Connecticut
Light & Power

The Northeast Utilities System

The Brattle Group

The United Illuminating Company

Overview of Integrated Resource Plan for Connecticut

- Key Topics -

Presented to the
Connecticut Energy Advisory Board

January 8, 2010

Agenda

Overview of Analytical Approach

Key Topics

1. Resource Adequacy
2. Demand Side Management
3. Renewable Energy
4. Transmission
5. Nuclear Power
6. Combined Heat and Power
7. Environment
8. Energy Security
9. Natural Gas
10. Emerging Technologies

Overview of Analytical Approach

Analytical Approach

Energy market simulations with the DAYZER model

- Key inputs: hourly loads, transmission, characteristics of every generator throughout ISO-NE, fuel prices, emissions allowance prices, etc.
- One simulation "run" for each year/scenario/resource strategy combination
- Outputs: hourly energy prices, unit-level generation and emissions, transmission flows/congestion

Capacity market model

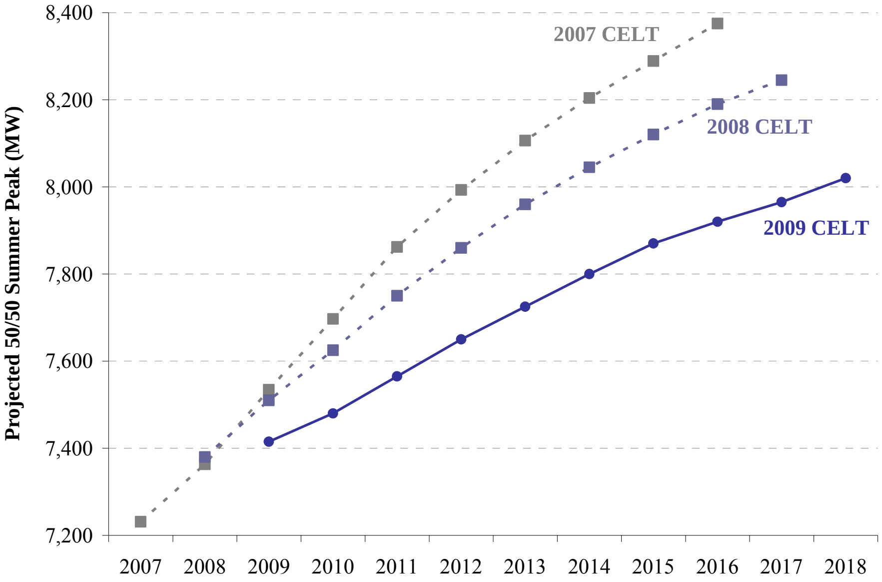
- Inputs: ISO-NE demand, cost characteristics of supply, FCM rules
- Outputs: annual prices, retirement/mothball decisions, expansion

Performance metrics

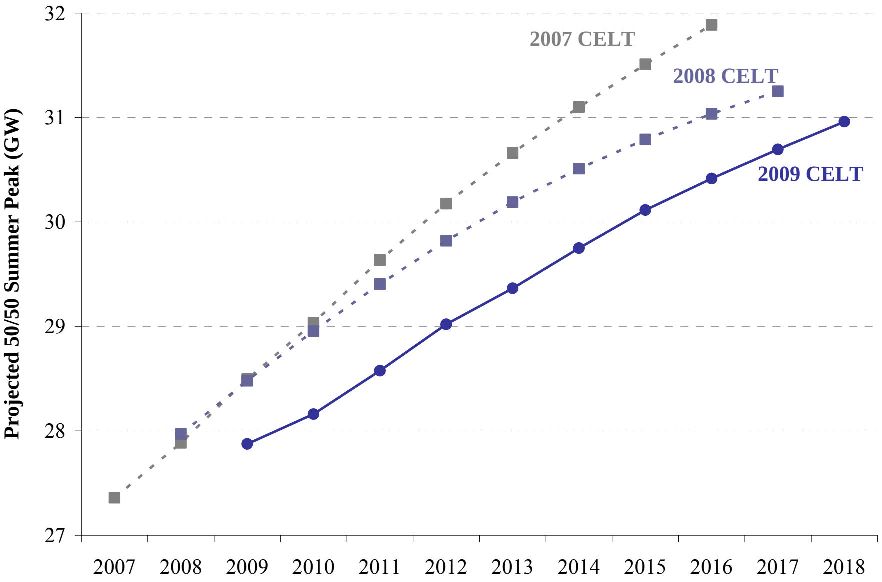
- All of the elements of customers' power supply-related customer costs
- CO_2, NO_X, SO_2 emissions; fuel use

Peak Load Forecasts Have Decreased

CELT Peak Load Forecast
Connecticut Sub-Area

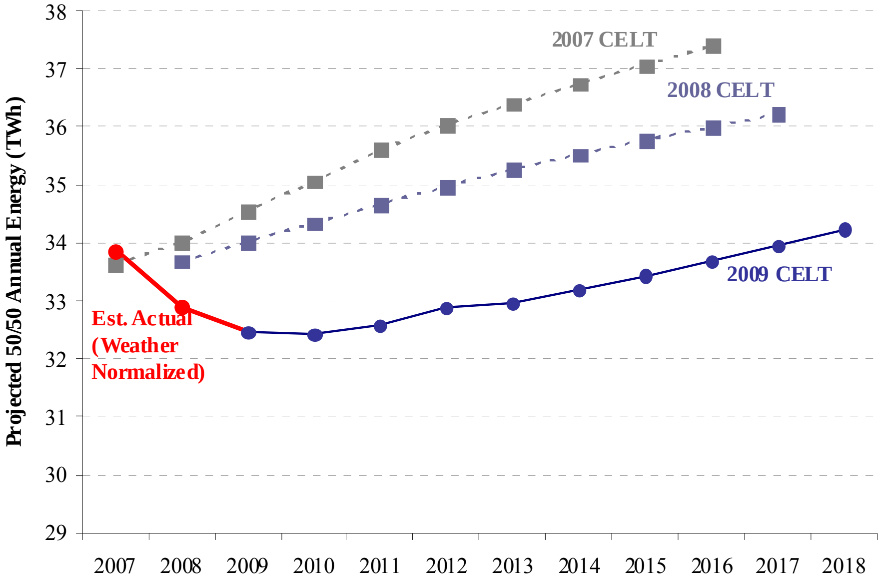


CELT Peak Load Forecast
New England

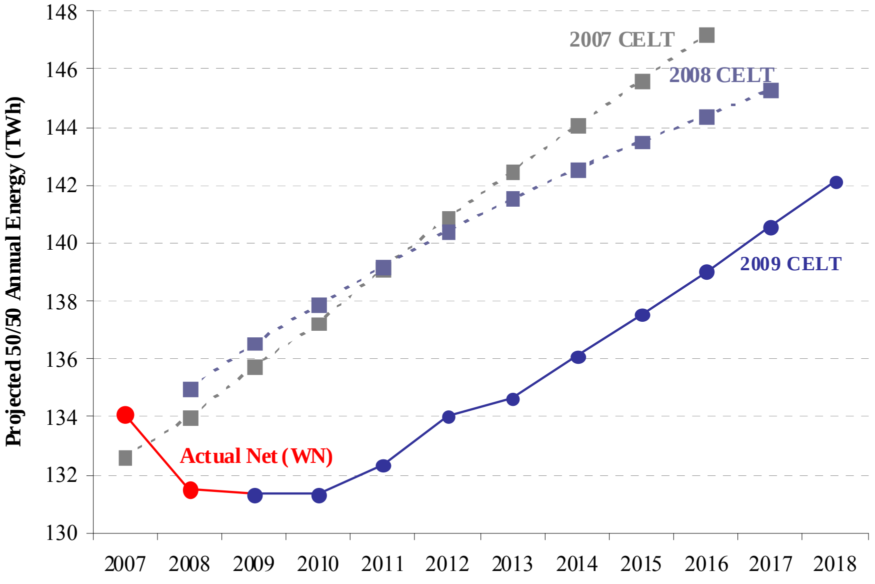


Energy Forecasts Have Decreased

CELT Energy Forecast
Connecticut Sub-Area



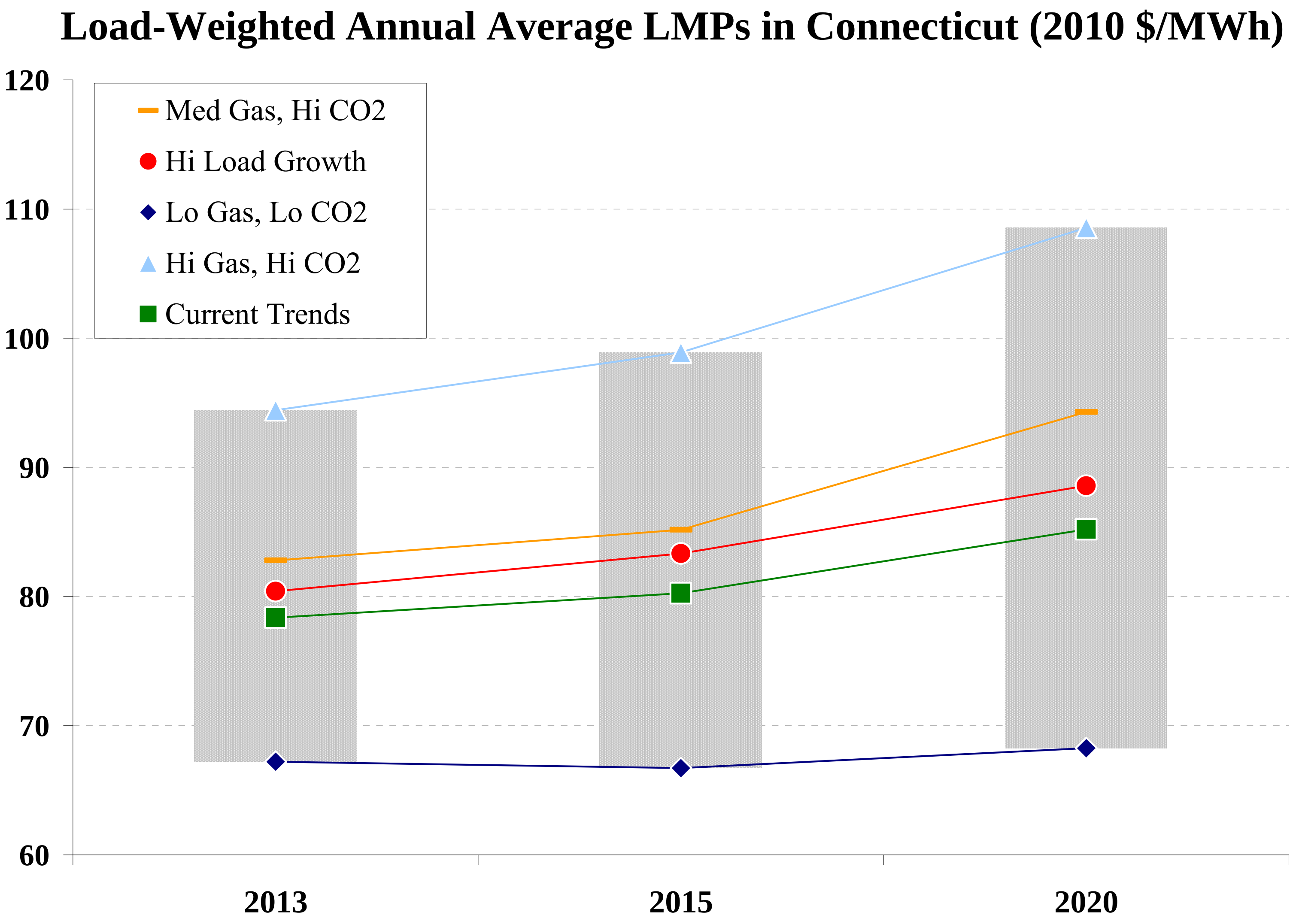
CELT Energy Forecast
New England



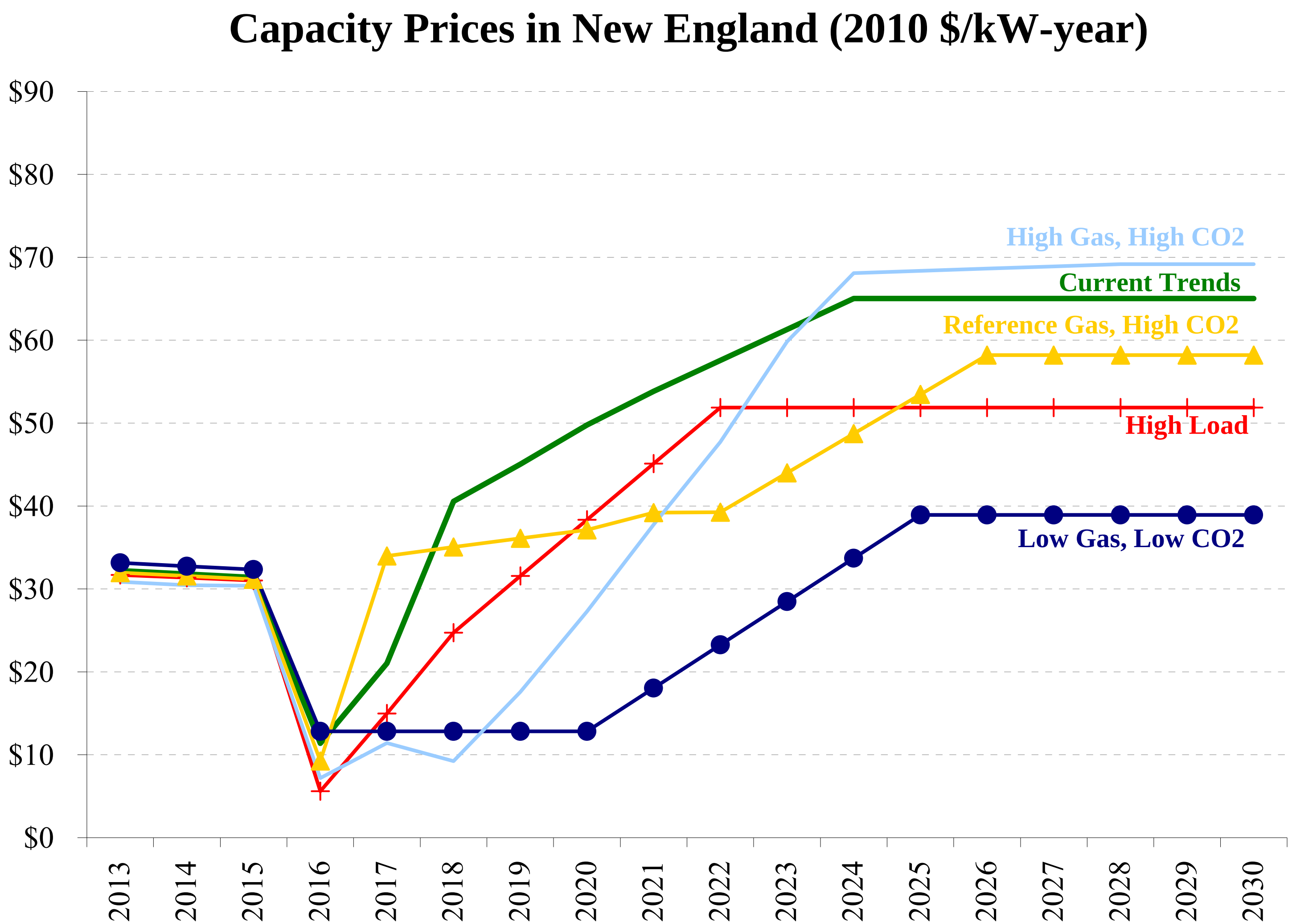
Scenario Definitions

Scenario	Gas Price	CO_2 Price	Load Growth
"Current Trends"	**Medium**: futures extrapolated	**Medium**: EIA "Basic Case" for Waxman-Markey	**CELT forecast**
"Lo Gas/Lo CO_2"	**Low**	**Low**: EIA "High Offset Case: for Waxman-Markey	**CELT adjusted up** by price elasticity
"Med Gas/Hi CO_2"	**Medium**	**High**: EIA "No International Case" for Waxman-Markey	**CELT adjusted down** by price elasticity
"Hi Load Growth"	**Medium**	**Medium**	**CELT High Economic Growth** forecast
"Hi Gas/Hi CO_2"	**High**	**High**	**CELT adjusted down** by price elasticity

