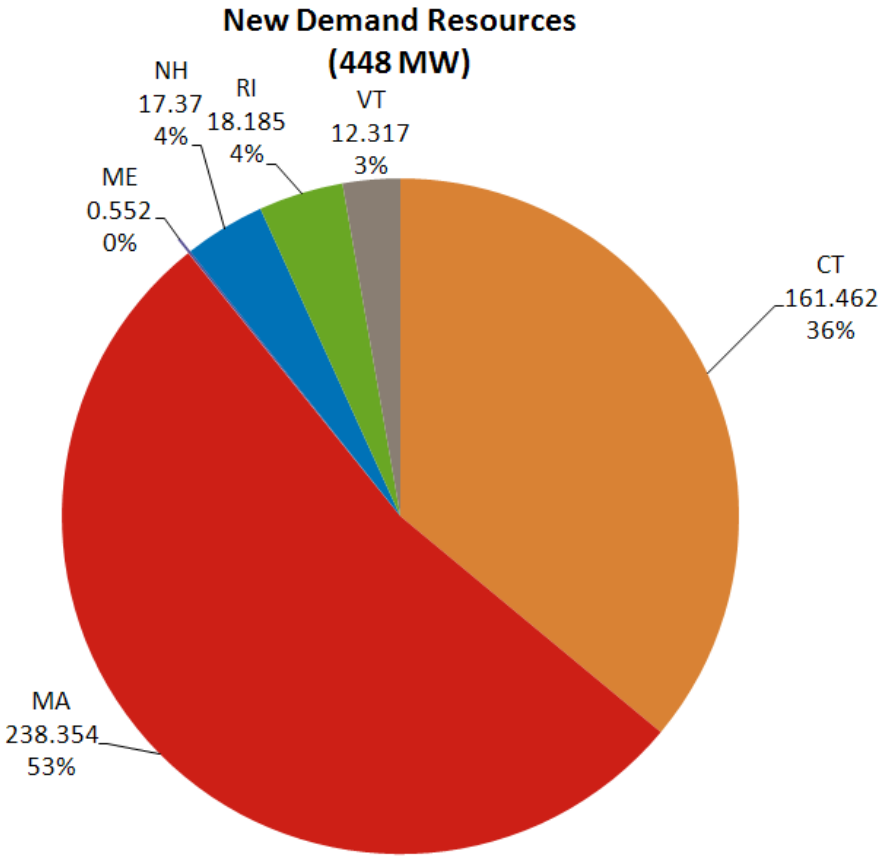


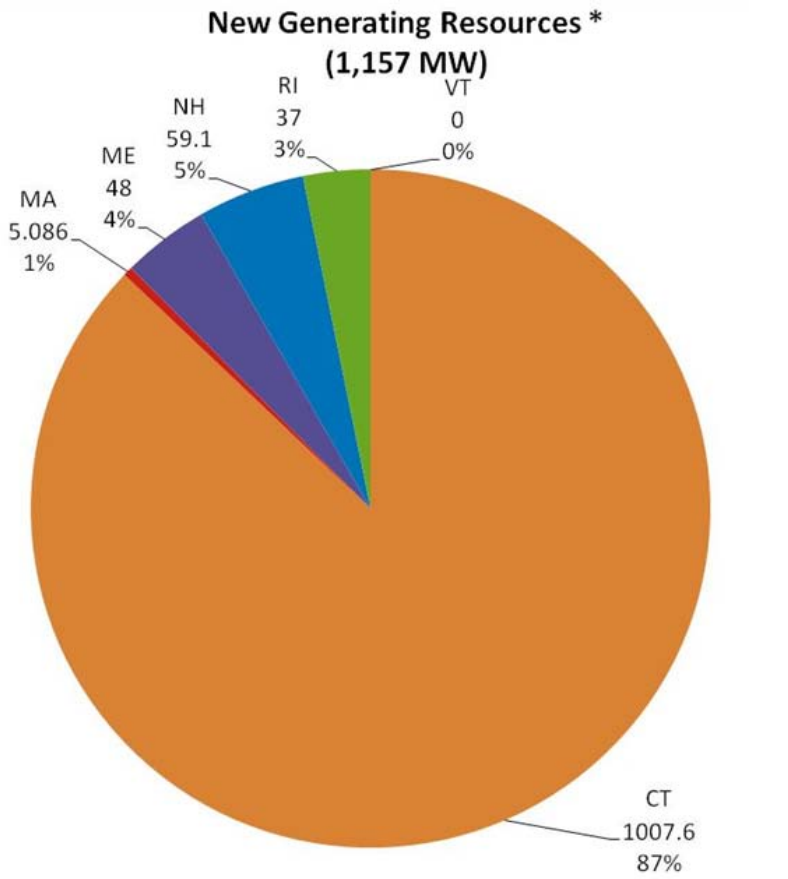
Demand Resources Growing in New England



New England Moving to Alternative Resources