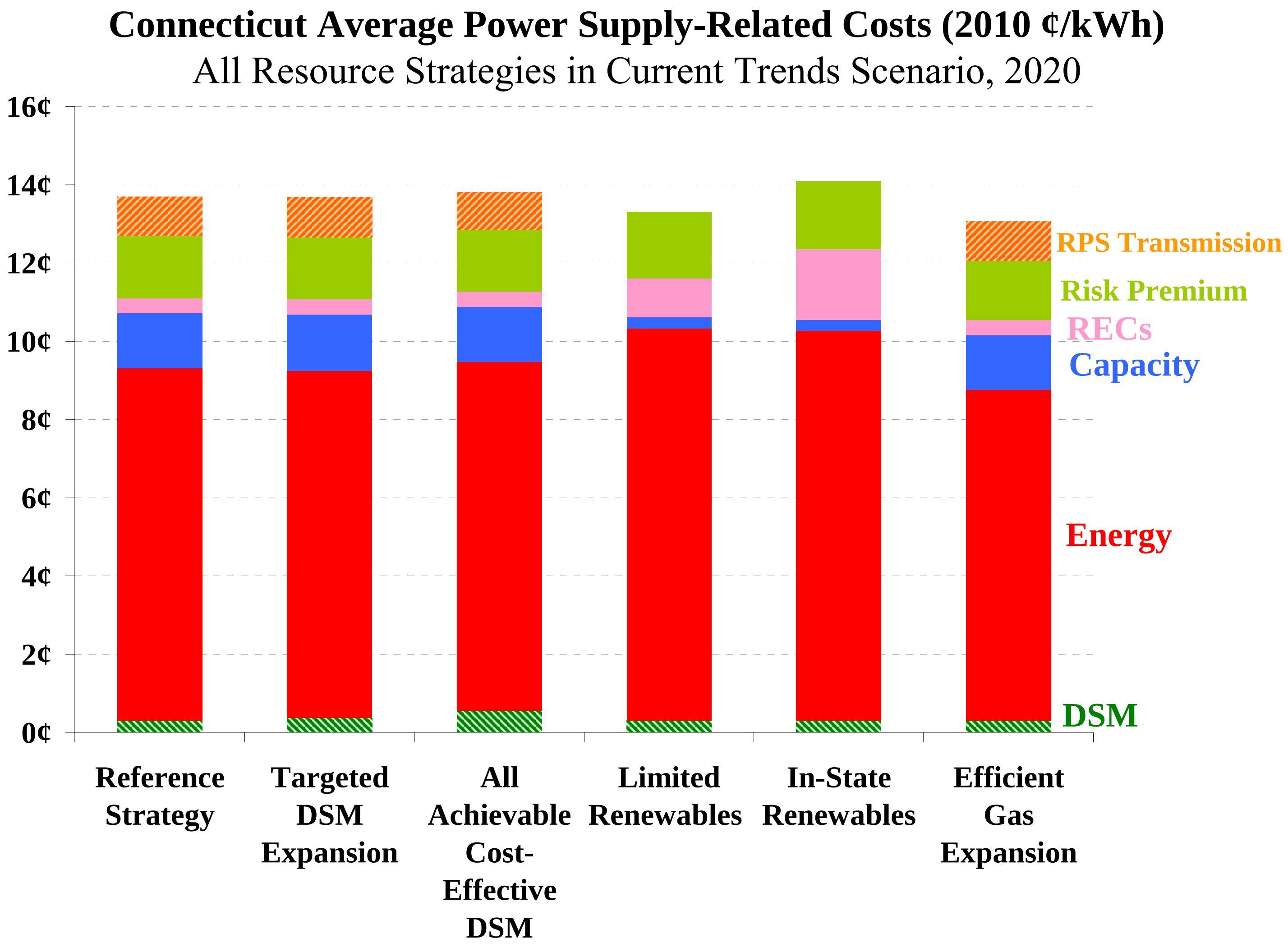
Energy Prices Across Scenarios



Capacity Prices Across Scenarios



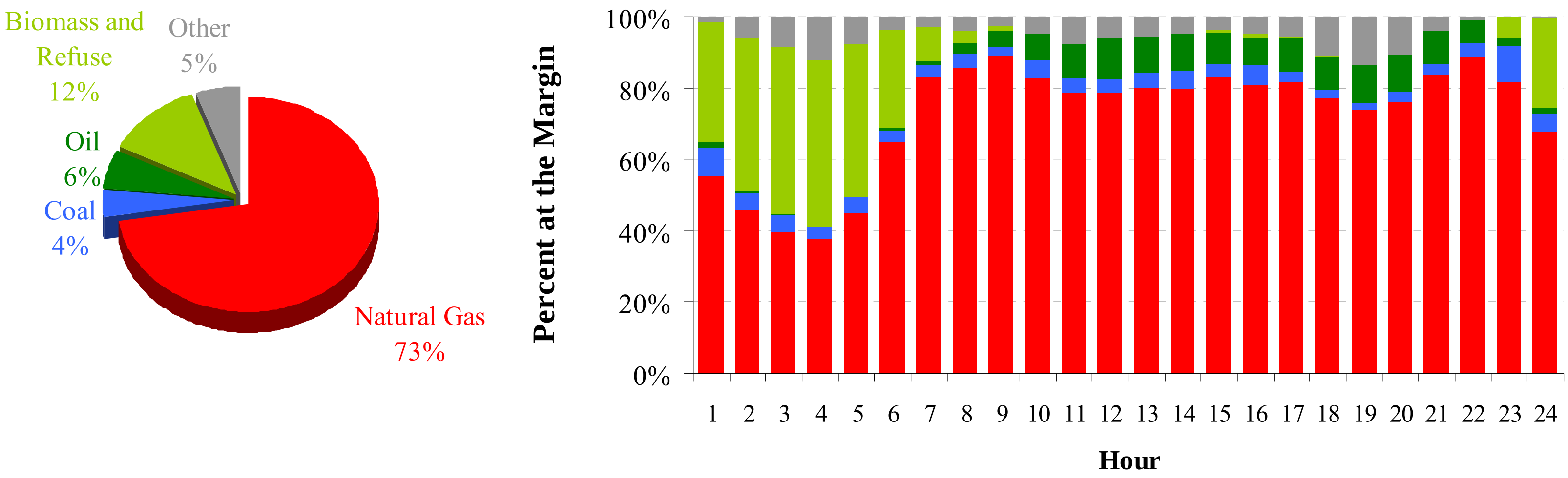
Components of Power Supply-Related Costs, 2020



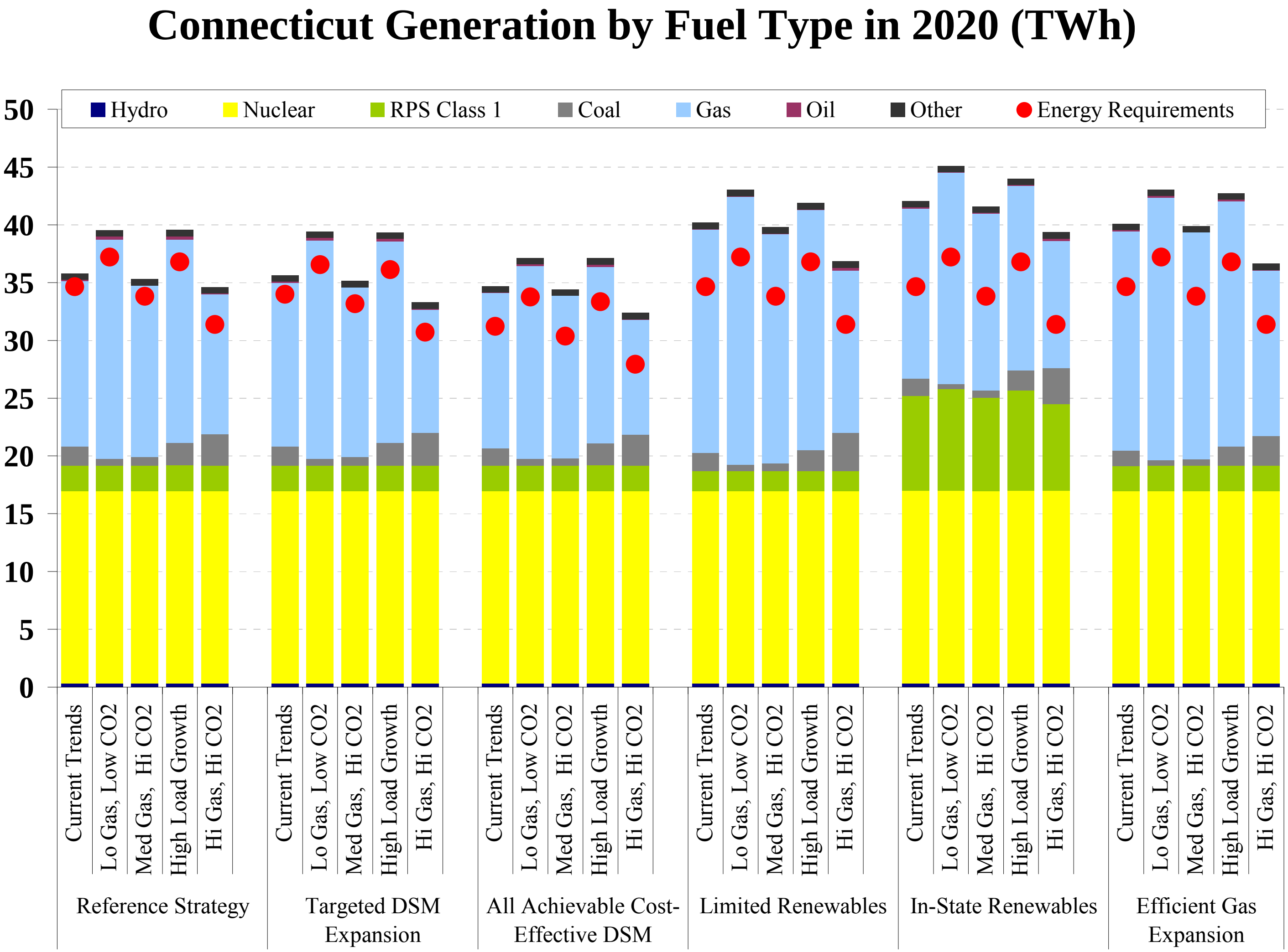
Marginal Generation by Fuel Type

New England Marginal Generation by Fuel Type in 2020

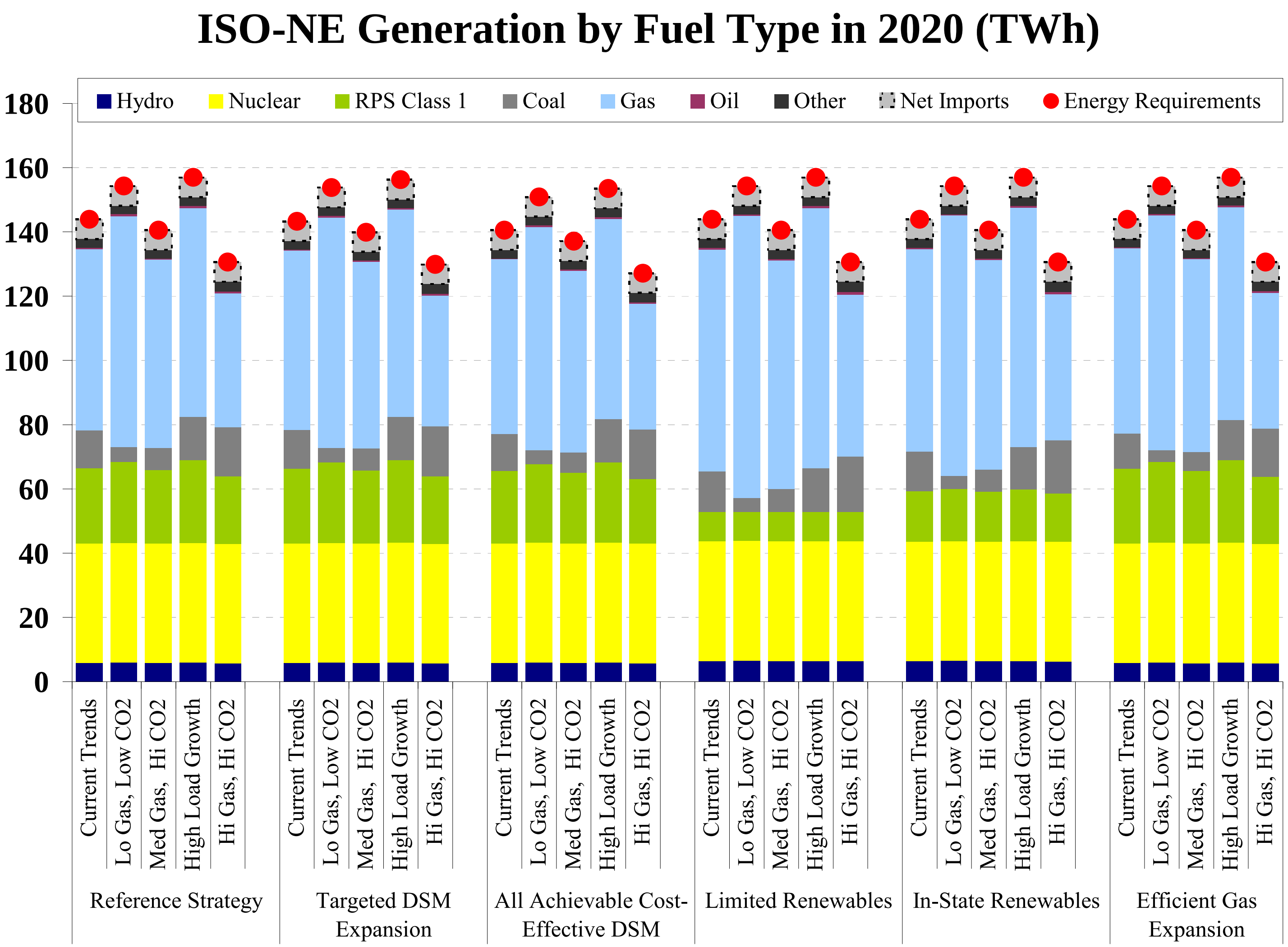
Based on DAYZER Simulations, Base Case



Generation by Fuel Type - Connecticut



Generation by Fuel Type – ISO-NE



1. Resource Adequacy

Objectives: Resource Adequacy

Scope

- Update 2009 IRP to assess Connecticut and ISO-wide future resource needs under a variety of scenarios, and identify potential shortfalls in resource adequacy, based on:
  - ICR: ISO-wide Installed Capacity Requirement
  - LSR: Connecticut Local Sourcing Requirement
  - TSA: Connecticut Requirement under Transmission Security Analysis (very similar to LSR but more stringent)
  - LFRM: Connecticut Local Forward Reserve Market Requirement

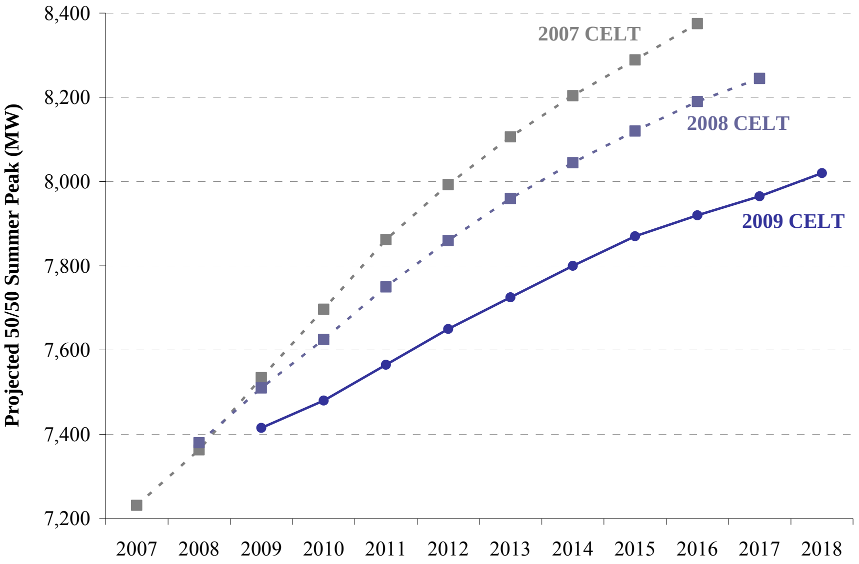
Approach

- Assess needs for each year 2009 through 2020
- Base Case: use the ISO's updated load forecast and reliability requirements, and current information on existing and planned new resources; project likely retirements based on revenues vs. costs and environmental requirements
- Scenarios: test the impact of changes in gas and CO_2 prices, and demand

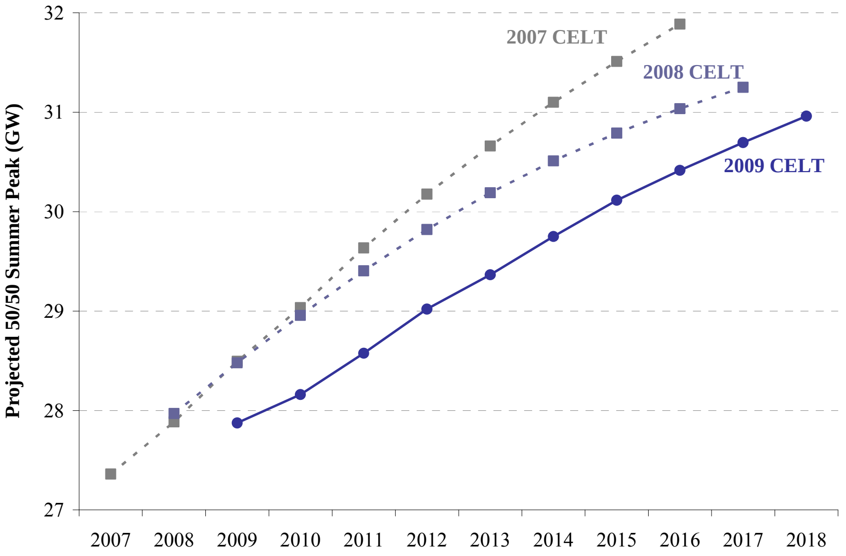
Demand Forecast has Decreased

The ISO's 50/50 peak load forecast under base economic growth conditions is 2-3% lower ISO-wide by 2016 compared to last year's forecast

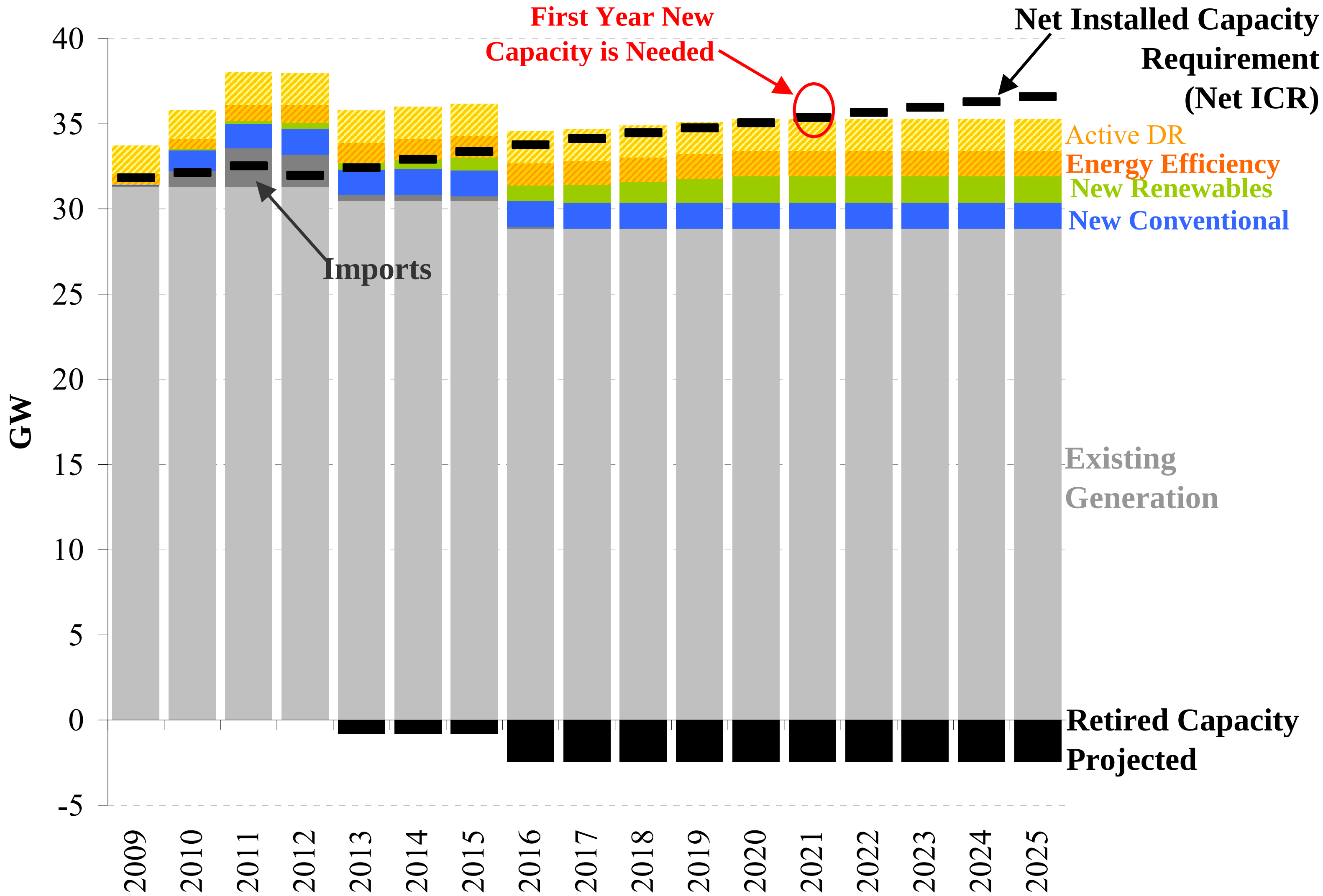
Connecticut



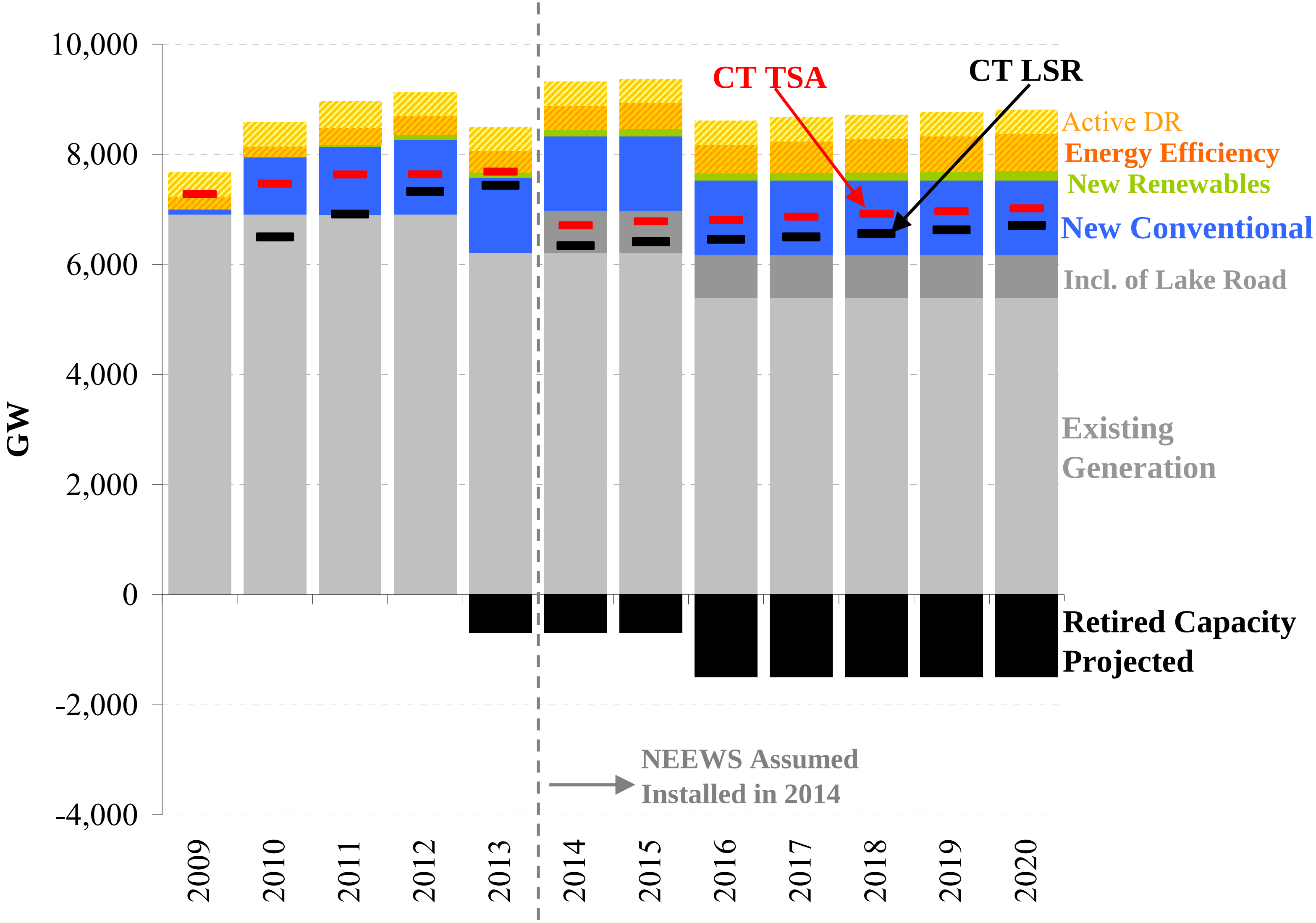
ISO



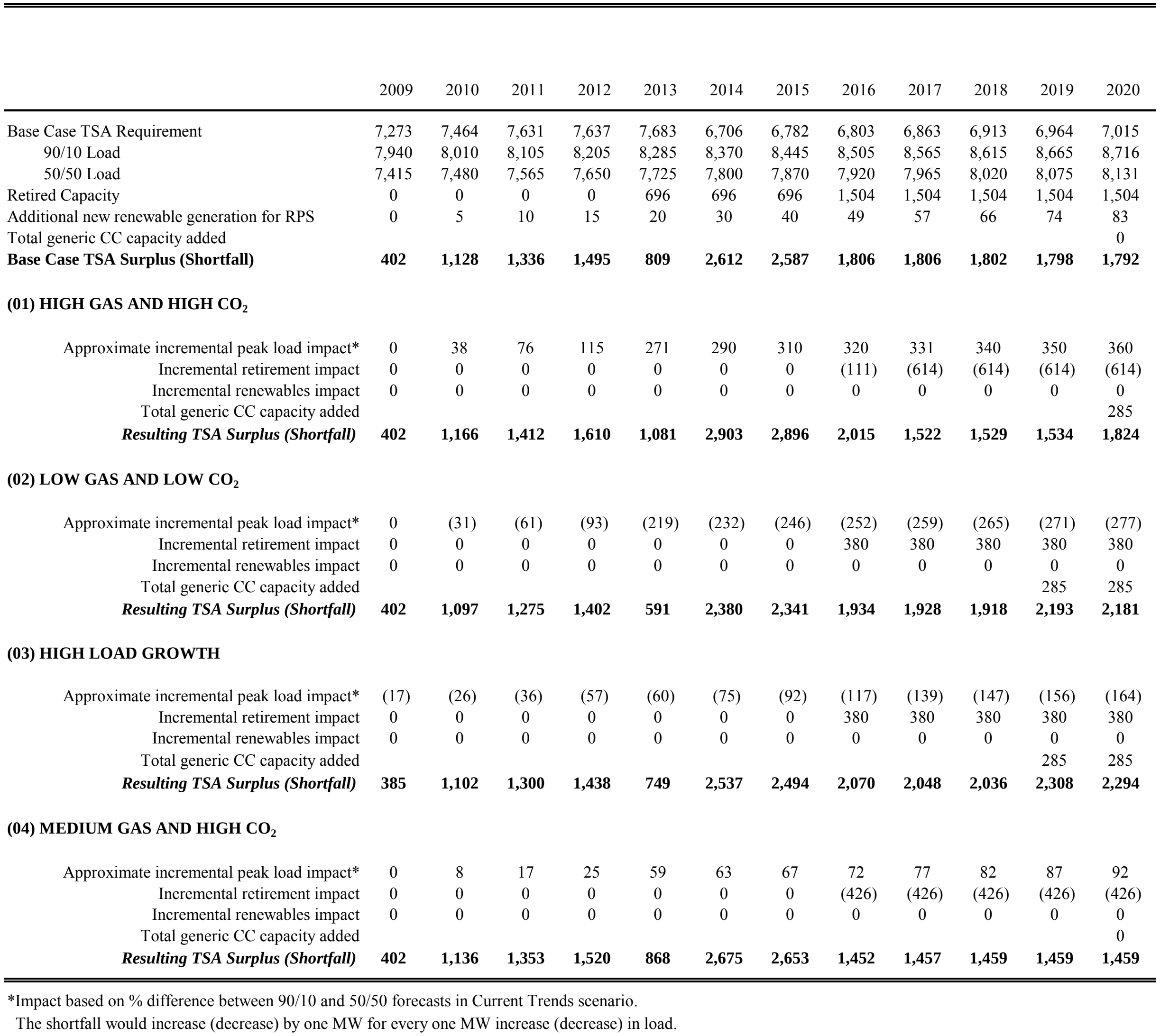
Resource Adequacy in ISO-NE (Base Case)



Locational Resource Adequacy in Connecticut (Base Case)



Most Stringent Connecticut Local Requirement (TSA) Exceeded in All Scenarios



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Base Case TSA Requirement	7,273	7,464	7,631	7,637	7,683	6,706	6,782	6,803	6,863	6,913	6,964	7,015
90/10 Load	7,940	8,010	8,105	8,205	8,285	8,370	8,445	8,505	8,565	8,615	8,665	8,716
50/50 Load	7,415	7,480	7,565	7,650	7,725	7,800	7,870	7,920	7,965	8,020	8,075	8,131
Retired Capacity	0	0	0	0	696	696	696	1,504	1,504	1,504	1,504	1,504
Additional new renewable generation for RPS	0	5	10	15	20	30	40	49	57	66	74	83
Total generic CC capacity added												0
Base Case TSA Surplus (Shortfall)	**402**	**1,128**	**1,336**	**1,495**	**809**	**2,612**	**2,587**	**1,806**	**1,806**	**1,802**	**1,798**	**1,792**
(01) HIGH GAS AND HIGH CO$_2$												
Approximate incremental peak load impact*	0	38	76	115	271	290	310	320	331	340	350	360
Incremental retirement impact	0	0	0	0	0	0	0	(111)	(614)	(614)	(614)	(614)
Incremental renewables impact	0	0	0	0	0	0	0	0	0	0	0	0
Total generic CC capacity added												285
Resulting TSA Surplus (Shortfall)	**402**	**1,166**	**1,412**	**1,610**	**1,081**	**2,903**	**2,896**	**2,015**	**1,522**	**1,529**	**1,534**	**1,824**
(02) LOW GAS AND LOW CO$_2$												
Approximate incremental peak load impact*	0	(31)	(61)	(93)	(219)	(232)	(246)	(252)	(259)	(265)	(271)	(277)
Incremental retirement impact	0	0	0	0	0	0	0	380	380	380	380	380
Incremental renewables impact	0	0	0	0	0	0	0	0	0	0	0	0
Total generic CC capacity added											285	285
Resulting TSA Surplus (Shortfall)	**402**	**1,097**	**1,275**	**1,402**	**591**	**2,380**	**2,341**	**1,934**	**1,928**	**1,918**	**2,193**	**2,181**
(03) HIGH LOAD GROWTH												
Approximate incremental peak load impact*	(17)	(26)	(36)	(57)	(60)	(75)	(92)	(117)	(139)	(147)	(156)	(164)
Incremental retirement impact	0	0	0	0	0	0	0	380	380	380	380	380
Incremental renewables impact	0	0	0	0	0	0	0	0	0	0	0	0
Total generic CC capacity added											285	285
Resulting TSA Surplus (Shortfall)	**385**	**1,102**	**1,300**	**1,438**	**749**	**2,537**	**2,494**	**2,070**	**2,048**	**2,036**	**2,308**	**2,294**
(04) MEDIUM GAS AND HIGH CO$_2$												
Approximate incremental peak load impact*	0	8	17	25	59	63	67	72	77	82	87	92
Incremental retirement impact	0	0	0	0	0	0	0	(426)	(426)	(426)	(426)	(426)
Incremental renewables impact	0	0	0	0	0	0	0	0	0	0	0	0
Total generic CC capacity added												0
Resulting TSA Surplus (Shortfall)	**402**	**1,136**	**1,353**	**1,520**	**868**	**2,675**	**2,653**	**1,452**	**1,457**	**1,459**	**1,459**	**1,459**

*Impact based on % difference between 90/10 and 50/50 forecasts in Current Trends scenario.
The shortfall would increase (decrease) by one MW for every one MW increase (decrease) in load.

Likely Retirements Based on Going-Forward Costs with Environmental Requirements

Over planning horizon, each Oil/Gas Steam unit makes optimum decisions whether to operate, mothball, or retire, considering:

- Revenues
  - Capacity prices consistent with surplus, which depends on level of retirements; eventually reaches Net CONE
  - Energy margins, net of fuel and variable O&M costs
- Costs
  - Ongoing FOM costs (1/2 avoidable if mothball)
  - Future CapEx: need SCR ($114/kW) to comply with NOx emissions rate limit of 0.07 lb/MMBtu by 2017, per our consultation with DEP

Results:

- 2,446 MW capacity likely to retire by 2016, incl. 1,504 MW in Connecticut
- Varies by scenario and resource strategy: 459 to 4,145 MW

Findings: Resource Adequacy

- There will likely be a substantial surplus relative to Connecticut's local resource requirements through 2020, due to a lower load forecast than utilized in prior IRPs, planned generation additions in Connecticut, planned DSM, and increased Connecticut import capability, even after accounting for forecasted retirements (which are substantial). Given this, Connecticut's access to adequate resources depends on resource adequacy in New England as a whole.

- A capacity surplus is expected in New England through at least 2015, and likely through 2020. This region-wide surplus is due to a lower load forecast than in prior IRPs, the likely addition of renewable generation to meet RPS requirements, planned DSM, and planned generation additions in Connecticut even after accounting for forecasted retirements (which are substantial). Some combinations of strategies and scenarios may lead to a need for additional resources after 2015 in cases that involve higher load, lower renewable additions, and/or higher retirements.

Findings: Resource Adequacy (continued)

- The prospect of capacity surpluses and consequently low capacity prices, combined with tighter environmental requirements, is likely to induce the retirement of substantial amounts of old, high emission, oil-fired steam units. Retirements are estimated at 2,446 MW in New England in the Base Case (1,504 MW in Connecticut). There is substantial uncertainty around these estimates; retirements could exceed 4,000 MW under market conditions that induce earlier new entry and reduced capacity prices.

2. Demand-Side Management

Objectives: Demand-Side Management

Evaluate the Cost and Emissions Impacts of Two Levels of Expanded DSM

Review Financing & Funding Options

Two Levels of Expanded DSM Were Evaluated

Targeted DSM Expansion resource strategy

- Four high-potential initiatives with average benefit:program cost ratios of 4.3
  - Residential New Construction (RNC) – “Zero Energy Homes”
  - Residential Cooling
  - High Potential C&I Measures
  - C&I Chiller Retirement
- Results in savings of 191 MW and 612 GWh/year (-2% CT load) by 2020. Achieves zero peak growth in 5 years

All Achievable Cost-Effective DSM resource strategy

- Based on the “Integrated Resource Plan Funding Scenario” in ECMB’s 2009 Energy Efficiency Potential Study
- Results in 561 MW and 3,439 GWh in additional annual savings (relative to Reference level DSM) by 2018

Funding/Financing Options

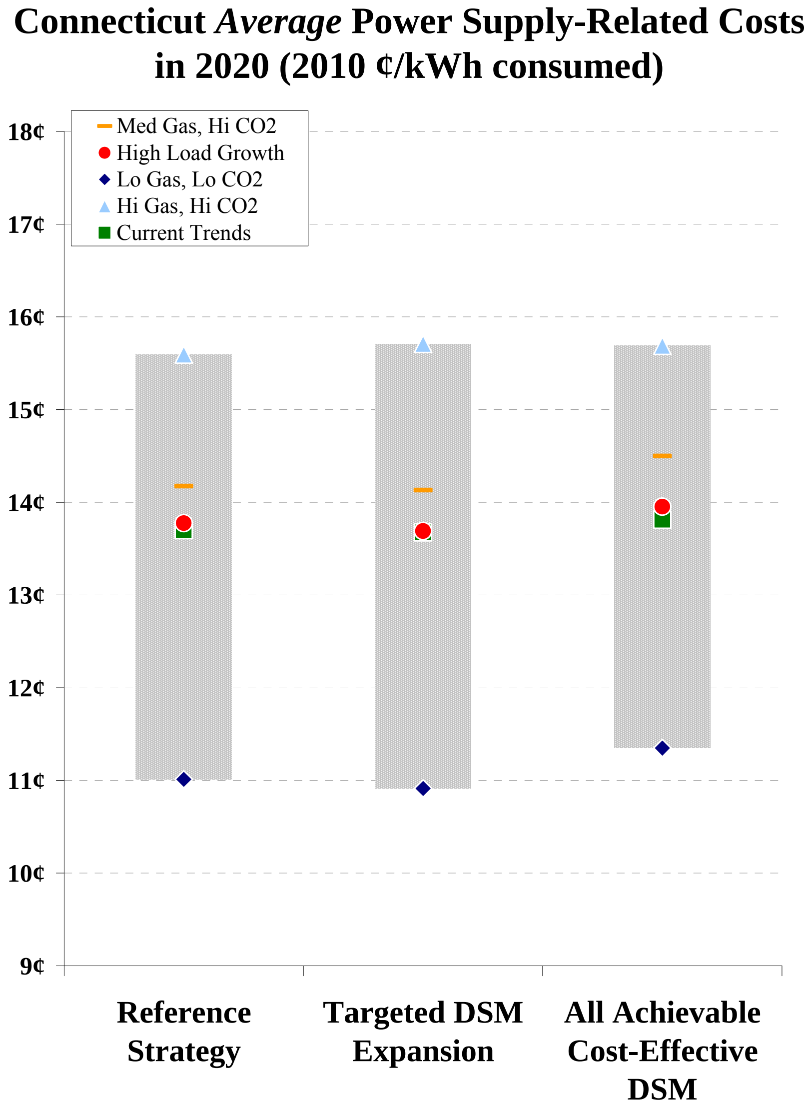
To Fund Program Costs:

- Continue Reference-level funding
  - 3 mill system benefits charge (SBC)
  - FCM funding
  - Class III REC program
  - RGGI
- Expand funding through
  - Increase SBC
  - Include program costs in distribution rate base

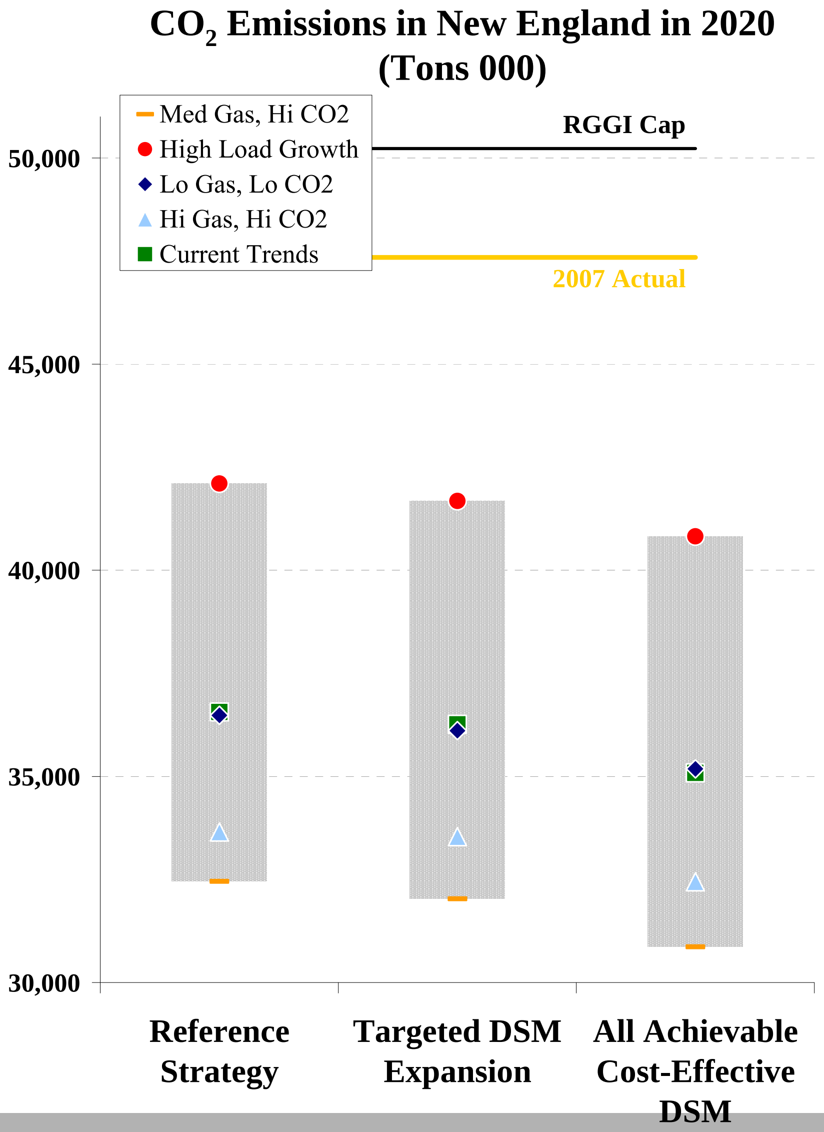
To Help Program Participants Finance Out-of-Pocket Costs:

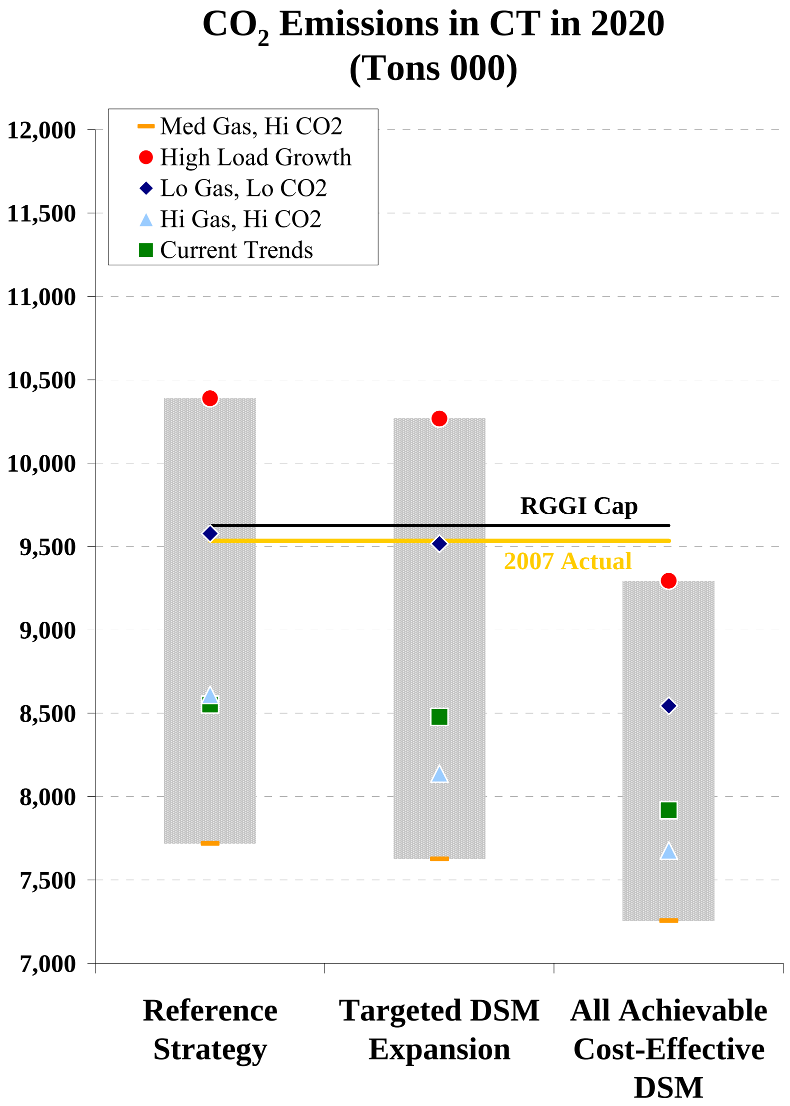
- Existing approaches: Small Business Program; residential financing (nascent)
- New approaches: municipal financing with property tax lien

Expanded DSM is Projected to Lower Power Supply-Related Costs (including program costs), but Slightly Higher Average Cost for All Achievable Cost-Effective DSM



Expanded DSM Lowers Emissions in All Cases





Findings: Demand-Side Management

- Although Connecticut is a leader in DSM, with established programs and demonstrated results, there is much unrealized, cost-effective, emissions-reducing potential remaining.
- The Targeted DSM Expansion Strategy meets the criteria established by the DPUC in its decision in Docket No. 08-07-01 for procurement absent an immediate reliability need by reducing total customer costs and CO_2 and NO_X emissions in all 5 scenarios tested, and by slightly reducing rates in all but one scenario. Funding this strategy through the system benefit charge (SBC) would require increasing the SBC rate from 3 mills to 3.7 mills, but based on the 2020 analysis, reduced generation service charge (GSC) costs and rates would more than offset the increase.
- The All-Achievable Cost Effective DSM Strategy also meets the criteria set forth in the Docket No. 08-07-01 decision; but while it reduces total customer costs and CO_2 and NO_X emissions in all 5 scenarios, it also raise average rates per kWh consumed. The SBC rate would increase to 5.6 mills, and the 2020 analysis indicates that the GSC rate impacts would not fully offset the SBC rate increase. Hence, costs for non-participants would increase while costs for participants would decrease (by a larger amount).

Findings: Demand-Side Management (continued)

- In summary, funding the Targeted DSM Expansion strategy would require an additional outlay of approximately $19 million per year (2010 dollars), and the All Cost-Effective DSM Strategy would require an outlay of approximately $65 million per year through 2020. Although both strategies would create cost savings in excess of the program costs (thus providing emissions reductions at a *negative* net cost), only the Targeted DSM strategy would result in lower rates for non-participants over time.
- Codes and standards are critical components of public policy complementing utility DSM programs, but they are not a substitute for such programs and do not effectively address existing structures.

3. Renewable Energy

Objectives: Renewable Energy

Develop and compare renewable resource development strategies using economic and environmental metrics

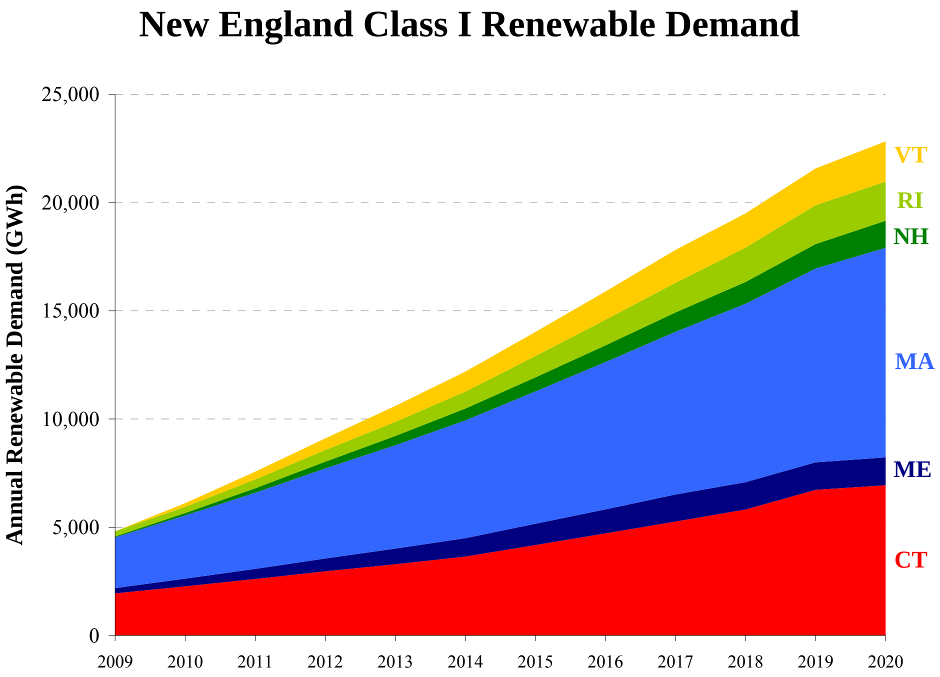
The three renewable resource strategies selected for analysis are:

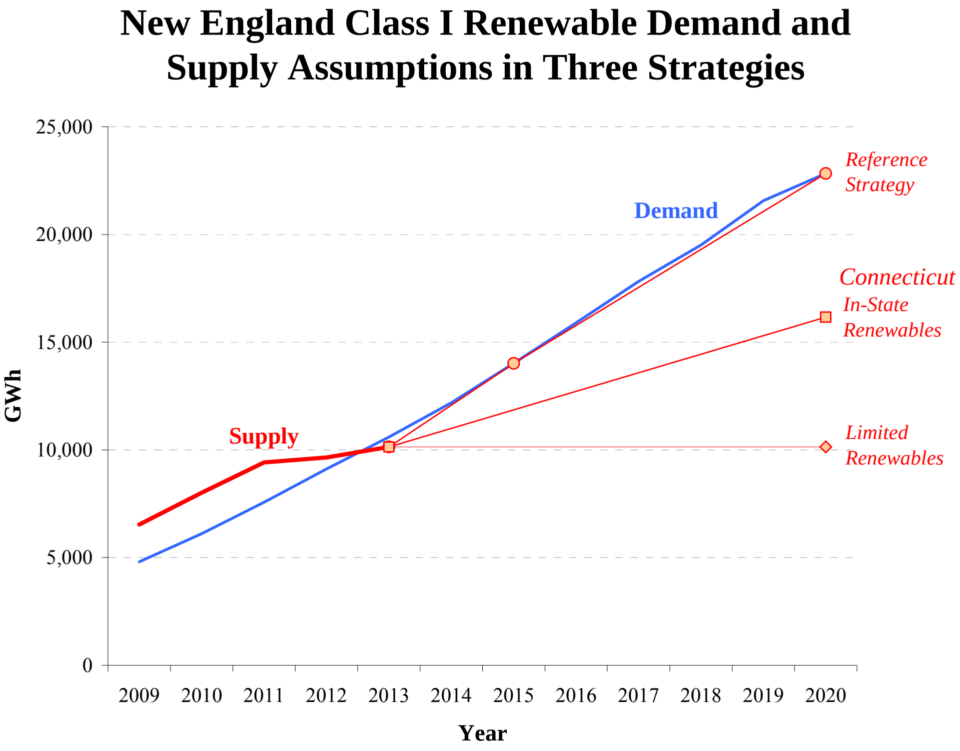
- **Reference Strategy**
  - Assumes that New England states meet their respective RPS through RECs from resources located in New England and imports.
  - Consistent with the vision of the Governors’ Renewable Blueprint, includes estimated transmission costs (based on the ISO-NE Renewable Scenario Analysis)

- **In-State Renewables Strategy**
  - Assumes Connecticut would meet the Connecticut RPS requirement through aggressive development of in-state renewable resources
  - Assumes the region does not develop sufficient renewables to meet RPS
  - No significant transmission build-out

- **Limited Renewable Strategy**
  - Assumes insufficient renewable resource development
  - No significant transmission build-out
  - Connecticut customers pay the ACP for most of their Class 1 renewables requirement.

Class I Renewable Energy Demand and Supply Assumptions Under Three Strategies





Supply Assumptions for Each Renewable Strategy

Renewable Technology	**Existing Renewable Capacity**	**New Renewable Capacity Additions**				
		Reference Strategy			In-State Renewables	Limited Renewables
	2009	2013	2015	2020	2020	2020
	(MW)	*(MW)*	*(MW)*	*(MW)*	*(MW)*	*(MW)*
Connecticut						
Biomass/Biofuels	0	51	55	66	100	51
Fuel Cells	3	30	42	66	693	30
Landfill Gas	8	20	22	27	20	20
Small Hydro	5	0	0	0	0	0
Solar PV	13	10	13	21	237	10
Wind	0	0	0	0	40	0
Offshore Wind	0	0	0	0	0	0
CT Total	**31**	**111**	**133**	**180**	**1,090**	**111**
ISO New England						
Biomass/Biofuels	457	145	221	382	194	145
Fuel Cells	4	30	42	66	693	30
Landfill Gas	111	36	38	43	36	36
Small Hydro	87	3	12	31	3	3
Solar PV	28	103	143	247	330	103
Wind	97	239	754	1,939	279	239
Offshore Wind	0	367	881	2,066	367	367
ISO-NE Total	**785**	**924**	**2,092**	**4,774**	**1,903**	**924**

Supply by 2013:

- Estimated from data for existing renewable units and planned additions through 2013.
- Data are based on: CELT, proposed project database from Velocity Suite, Project 150, state-level qualification databases, and assumed probabilities of project completion

Supply for Beyond 2013:

- For technologies other than onshore and offshore wind, 2013 capacity is assumed to increase modestly towards technical potential.
- ***Reference Strategy***: assumes additional wind be added to meet RPS (50/50 MW split between onshore and offshore).
- ***In-State Renewables Strategy***: assumes that Connecticut will meet RPS with in-state resources by 2020 by adding significant amounts of fuel cells (after tapping out biomass at 100 MW, solar at 237 MW and wind at 40 MW). Other states do not meet their respective RPS.
- ***Limited Renewable Strategy***: assumes no incremental renewable capacity is added after 2013.

Estimated REC Payment Required for Each Renewable Technology

Required REC payments are estimated based on the difference between the projected costs (fixed, variable, fuel, CO_2) and the revenues (energy, capacity, federal tax credits).

REC payments are expected to decrease as the revenues from energy and capacity markets increase.

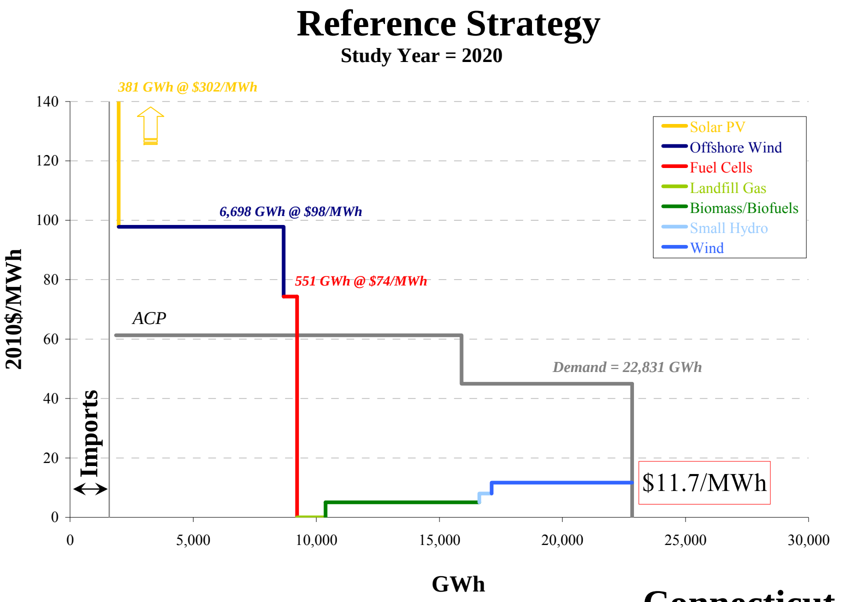
Projections for 2013 Current Trends

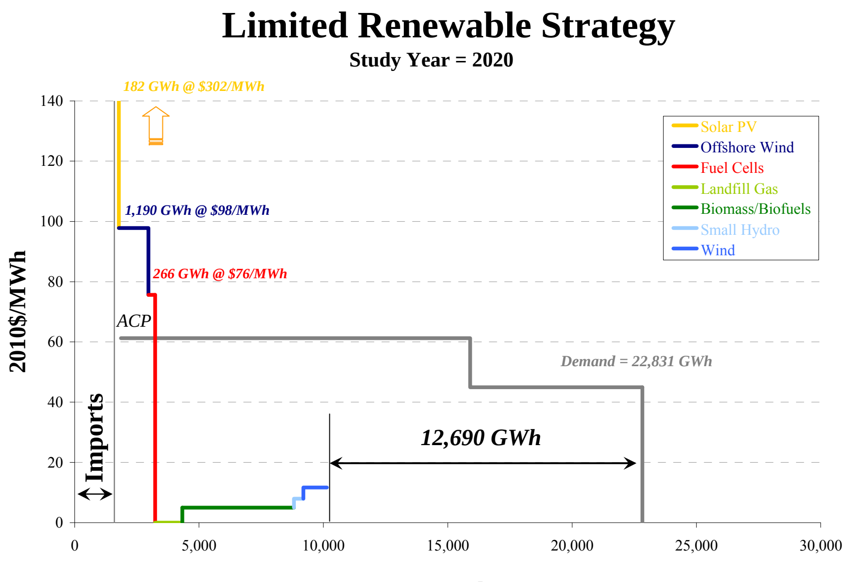
Technology	**Estimated Levelized Costs**	**Estimated Levelized Revenues**				**Estimated REC Price Needed**
		Energy	Capacity	PTC/ITC	TOTAL	
	($/MWh)	*($/MWh)*	*($/MWh)*	*($/MWh)*	*($/MWh)*	***($/MWh)***
	[a]	[b]	[c]	[d]	[e]=[b]+[c]+[d]	**[f] = max{[a]-[e],0}**
Landfill Gas	56.6	76.6	4.3	7.2	88.0	**0.0**
Biomass/Biofuels	110.1	76.6	4.3	14.3	95.2	**14.9**
Hydro	110.0	76.6	7.6	7.2	91.3	**18.6**
Wind	112.5	76.6	2.2	14.3	93.1	**19.4**
Fuel Cells	174.4	76.6	4.1	15.6	96.3	**78.1**
Offshore Wind	199.2	76.6	2.6	14.3	93.5	**105.7**
Solar PV	520.2	76.6	9.3	120.7	206.5	**313.7**

Under all scenarios, landfill gas, biomass, hydro and on-shore wind require REC payments less than the Connecticut ACP

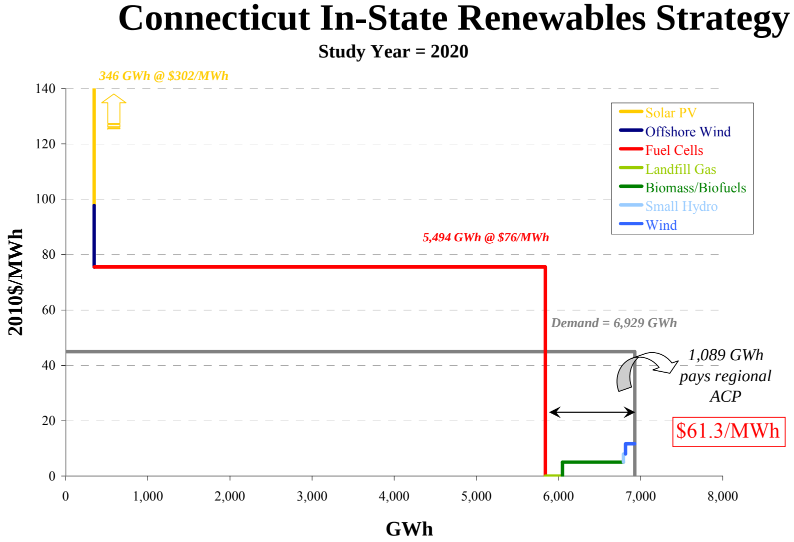
Fuel cells, off-shore wind and solar PV require REC payments greater than the ACP; out-of-market payments would be needed