Many New Demand-Side Resources





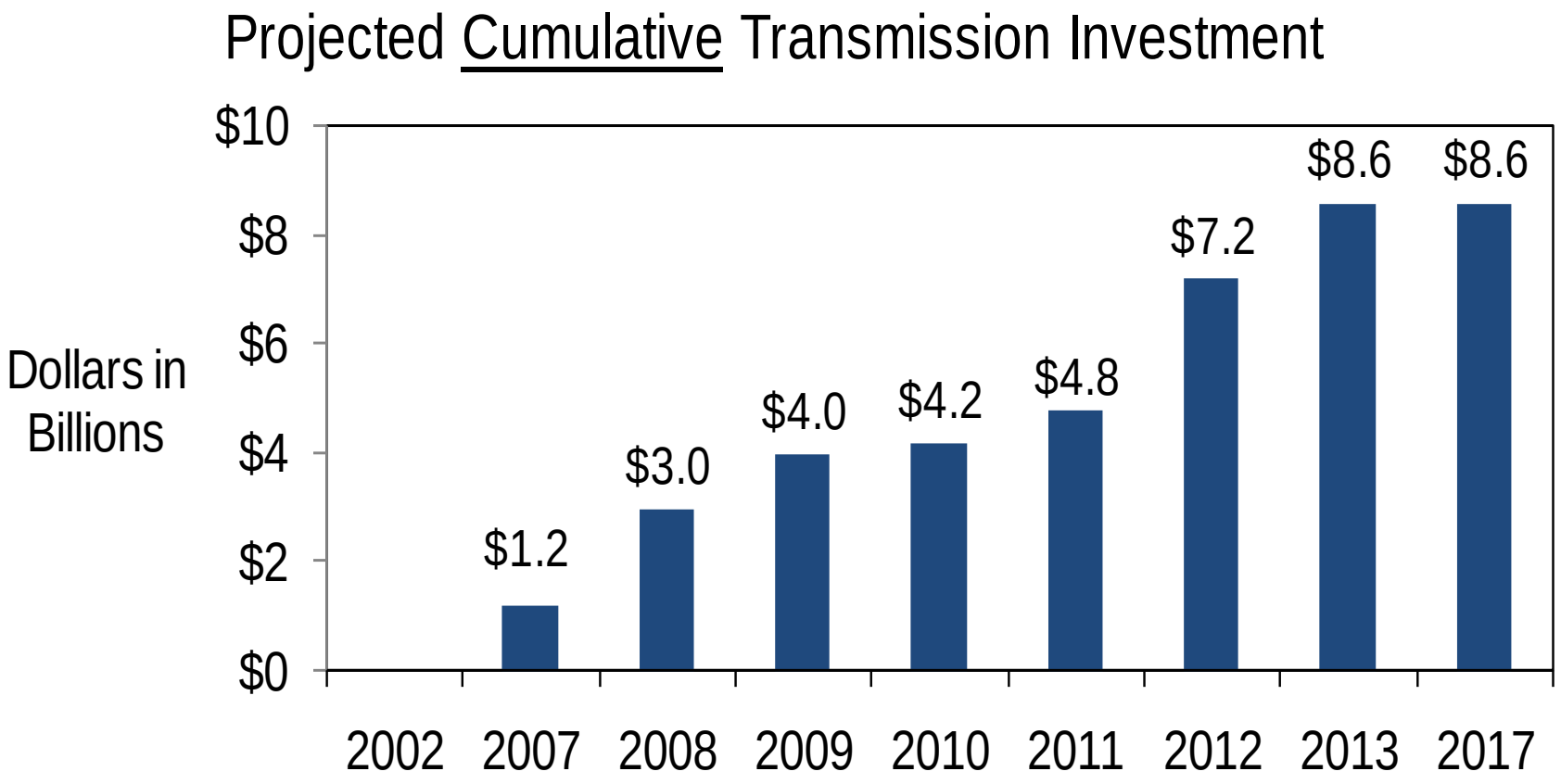
*** Includes 1,007.6 MW of Connecticut RFP Resources**