Supply and Demand Balance Analysis and Estimated REC Prices for 2020

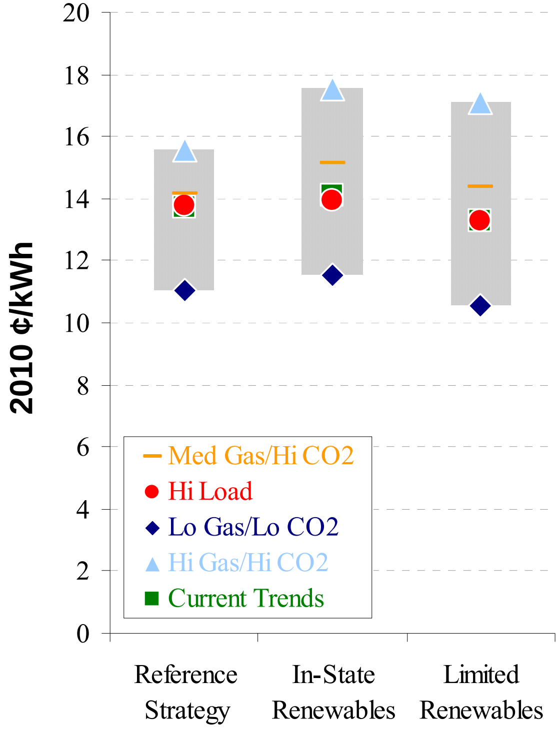




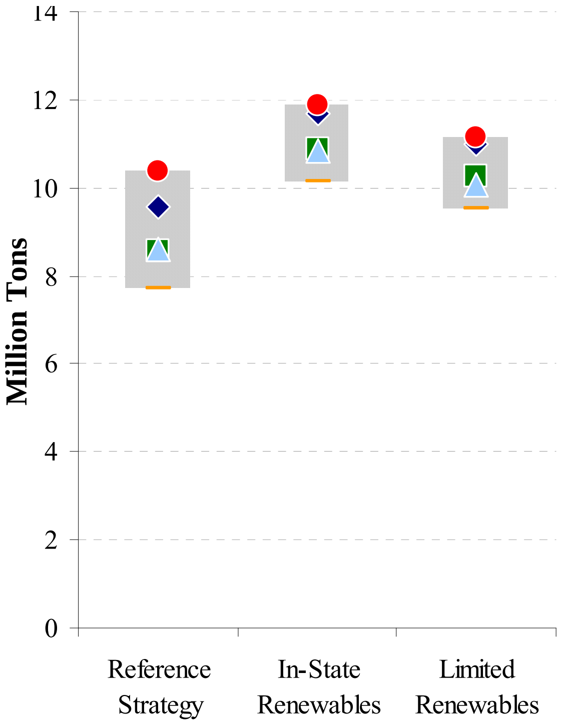
Based on Connecticut-Only Demand



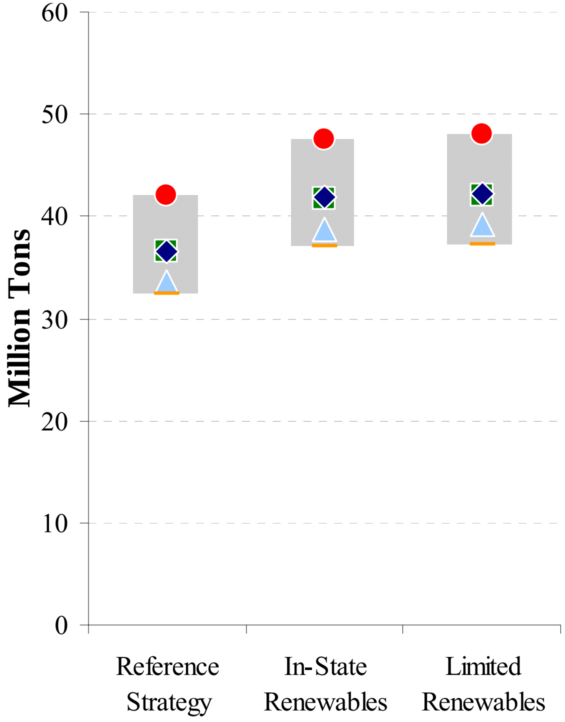
2020 Cost and Emissions Metrics



Average Power Supply-Related Costs



Connecticut CO_2 Emissions



New England CO_2 Emissions

Reference Strategy is likely to be less costly than In-State Renewables Strategy, and not significantly more costly than not meeting the RPS.

The two alternative strategies have costs that vary more greatly with natural gas and CO_2 prices than in the Reference Strategy, and do not provide substantial emissions benefits relative to their costs.

Estimated Capital Costs of Meeting Regional RPS

Approximately ~$20 billion of generation investment capital will be needed to meet the region's Class I RPS in 2020

- Much of this capital investment will be paid for through energy, capacity, and REC payments from the market
- Out-of-market payments in addition to tax credits will also be required for some resources

Another ~$10 billion of transmission investment will be needed to support the integration of new renewable resources, particularly wind.

- This implies ~0.9¢/kWh incremental transmission cost

Findings: Renewable Energy

- The optimal strategy for meeting the State’s RPS requirement is to procure renewable energy as part of a New England regional market.
- Renewable potential in New England is substantially larger than needed to meet RPS.
- Connecticut has limited cost-effective renewable potential in-state.
- The RPS requirements of the New England states are likely to be met through 2012. There is significant uncertainty regarding the overall supply and demand balance and the likely REC prices beyond 2012.
- Substantial transmission investment will be needed to connect sufficient renewables to meet regional RPS requirements. The cost of such transmission is likely to be large, but much less than the cost of building renewables in-state, and not significantly larger than the cost of failing to meet the RPS entirely.
- An in-state renewable strategy would rely heavily on natural gas powered fuel cells, and would not significantly abate CO_2 emissions.

Findings: Renewable Energy (continued)

- Based on current cost and price projections, landfill gas, biomass, small hydro, and onshore wind require REC prices that are below the Connecticut's ACP. However, fuel cells, offshore wind and solar PV would require payments greater than the ACP and would require support from additional subsidies or out-of-market instruments to be developed.
- Investing in new renewable generation provides significant environmental benefits to New England.
- Constructing sufficient new renewable generation in New England would require a major capital investment, in the range of about $20 billion for the generation plus about $10 billion for associated transmission by 2020. Much of the capital investment in generation would be paid for by revenues from the energy and capacity markets, but REC payments and out-of-market payments would also be required for some resources.
- Connecticut policy makers need to engage with other New England states to develop a comprehensive regional renewable energy policy. The New England states should work to define the best and most cost-effective means to expand renewable energy development in New England and the surrounding regions while meeting environmental goals.

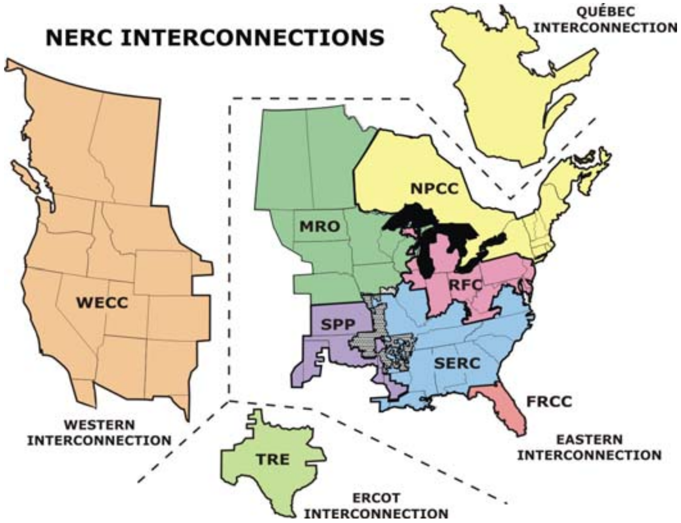
4. Transmission

Objectives: Transmission

- **Describe the transmission planning process in New England and how various national and regional entities work together to ensure a reliable transmission system.**
- **Propose a planning process that integrates Connecticut state processes with regional planning processes.**
  - Provide an efficient and effective means of considering alternatives to transmission upgrades located in Connecticut.
  - Propose a criteria to identify viable candidates for consideration as alternate means of satisfying reliability needs.
  - Apply proposed criteria to ISO-NE RSP 2009 projects in Connecticut.
- **Provide a status update on NEEWS.**

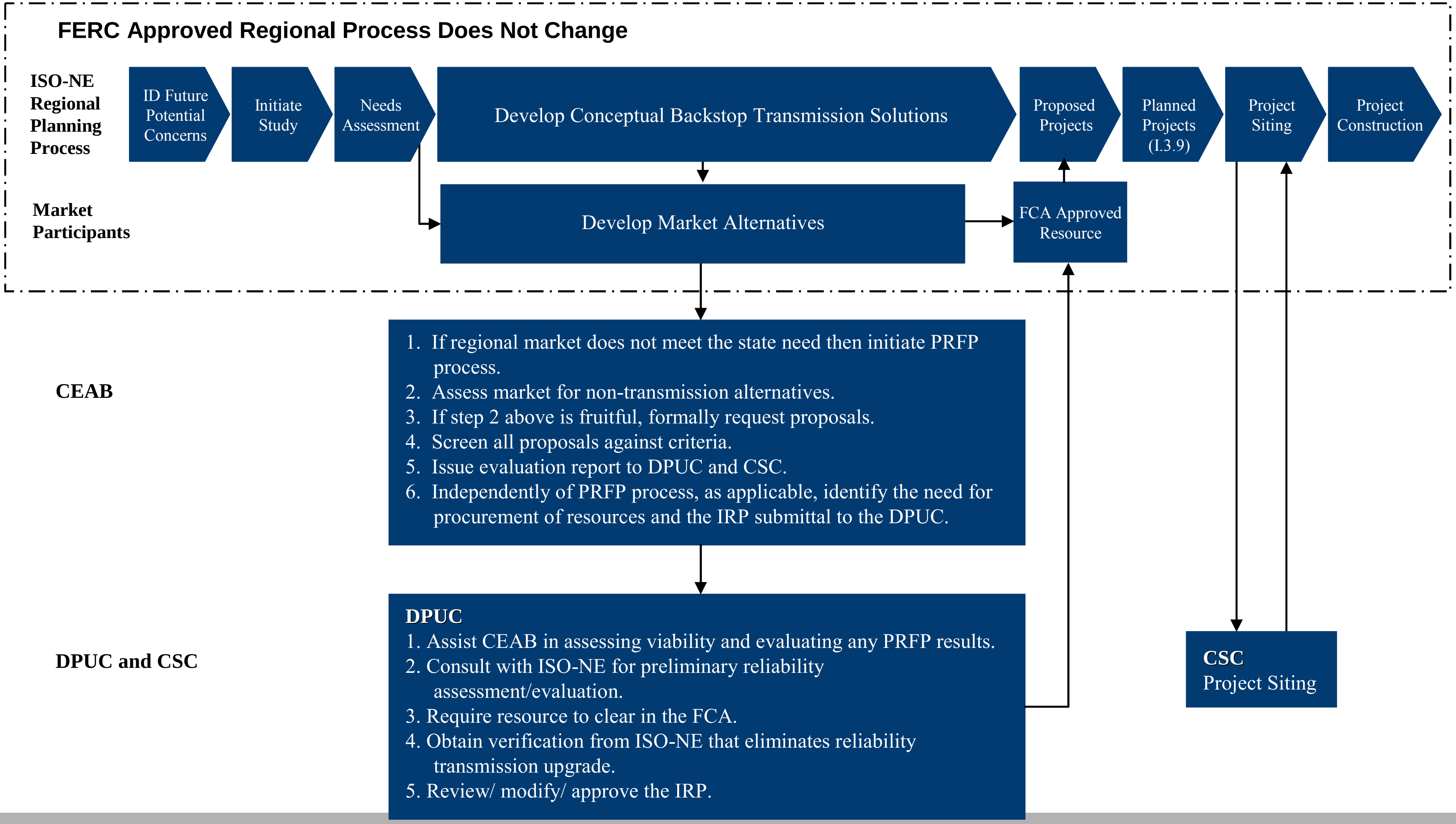
Background

- FERC ensures the reliability of the interstate transmission system.
- NERC, designated by FERC as the ERO, enforces mandatory reliability standards which are applicable across North America.
- NPCC, designated by NERC as the Regional Entity, enforces reliability standards and criteria that are more stringent than NERC.
- ISO-NE, designated by FERC as the Planning Authority for New England, plans and operates the New England transmission system.
- ISO-NE and the TOs are responsible for planning and operating the New England transmission system in full compliance with mandatory NERC and NPCC reliability standards.



Process

CL&P/UI Proposed Connecticut Process to Address Identified Reliability Needs



FERC Approved Regional Process Does Not Change

ISO-NE Regional Planning Process

ID Future Potential Concerns

Initiate Study

Needs Assessment

Develop Conceptual Backstop Transmission Solutions

Proposed Projects

Planned Projects (I.3.9)

Project Siting

Project Construction

Market Participants

Develop Market Alternatives

FCA Approved Resource

CEAB

1. If regional market does not meet the state need then initiate PRFP process.
2. Assess market for non-transmission alternatives.
3. If step 2 above is fruitful, formally request proposals.
4. Screen all proposals against criteria.
5. Issue evaluation report to DPUC and CSC.
6. Independently of PRFP process, as applicable, identify the need for procurement of resources and the IRP submittal to the DPUC.

DPUC and CSC

DPUC

1. Assist CEAB in assessing viability and evaluating any PRFP results.
2. Consult with ISO-NE for preliminary reliability assessment/evaluation.
3. Require resource to clear in the FCA.
4. Obtain verification from ISO-NE that eliminates reliability transmission upgrade.
5. Review/ modify/ approve the IRP.

CSC
Project Siting

NOTE: See Figure 4.3 in 2010 IRP for entire discussion

Proposed Criteria

Proposed Criteria to identify Viable Candidates for Consideration as Alternative Means of Satisfying Reliability Needs

New Substation Facilities

Category (A)

- New planned substation facilities
- Statutory change exempted this type of project from Reactive RFP
- See Table 4-1

Infrastructure Upgrades

Category (B)

- Reliability upgrades to existing equipment, for example; capacitor bank upgrades, circuit breaker replacement, relaying upgrades, transformers, and other existing transmission infrastructure
- See Table 4-2

RFPs are not likely to result in viable alternatives

New Transmission Lines

Category (C)

- New transmission lines (typically 115 kV or 345 kV)
- Address reliability needs that cannot be resolved by upgrading existing infrastructure
- See Table 4-3

Reliability Studies in Connecticut

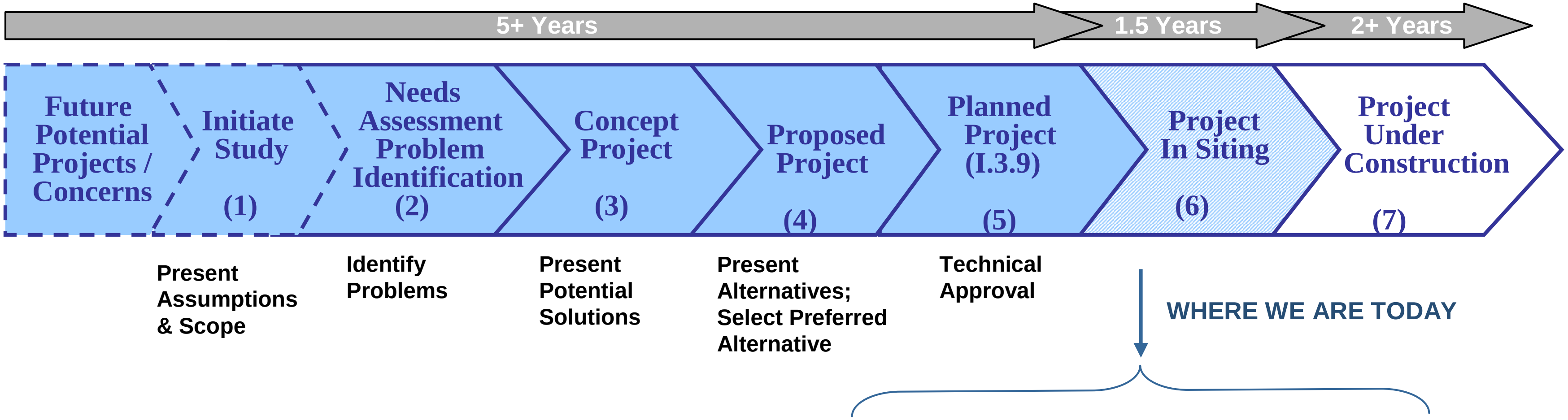
- Reliability assessments are currently underway by ISO-NE and the TOs for various areas in Connecticut
- For reliability studies in Connecticut see Section 4.E

Under certain circumstances, RFPs may be applicable for soliciting alternatives

NOTE: For additional detail see Section 4.D and 4.E in 2010 IRP for entire discussion of proposed projects

NEEWS Project Update

High Level Planning and Siting Process Summary



Present Assumptions & Scope

Identify Problems

Present Potential Solutions

Present Alternatives; Select Preferred Alternative

Technical Approval

WHERE WE ARE TODAY

	Planned Project (I.3.9)	Preparing for Siting	Municipal Consultation	Project in Siting	Construction
Greater Springfield	✓	✓	✓	✓	
Interstate	✓	✓	✓		
Central Connecticut	✓	✓			

Findings: Transmission

- The EDCs have proposed a process that will provide an efficient and effective means of considering alternatives to transmission upgrades by integrating Connecticut state processes and statutes with the region-wide open and transparent planning process administered by ISO New England.

- Connecticut state agencies (*e.g.*, DPUC, CEAB, OCC) will benefit from early warning of upcoming major transmission projects and have an opportunity to influence outcomes by monitoring the Regional System Plan and the multiple ongoing Connecticut-related transmission studies and participating in regional processes (as appropriate).

5. Nuclear Power

Objectives: Nuclear Power

Update the 2009 IRP assessment of nuclear power as a potential baseload addition

Illustrate the potential long-run market cost and emissions impacts of a nuclear expansion resource strategy for Connecticut

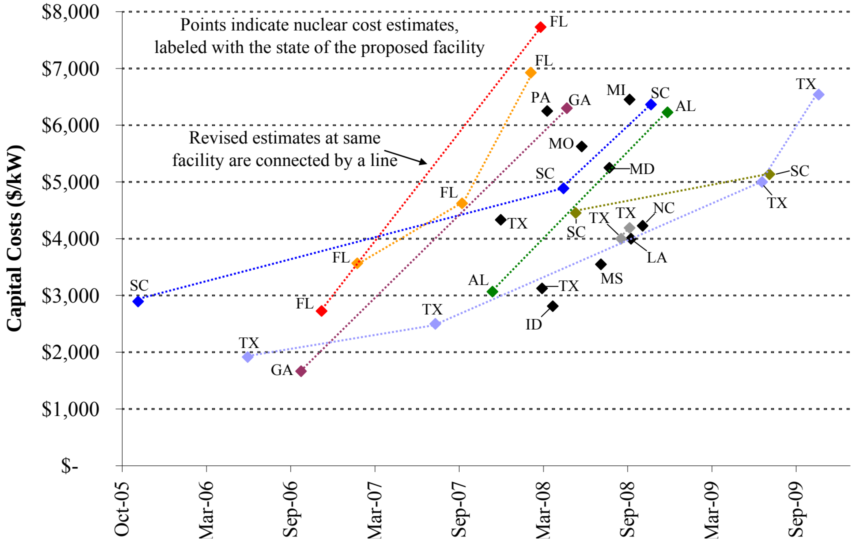
Status of Nuclear Industry

- U.S. nuclear fleet has performed well in past decade, providing reliable, low-cost baseload power
  - Capacity factors about 90%
  - Operating costs around 2¢/kWh
- About 25 new nuclear plants have been proposed in the U.S., with safer and simpler designs (Generation III, III+) than currently operating reactors (Generation II)
- The projected construction cost for nuclear increased sharply from about 2005-2008, not so much since
- Nuclear plants take 10-15 years to permit and construct
- Connecticut has a moratorium on new nuclear construction until long-run waste issue is resolved

Analysis Assumptions for Nuclear Strategy

A Nuclear Strategy was modeled to illustrate the potential long-run market cost and emissions impacts

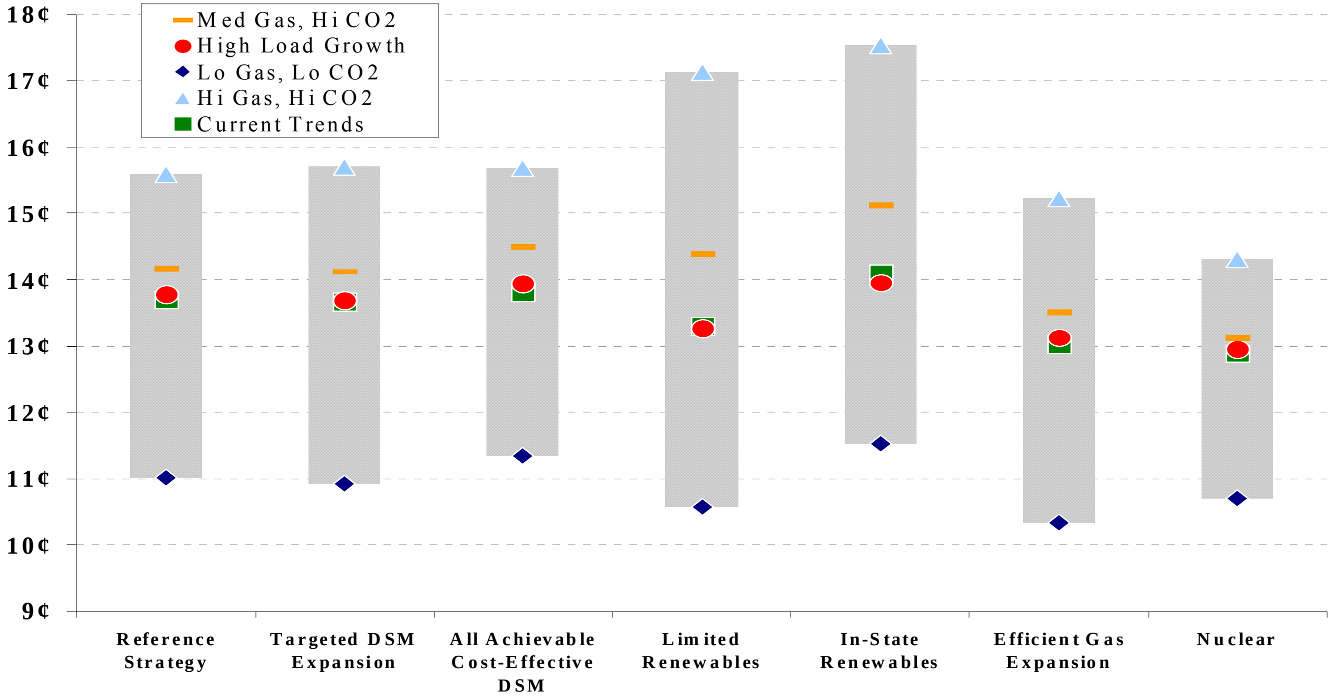
- Westinghouse AP1000 sited at Millstone
  - Assumed in service 2020, although would take longer to permit & construct even if decision to proceed made now
  - 1,100 MW expansion @ $5,000/kW overnight capital cost


Points indicate nuclear cost estimates, labeled with the state of the proposed facility

Revised estimates at same facility are connected by a line

Average Cost of Nuclear Strategy Across Scenarios

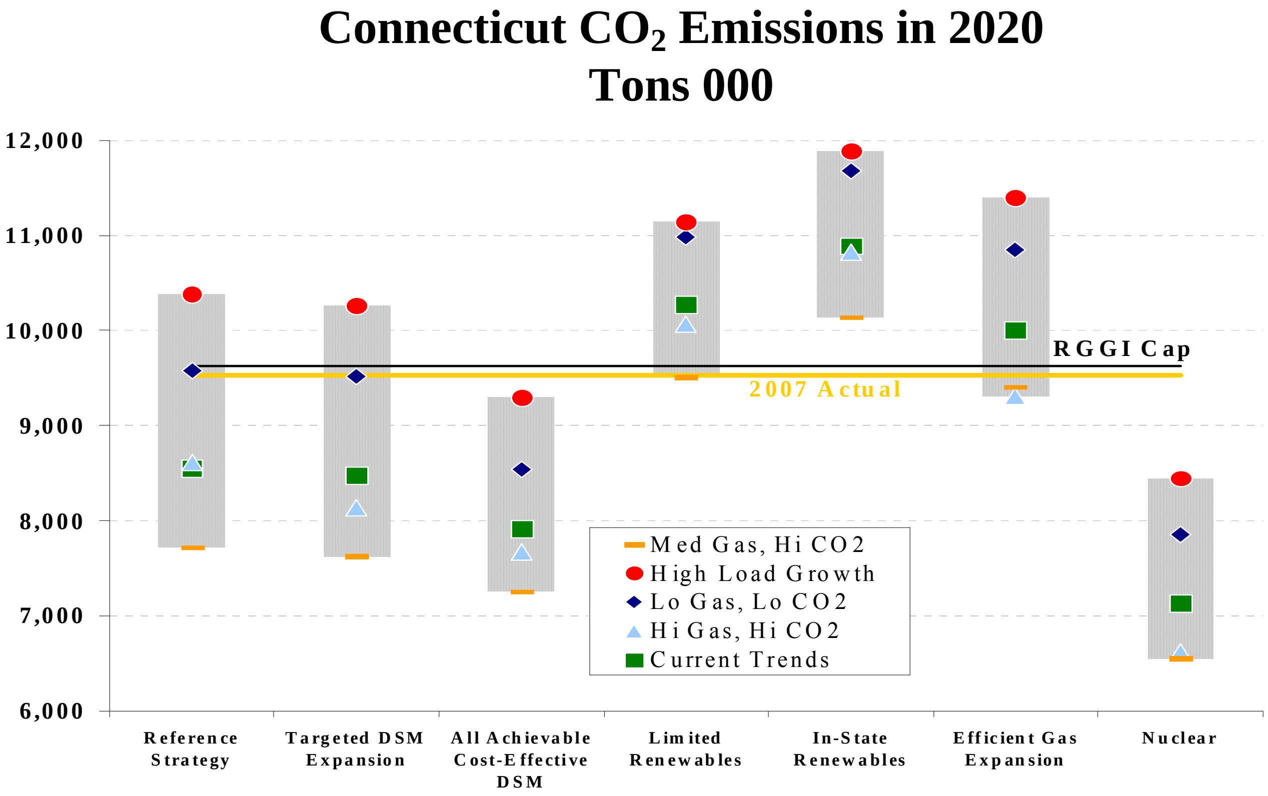
Average power supply-related cost of nuclear strategy analyzed compares well to other resource strategies, with less variation across scenarios



2020 Average Power Supply-Related Cost
(2010 ¢/kWh)

CO_2 Emissions are Lower with Nuclear

Nuclear strategy produces lower CO_2 emissions compared to other resource strategies

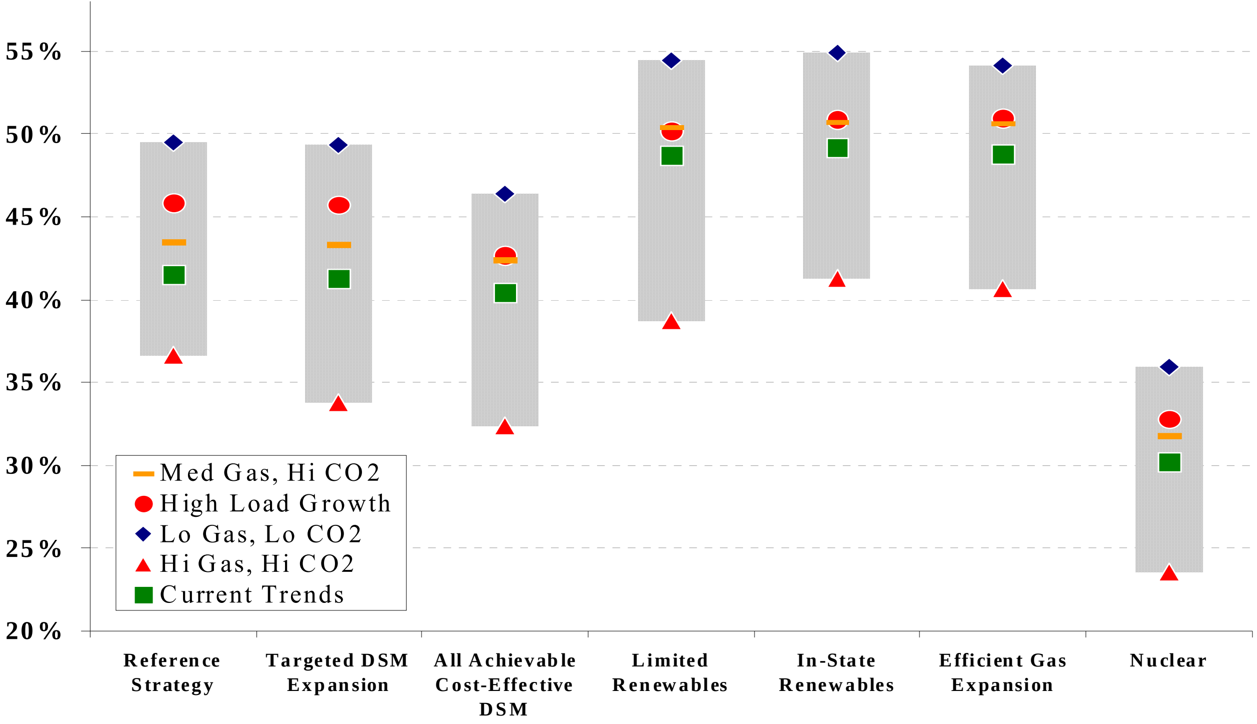


Connecticut CO_2 Emissions in 2020
Tons 000

Natural Gas Consumption is Lower with Nuclear

Nuclear strategy reduces reliance on natural gas generation compared to other resource strategies

Share of Natural Gas Fired Generation in Connecticut in 2020



Findings: Nuclear Power

- Nuclear generation has significant environmental benefits, including displacing fossil generation and associated greenhouse gases, while making Connecticut less reliant on natural gas generation.
- Nuclear capacity expansion is a long-term prospect – 10 to 15 years from the start of preparing a license application to commercial online date.
- New merchant nuclear capacity is unlikely to be developed in New England without a cost recovery approach that can mitigate the risks of high and uncertain capital costs, long lead time and the potential for costly delay.
- In light of the potential benefits of a nuclear strategy identified in our analysis, UI recommends that the CEAB conduct, sponsor or otherwise support a more detailed study of the potential costs and benefits of nuclear power, with the objective of providing a more complete picture of the tradeoffs encountered in considering nuclear power as a long-term resource strategy for Connecticut.

6. Combined Heat and Power

Objective: Combined Heat and Power

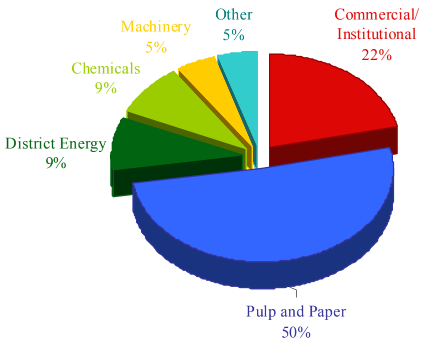
Update the Combined Heat and Power (CHP) analysis in the 2009 IRP and to summarize current status of CHP in Connecticut and potential for CHP expansion.

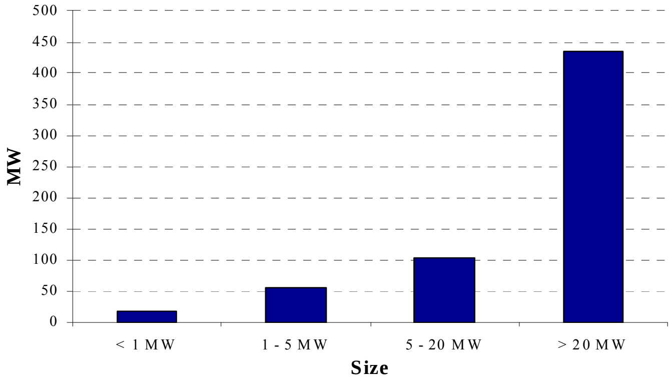
Current Status of CHP in Connecticut

Connecticut has over 600 MW of CHP capacity, primarily large (>20 MW) facilities associated with the pulp and paper industry

Connecticut CHP Capacity by Technology

CHP System	Electric Utility (MW)	Industrial (MW)	Commercial/ Institutional (MW)	Other (MW)	TOTAL (MW)	TOTAL (%)
Reciprocating Engine	0	6	17	3	27	4%
Gas turbine	0	127	70	0	198	32%
Steam turbine	0	231	24	0	254	42%
Microturbine	0	0	1	0	1	0%
Fuel cells	0	1	3	0	3	1%
Combined Cycle	56	56	17	0	129	21%
Total	**56**	**421**	**132**	**3**	**611**	**100%**



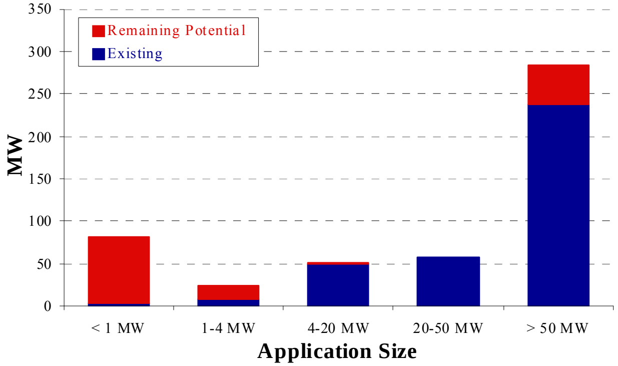


Remaining CHP Potential in Connecticut

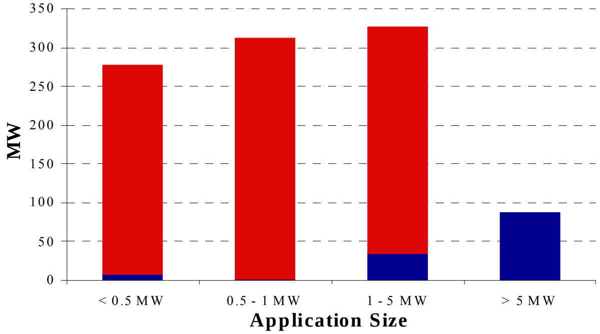
Remaining technical potential in Connecticut is primarily small applications (<5 MW) in commercial and institutional settings

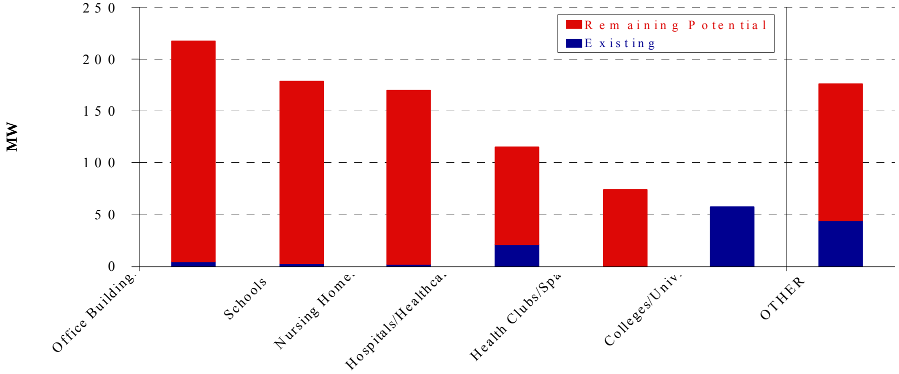
Estimated Technical Potential in Connecticut

Industrial



Commercial/Institutional





Findings: Combined Heat and Power

- Connecticut already enjoys high penetration of CHP for the most attractive large industrial applications, so there is limited remaining potential in this sector.
- Smaller, mostly commercial and institutional applications have significant remaining technical potential in Connecticut.