Results of second Forward Capacity Auction (For delivery in 2011)
Values represent MW and percent

Electricity System Is More Reliable Efficient, and Environmentally Friendly

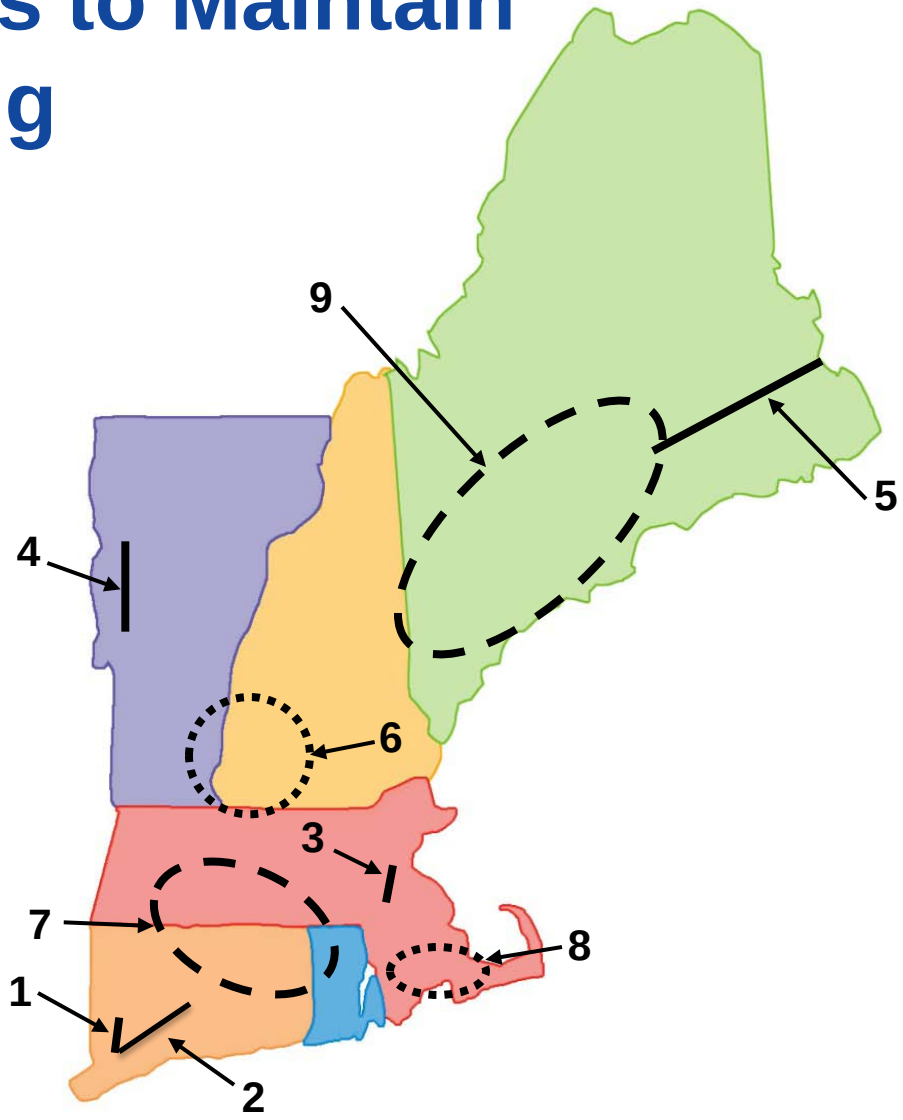
- Major transmission projects have been developed
  - More than 200 transmission upgrades have been put into service since 2002, with another 62 projects expected to be completed this year
  - Six major 345 kilovolt (kV) projects are in various stages of construction or are in service; another six are in the planning and engineering stages—all total about $8 billion in investment over a 10-year period.
  - Approximately $1.0 to $2.0 billion of economic transmission investment under study for development of renewable resources
- Major transmission investment provides reliability *and* economic benefits
    - Reduce need for reliability agreements (i.e. RMRs)
    - Reduce local congestion by improving transfer limits and thereby lowering market prices
    - Reduces system losses, which are a component of market prices
    - Improves ability to import and export electricity with Canada