7. Environmental Regulations Affecting Electricity

Objective: Environmental Regulation

Describe existing and potential future environmental regulations that affect the power generation sector

- Work collaboratively with DEP to assess emission rate limits that may be need to be imposed to satisfy air quality standards, which may influence generator retirements
- Assess prospects for Federal greenhouse gas (GHG) legislation and likely CO_2 prices
- Other requirements that may add costs to generation

Collaboration with DEP on Emission Controls

The EDCs collaborated with CT DEP to analyze NO_X emissions on highest energy demand days (HEDD) with simulations

- Under current controls and expected load growth and generation NO_X HEDD emissions would exceed target levels in 2013, 2015 and 2020
- DEP determined that it would likely be necessary to impose controls on oil- and gas-fired steam units
  - 0.125 lb/mmBtu by 2013
  - 0.070 lb/mmBtu by 2017
- These limits were assumed adopted throughout New England, and resulted in retrofit controls and some generator retirements
  - Retrofit & retire decisions were used as a basis for all simulations
  - Results are detailed in Resource Adequacy Section III.1

Tighter Emission Limits Lead to Retrofits and Retirements

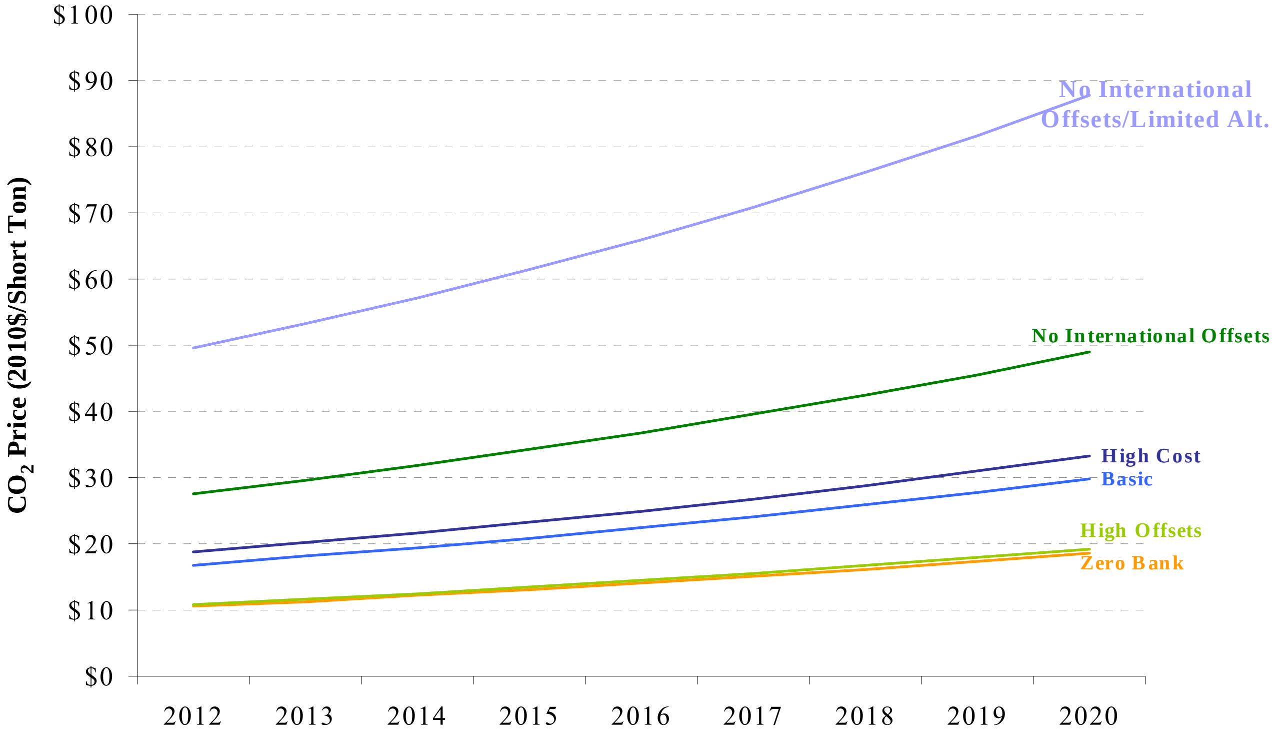
Simulation results for Connecticut show that:

- 1,504 MW of oil-fired steam capacity would retire by 2017
- 646 MW would install selective catalytic reduction (SCR) controls for NO_X
- These retirements and investments result in lower HEDD NO_X emissions.
  - Connecticut complies with the NO_X target in 2013, but exceeds it on two days in 2015, and exceeds it on five days in 2020
  - To meet NO_X targets in the future, therefore, CT DEP may have to apply even more stringent standards than analyzed here

CO_2 Price Forecasts Show Wide Range

The availability and use of domestic and international offsets (credits) for CO_2 emission reduction has significant impact on near-term CO_2 allowance prices

CO_2 Allowance Price Forecasts from EIA Analysis of Waxman-Markey

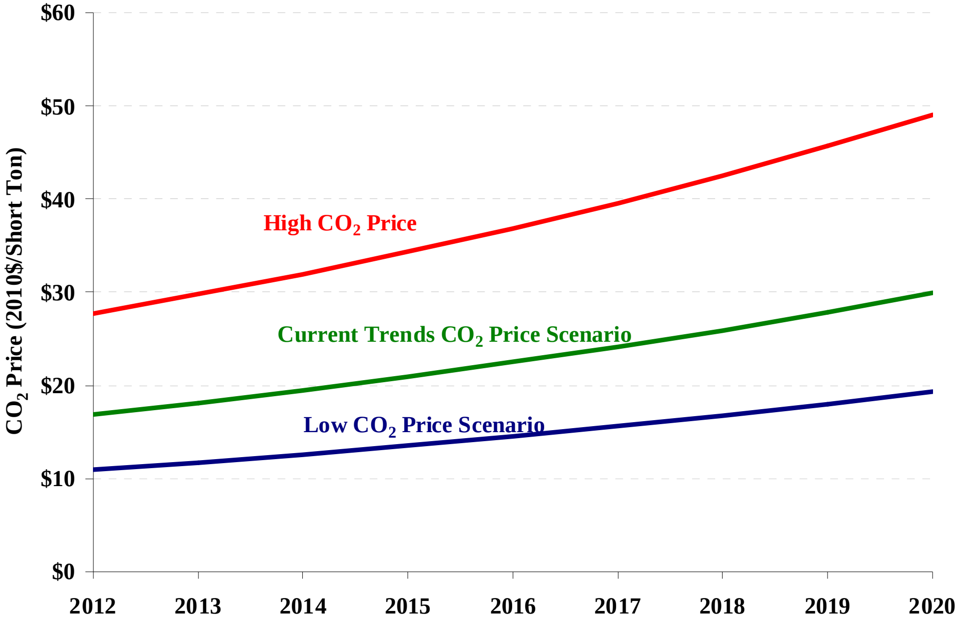


Source: EIA, Energy Market and Economic Impacts of H.R. 2454, Aug. 4, 2009.

CO_2, NO_X and SO_2 Allowance Prices Are Related

We selected reference, high and low CO_2 prices based on EIA forecasts under different assumptions regarding offsets, and adjusted SO_2 and NO_X allowance prices accordingly

CO_2 Allowance Prices Used in Scenarios



CO_2, NO_X and SO_2 Prices

	(units)	2013	2015	2020
REFERENCE CO2				
CO_2	*($/ton)*	18	21	30
NO_x	*($/ton)*	1962	2147	0
SO_2	*($/ton)*	726	831	301
HIGH CO2				
CO_2	*($/ton)*	30	34	49
NO_x	*($/ton)*	0	105	0
SO_2	*($/ton)*	339	160	3
LOW CO2				
CO_2	*($/ton)*	12	14	19
NO_x	*($/ton)*	2423	2592	2417
SO_2	*($/ton)*	756	762	936

Sources and Notes:
U.S. Energy Information Administration.
All values are in 2010$ per short ton.

Other Environmental Requirements on Generation

- Clean Water Act
- Coal Ash
- Environmental Justice

Findings: Environmental Regulation

- While there is uncertainty regarding future Federal climate legislation, the prospects appear likely enough for a range of CO_2 prices to be reflected in our analysis.

- Because Connecticut and other parts of New England are not in attainment with air quality standards, additional NO_X control requirements will likely be imposed on generators. The EDCs and CTDEP worked together to establish likely future NO_X emission requirements which were reflected in the simulation of the New England electricity market. The cost of these controls is projected to cause retirements of older fossil steam units in our analysis.

Findings: Environmental Regulation (continued)

- Emission allowance prices – for SO_2, NO_X, and CO_2 – will raise the costs of generation in proportion to unit emission rates, and will impact the dispatch of resources in New England and thereby reduce overall emissions. Although the prices of allowances for each pollutant are determined by aggregate emissions relative to an emission cap, these markets are not wholly independent. In particular, the price of CO_2 allowances can influence the price of SO_2 and NO_X allowances, an effect that was reflected in the analysis.

- The imposition of new regulations for other environmental sectors (not air) have the potential to introduce greater costs to generators, though the potential impact of these costs can not be determined at this time and thus were not reflected in the analysis.

8. Energy Security

Objective: Energy Security Analysis

Evaluate potential energy security concerns associated with energy resources for Connecticut

- Energy security relates to the “reliability of the power system … vulnerability to natural disasters, terrorism, fuel supply disruptions, or over reliance on foreign sources of fuel. ” (CEAB)
- Energy security is interpreted here to mean the reliable delivery of sufficient electric power to meet load under severe adverse events
  - The system is already planned, designed and operated to meet numerous strict reliability criteria
  - The analyses here go beyond traditional reliability requirements to look at key extreme events – to determine whether the system would likely avoid involuntary load curtailment in such an event

Power System is Managed for High Reliability

The power system is planned, designed, and operated to maintain energy security at very high levels

- Many organizations at national, regional and state levels are involved in energy security and reliability – *e.g.*:
  - DOE, DHS, FERC, NERC,
  - NPCC, ISO-NE
  - CSC, CEAB, DPUC, Connecticut DEMHS, local law enforcement
- Achieve reliability through resource requirements for spare capacity, redundancy, and operational flexibility
  - Installed Capacity Requirement (ICR), locational generation requirements (LSR, TSA, LFRM)
  - Regional System Plan (RSP)

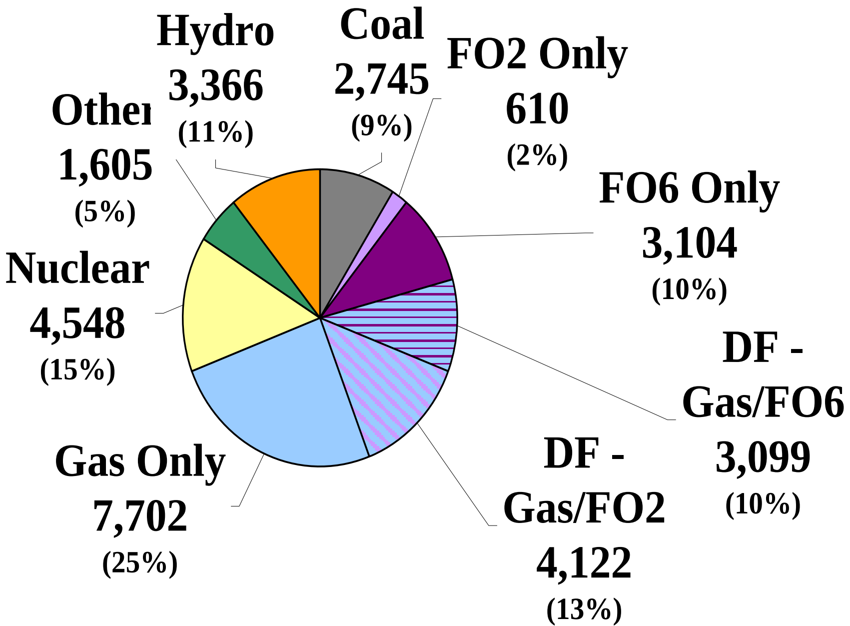
Market incentives further encourage merchant generators to provide power reliably

Gas and Nuclear are Key Generating Resources

Highest reliance on these resources

- May also be exposed to large-scale operability risks
- Capacity (not energy) is a better indicator of reliance

2008 New England Capacity (Summer MW)



Total: 30,902 MW

New England is generally the right geographic scope for energy security

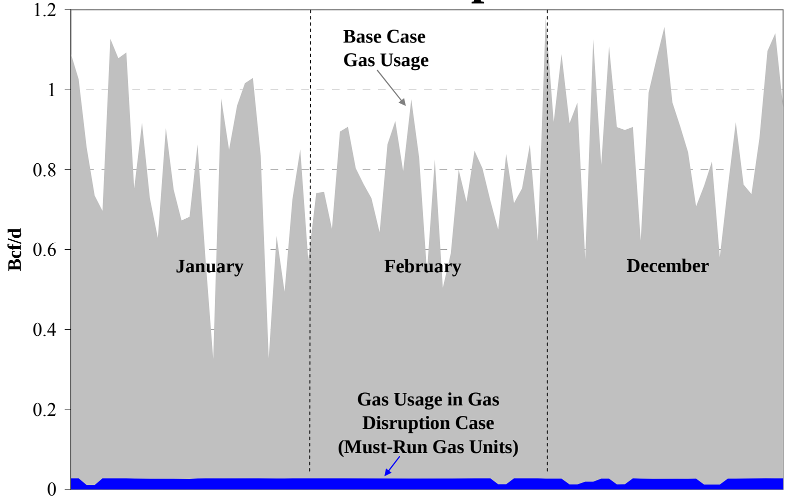
- Connecticut is well integrated with New England and does not stand as a separate entity.
  - Connecticut is expected to have a large surplus relative to locational needs, due to recent and planned transmission upgrades and resource additions

Energy Security: Winter Natural Gas Reliance

Natural gas reliance has been a concern during the winter heating season when gas demand is highest

- ♦ Core heating customers often have priority for gas, raising concerns about access to fuel supplies

Winter Natural Gas Usage, 2020
Base Case vs Gas Disruption Simulation



Simulation suggests that in future, it may be possible to meet winter load even in a (brief) total gas shutoff

- ♦ Dual fuel capability
- ♦ Three seasonal factors in winter:
  - Lower electric loads
  - Higher generating capacities
  - More wind

Energy Security: Nuclear Reliance

Nuclear: New England has 4,600 MW of nuclear capacity; a multi-unit shutdown could stress the system's ability to meet load

- *E.g.*, precautionary shutdown due to safety concerns, coinciding with summer peak loads

Simulated outage of two Millstone units (total 2,100 MW) in 2020

- Region-wide (not just Connecticut) capacity deficiency in ~60 high-load hours, up to ~2,000+ MW
- ISO identifies 4,600–5,600 MW available via established operating actions before involuntary load curtailment, e.g.:
  - Utilize operating reserves
  - Rely on neighboring control areas
  - Voluntary load curtailment

Energy Security: Transmission Reliance

The transmission system is designed and operated with redundancy and flexibility to absorb contingencies

- ♦ Three-stage response to contingency:
  - Operational response – dispatch around the contingency
  - Temporary repair – may be used to restore near-normal operation quickly
  - Permanent repair – restore full and permanent system capability
- ♦ Advance preparations facilitate rapid and effective response:
  - Critical transmission components are identified and spares are located strategically
  - Use mutual assistance agreements with other transmission owners – share crews, equipment, spare components

Most transmission contingencies will not interrupt customer service

- ♦ Even in an extreme event, any service interruption is likely to be brief

Findings: Energy Security

- The power system is planned, designed, and operated to maintain high energy security, building in spare capacity, redundancy, and operational flexibility. A number of organizations at the national, regional and state levels oversee and enforce reliability.

- Key resources for energy security include natural gas and nuclear generation, because of the system's heavy reliance on these generation types and the risks that could affect their operability, as well as the electric transmission system. Other resources – oil, coal, renewables – are unlikely to pose energy security concerns of comparable magnitude, due to the smaller role these resources play in providing power, and also because of a lack of exposure to significant risks.

- Natural Gas: The New England power system's reliance on natural gas was stress-tested by analyzing the loss of access to natural gas for several days during the winter months. This analysis suggests that there would be adequate other generation resources available to serve winter load, with no or virtually no reliance on natural gas. This is due to several seasonal factors that improve the winter resource balance, plus dual fuel capability that allows many gas-fired generators to utilize oil if gas is not available.

Findings: Energy Security (continued)

- Nuclear: A prolonged, simultaneous shutdown of multiple nuclear units at peak load times could stress the system's ability to serve load. However, it appears that even with the loss of both Connecticut nuclear units, the implementation of existing emergency operating procedures and additional reliance on imports from neighboring regions would allow the system to continue to serve load.
- Transmission: The electric transmission system is designed and operated with a level of redundancy that allows it to absorb isolated failures with no impact on customers. If an extreme event were to cause a more widespread transmission failure, the transmission owners' recovery capabilities and procedures ensure that any service interruption would be brief.

9. Natural Gas

Objectives: Natural Gas Analysis

Review the long-term regional market outlook for natural gas

- Commodity availability/price
- Interstate pipeline/LNG infrastructure
- Supply constraints
- Demand scenarios

Develop natural gas price forecasts for simulation analyses

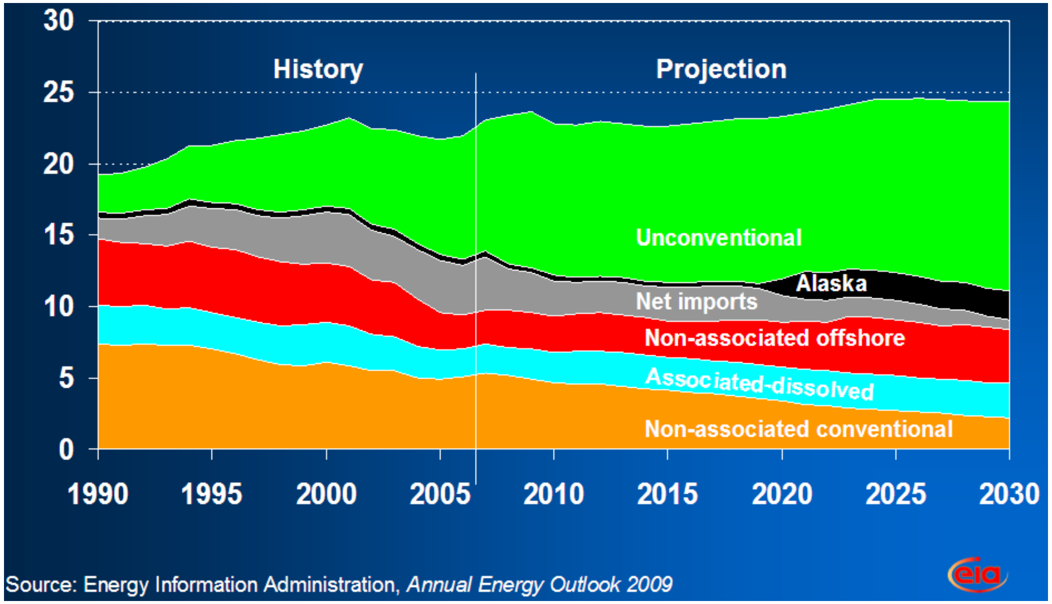
- Base Case: NYMEX + Basis + Local Transport (if applicable)
- Low Price Case: Robust supply availability
- High Price Case: Constrained supply environment

New Natural Gas Supply Sources

Unconventional gas supplies change supply outlook dramatically

- Proved reserves have risen significantly
- Production is increasing despite lower drilling activity
- Expanding supply at reasonable cost ($4-6/MMBtu)
- Conventional gas supplies (including Canadian) are less critical
- Possible constraint: shale gas water usage and potential contamination

Sources of Natural Gas Supply (Tcf)



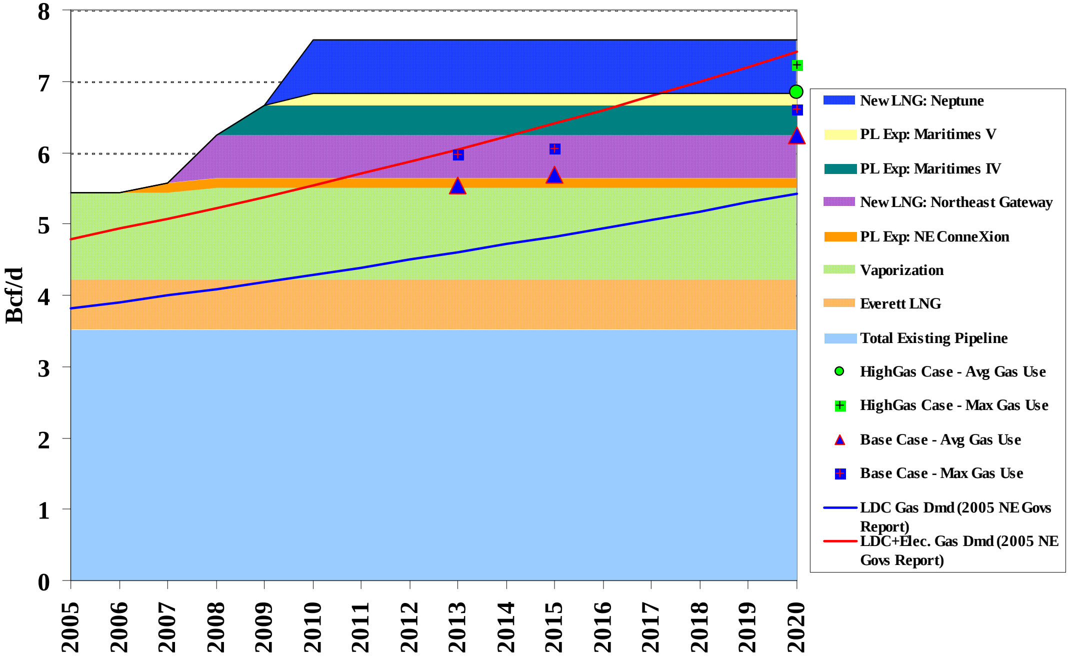
Source: Energy Information Administration, *Annual Energy Outlook 2009*

The Marcellus shale – a particularly promising formation – is in New York and Pennsylvania, very close to Connecticut

Natural Gas Delivery Capacity

New interstate pipeline and LNG import capacity have already improved New England delivery infrastructure. New projects in development could further enhance supply availability/reliability.