Major Transmission Investment in New England



Transmission Projects to Maintain Reliability Progressing

1. Southwest CT Phase I
2. SWCT Phase II
3. NSTAR 345 kV Project, Phase I and II
4. Northwest Vermont
5. Northeast Reliability Interconnect
6. Monadnock Area
7. New England East-West Solution
8. Southeast Massachusetts
9. Maine Power Reliability Program



In service

Under construction

Under study

Key Challenges

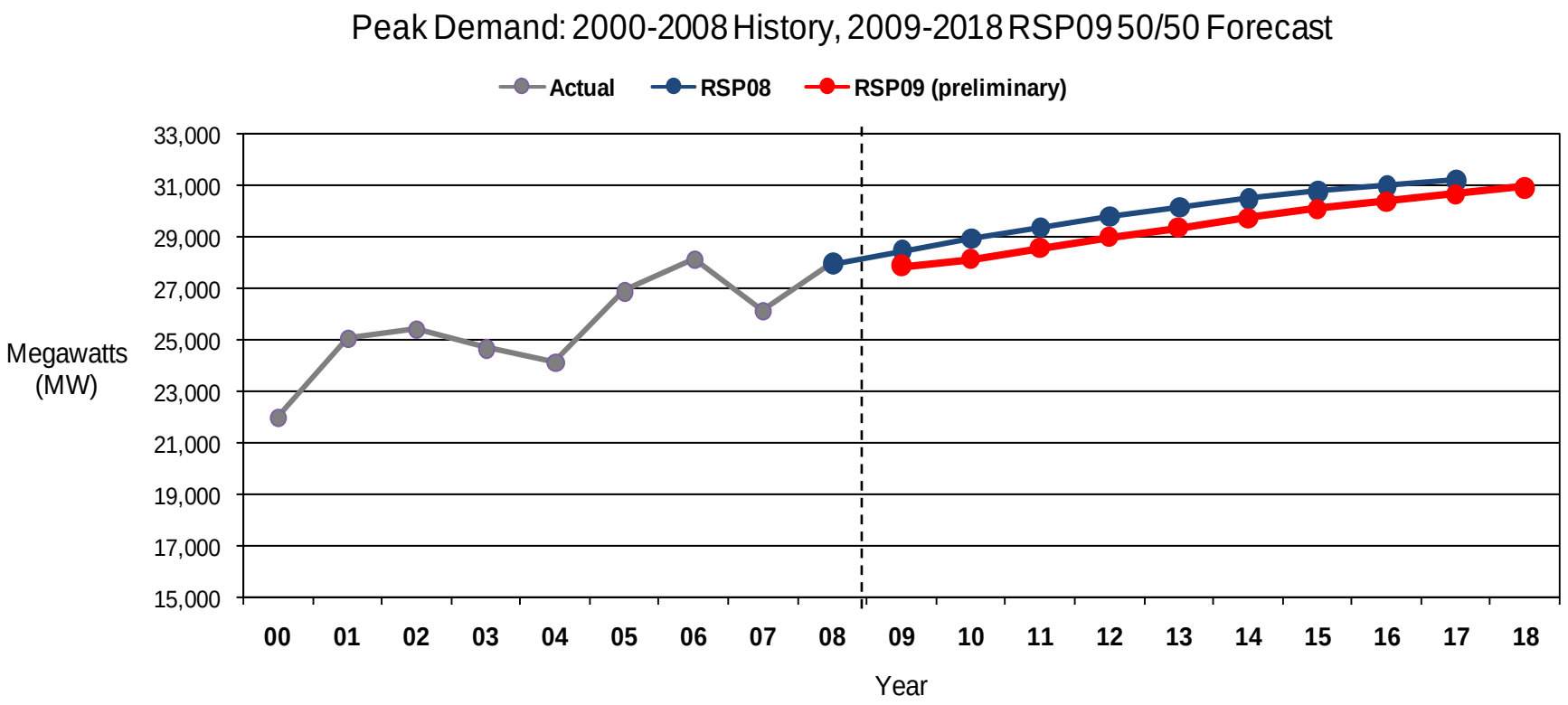
Key Challenge for New England

Meeting peak demand for electricity

- **Peak demand is on the rise**
  - 28,130 MW—all-time peak set August 2, 2006
  - New England is summer peaking system
- **Projected annual growth 2008-2017**
  - Average demand: 0.8%
  - Peak demand: 1.2% (365 MW per year)
    - Equivalent of needing to build a good-sized power plant every year just to maintain current capacity reserve margins
- **Growing faster than overall demand**
  - Creates need for additional, costly power system infrastructure and an overall inefficient system
  - Increases need for energy efficiency and stronger wholesale/retail linkages
  - Integrating the growing level of demand resources into system and market operations is a priority for ISO-NE

Peak Use Is Growing

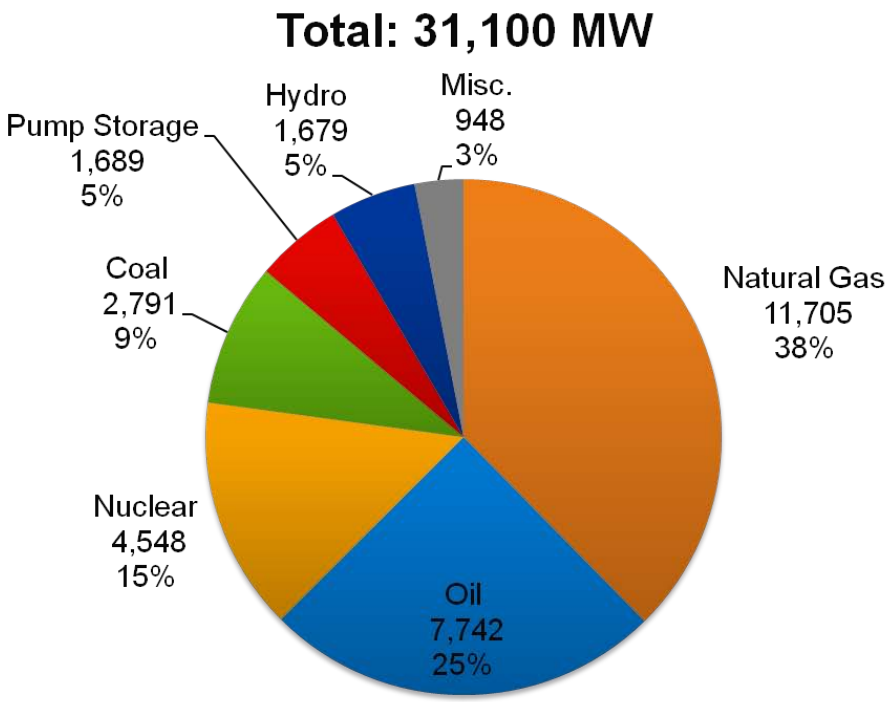
Even with the current economic slowdown



Key Challenge for New England

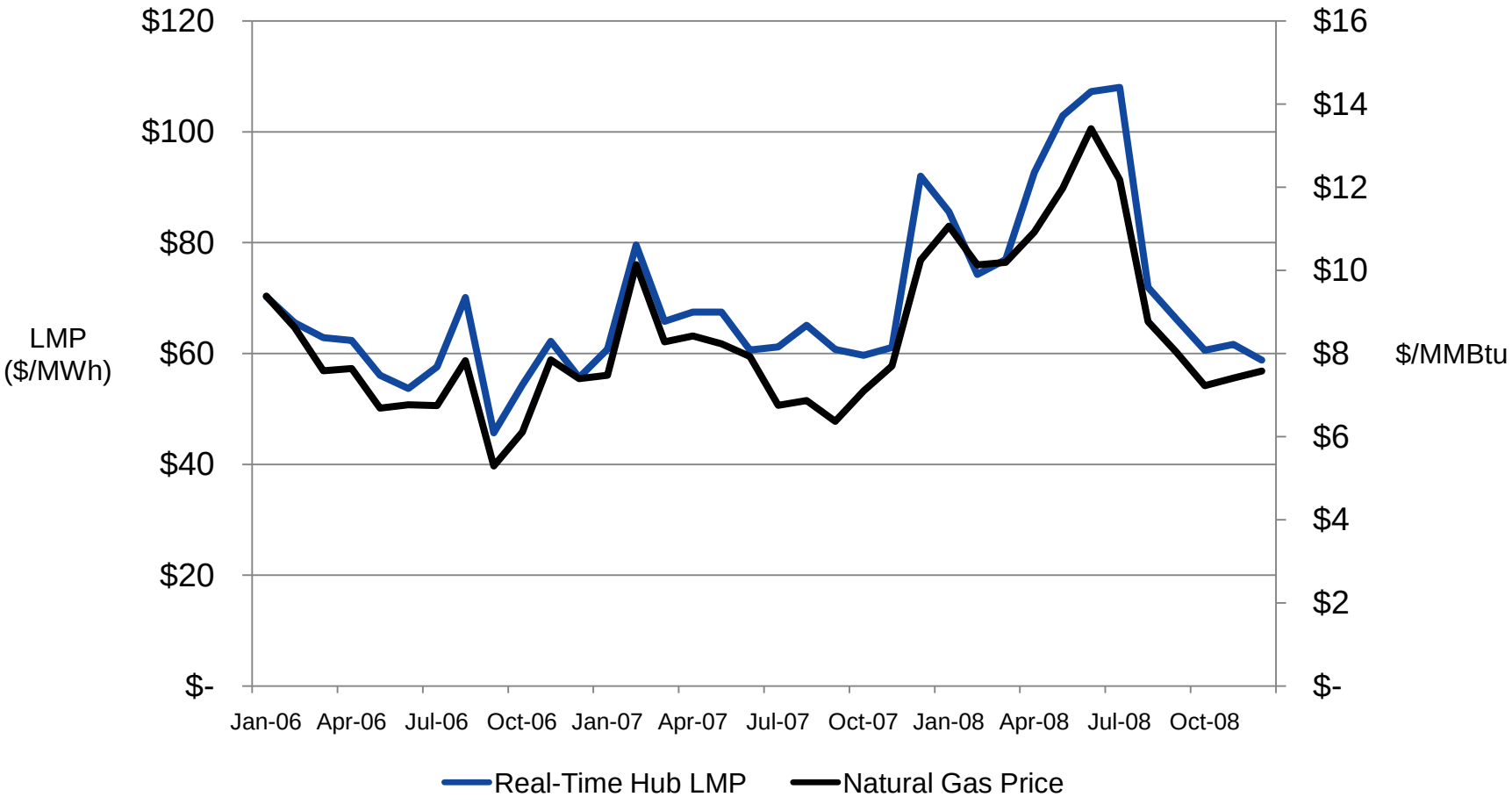
Over reliance on natural gas

- **Natural Gas Is Primary Fuel for Nearly 40% of Region's Existing Capacity**
- **Electricity costs driven by cost of fuel used to produce it**
- **Creates need for fuel diversity**

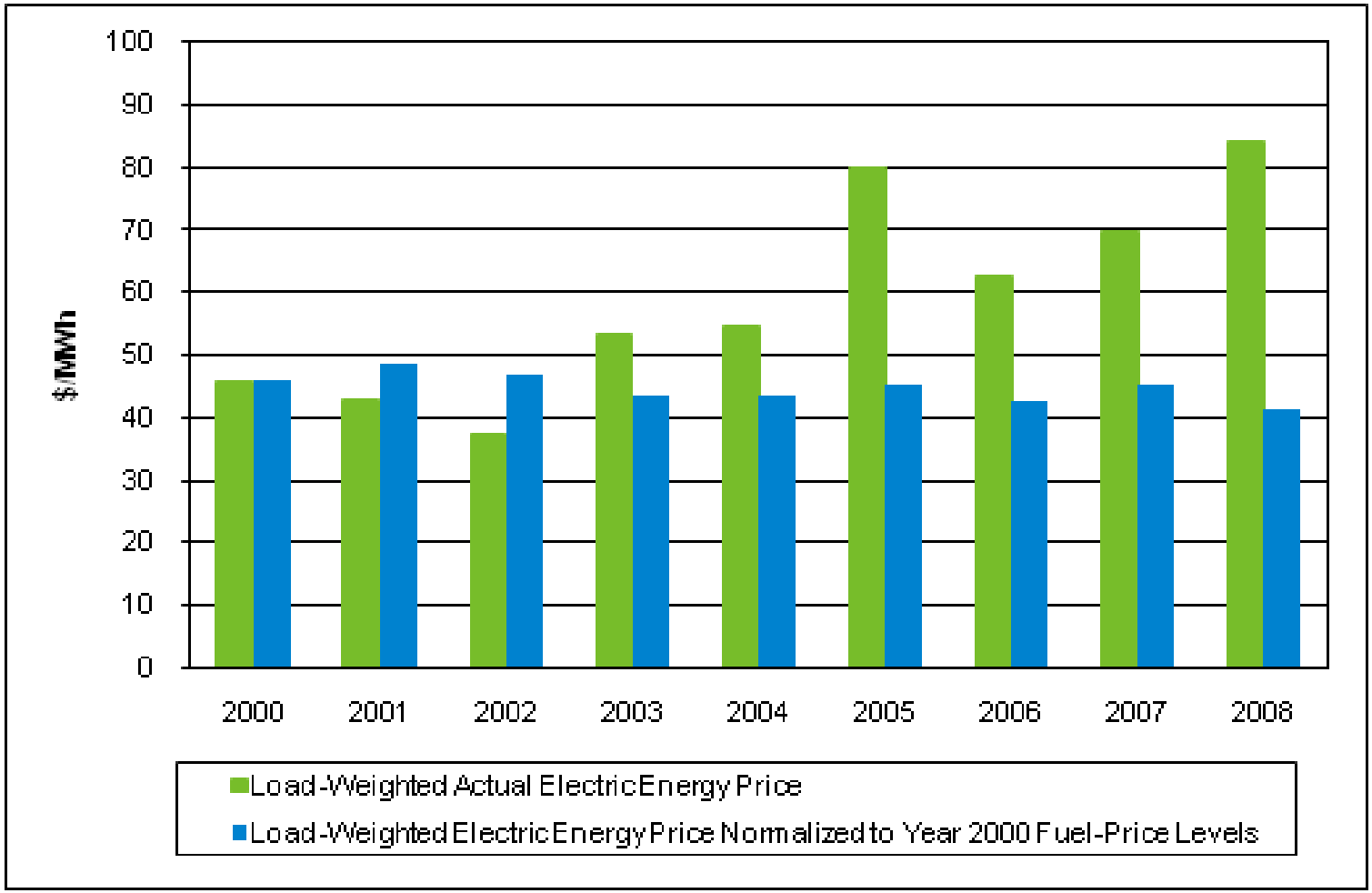


Current Generation Capacity Mix by Primary Fuel Type. The "Other Renewables" category includes landfill gas, other biomass gas, refuse (municipal solid waste), wood and wood-waste solids, wind, and tire-derived fuels.)

Wholesale Electricity Prices Track Natural Gas Prices (2006-2008)



Actual and fuel-adjusted average real-time electric energy prices, 2000 to 2008



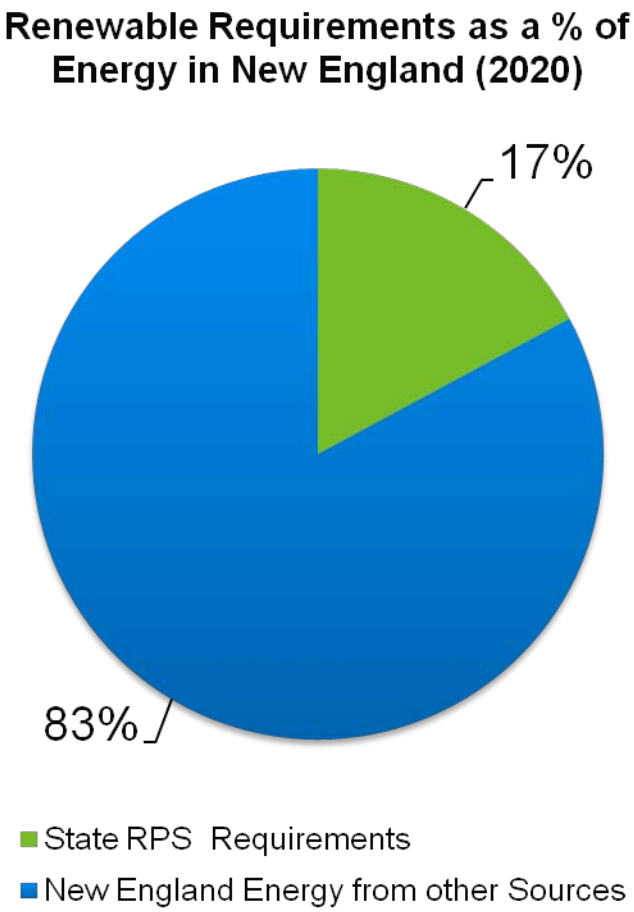
Key Challenge for New England

Meeting increasing environmental standards

- **Emerging federal, state, and regional environmental regulations require fossil fuel emissions from power plants to decrease**
  - Will require stronger conservation and energy-efficiency measures, the addition of low- or zero-carbon emitting generation (“renewables”), or a combination of both
  - Will also require transmission investment to provide access to potential renewable supply
  - Must determine how to balance environmental standards with reliability and costs to consumers

States Seek Renewable Energy

Requirements projected to significantly increase over the next decade



- Renewable requirements projected to increase from nearly 7% of total energy in 2008 to 17% in 2020
  - Adding Energy Efficiency increases the number to 27.8%
- 17% energy requirement in 2020 equivalent to:
  - 9,000 MW of wind capacity, or
  - 3,200 MW of biomass capacity
- Proposed renewable projects in New England: 3,000 megawatts (MW)

Renewable Projects in the Queue by Type

Wind is Predominant Resource