New England Peak-Day Delivery Capacity and Winter Demand for Natural Gas



This is not a complete peak-day LDC deliverability analysis; constrained areas within New England continue to exist and may require incremental expansion projects.

Note: Gas use for electric generators represents the Base Case (2013, 2015, and 2020) and a High Gas Demand Case (2020) from the 2010 IRP simulations.

LNG

Imported LNG (as well as Canadian conventional gas) may become less important for augmenting New England gas supplies, due to the advent of new domestic supplies at lower prices

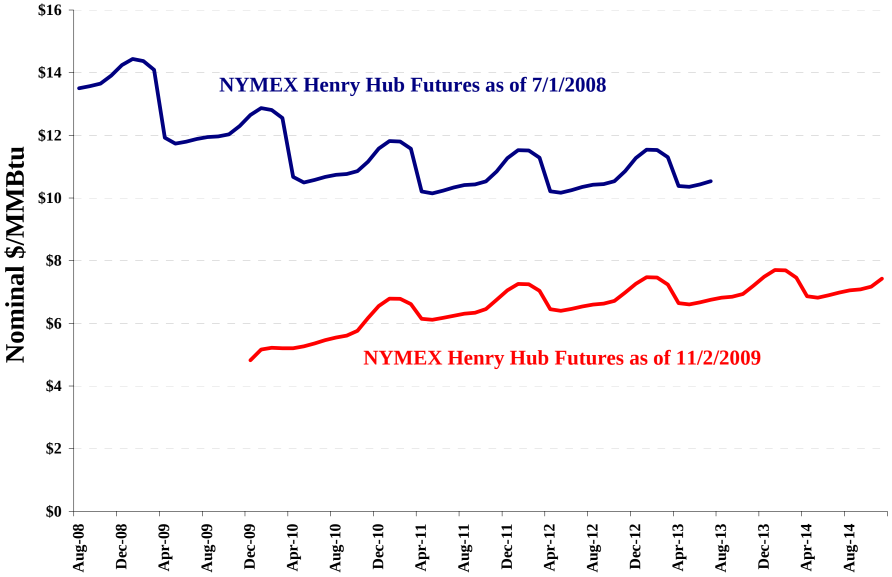
- This contrasts with expectations as recent as a couple years ago, which were part of the rationale for expanding the LNG import infrastructure
- Even so, the added infrastructure means imported LNG will provide a potential backstop for domestic supply, if availability becomes tight or prices get high
- New England will continue to rely on LNG for peak deliverability

Gas Price Scenarios

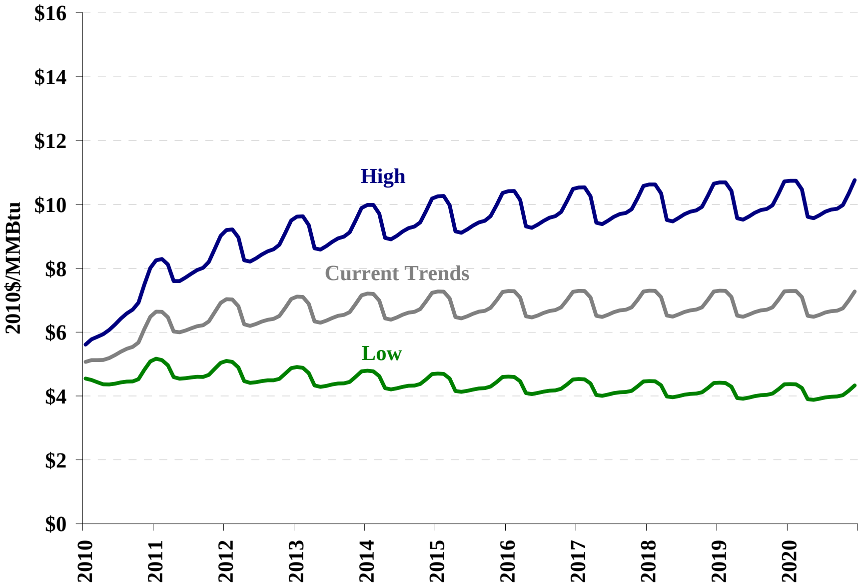
Natural gas futures prices have fallen considerably; future gas prices remain uncertain, though around a lower expected price

- Gas prices are expected to remain around $7/MMBtu in real terms

Natural Gas Futures Price Change July 2008 to November 2009



Natural Gas Price Scenarios for Simulation Analyses



Findings: Natural Gas

- The overall supply picture for domestic natural gas appears promising, due particularly to the advent of new unconventional gas supplies such as shale gas. This expanding supply should be adequate to accommodate even increased gas demand, though the ultimate extent and pace of the new supplies coming online is not certain.
- Pipeline and LNG delivery capacity to New England have increased over the past several years, with additional new expansion projects still in development for the near future. Gas delivery capacity to serve average and peak needs has improved measurably from a few years ago (though this does not address gas local distribution company (LDC) deliverability issues, where additional expansions may be necessary).

Findings: Natural Gas (continued)

- LNG and Canadian conventional gas may be less important for augmenting New England gas supplies than was expected in the recent past, due to the advent of new domestic supplies at lower prices. They will nonetheless continue to serve as a backstop for the availability and price of domestic gas supplies. Regardless of whether it actually does substitute for domestic gas more widely, LNG will remain a crucial component of New England's ability to meet peak gas demands in the winter heating season.

- Natural gas prices are expected to remain reasonable at around $7.00/MMBtu (real dollars) in the long term, driven largely by new unconventional supply sources. However there is no certainty that these current price expectations will be fulfilled; a long-term gas price range of approximately $4-10/MMBtu was examined in this study. Regardless of what happens to the long-term price of gas, short-term gas prices can be volatile.

Emerging Technologies

Objective: Emerging Technologies

Explore two emerging technologies that have the greatest potential to influence demand over the next decade:

- Plug-in electric Vehicles (PEVs) – rechargeable battery vehicles that could add to electric loads
- Advanced metering infrastructure (AMI) – part of the “Smart Grid” concept that has attracted much attention

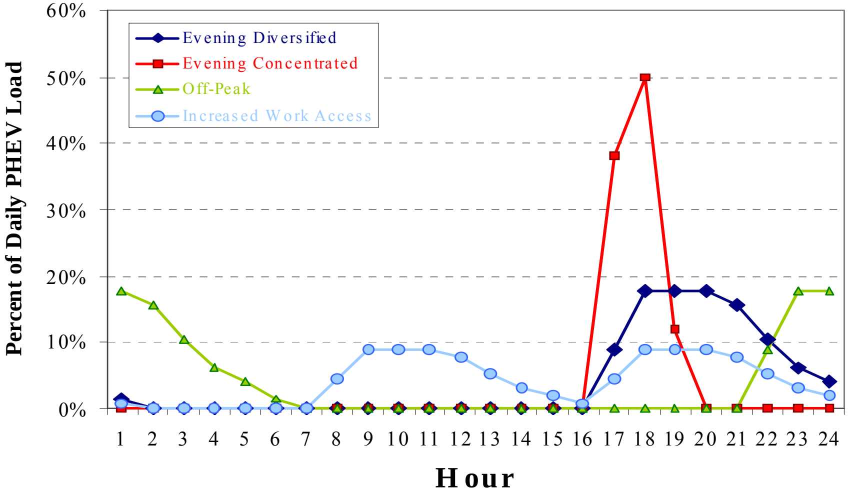
PEV Penetration and Charging Behavior Will Determine Impacts on Grid

PEV penetration into the fleet will be slow, but could rise to as much as 5% of the on-road fleet by 2020, and 25% by 2030

- This is an optimistic scenario that implies about 20% share of new car sales by 2020 and 50% by 2030

Impact on the grid depends on owners' charging patterns

- Depends on availability of charging stations at home, work and elsewhere – as well as preferences for fast/slow charging:

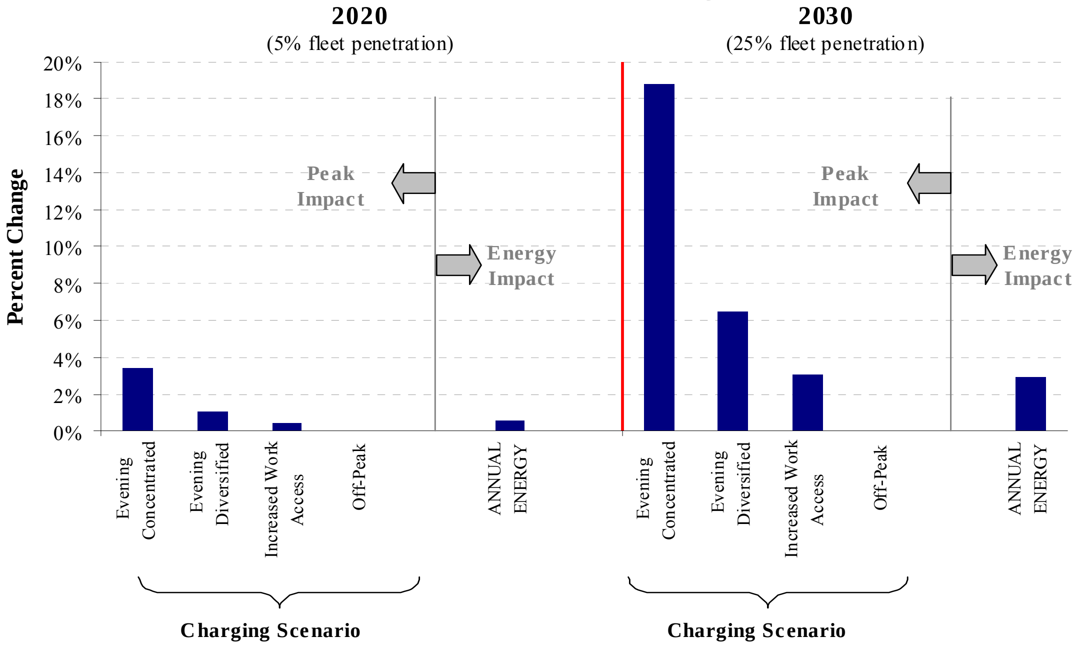


PEV Grid Impacts Are Likely to be Manageable

High PEV penetration does not appear to have unmanageable impact on peak or energy demand

- Assume some diversity in charging behavior
- Any significant impacts on peak are long run (2030)

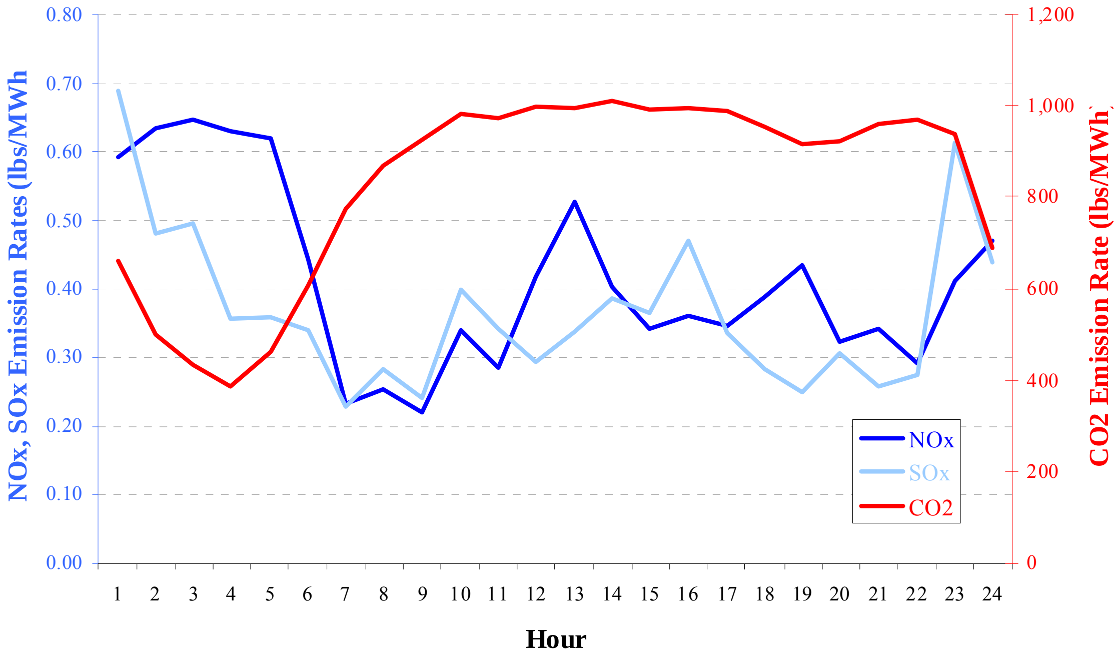
Potential Impact of PEVs on New England System Demand



Emission Impacts of PEV Depend on Charging Behavior

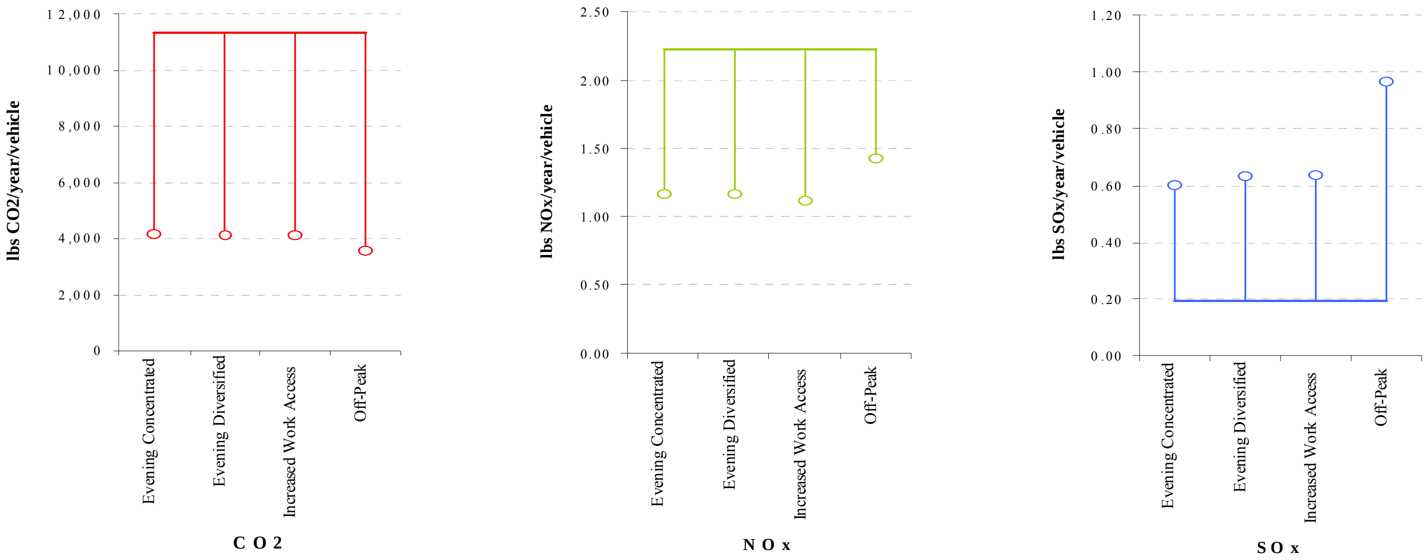
New England hourly emission rates vary, so different charging patterns will have varying impact on overall emissions

Average Hourly Marginal Emission Rates for Electricity Generation in New England in 2020



Modest Environmental Benefits Expected from PEVs

Annual Net Emission Impact per Vehicle
(assume PEV-40 replaces 25 mpg ICE car)



PEV penetration will reduce net CO$_2$ and NO$_X$ (accounting for vehicle and generation emissions) but increase SO$_2$ emissions

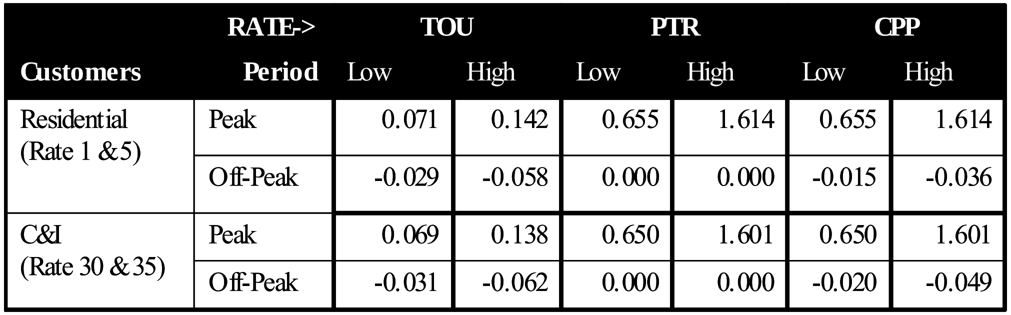
- **A 5 percent fleet penetration by 2020 would:**
  - **reduce net CO$_2$ by an equivalent of 4% of generation emissions**
  - **reduce net NO$_X$ by an equivalent of 1.5% of generation emissions**
  - **increase SO$_2$ by an equivalent of 0.4% of generation emissions**

AMI Investments Are Happening in Connecticut

AMI has gained momentum in Connecticut and elsewhere as part of the expanding “Smart Grid” Concept

- UI began to implement its meter enhancement plan
- CL&P conducted a pilot project to test AMI, dynamic pricing and enabling technology on residential, commercial and industrial (C&I) customers during the summer
  - Examined customer responses to critical peak pricing (CPP), peak time rebate (PTR) and time-of-use (TOU) rates

Rate Price Differentials by Rate Design ($/kWh)



	RATE->	TOU		PTR		CPP	
Customers	**Period**	Low	High	Low	High	Low	High
Residential (Rate 1 &5)	Peak	0.071	0.142	0.655	1.614	0.655	1.614
	Off-Peak	-0.029	-0.058	0.000	0.000	-0.015	-0.036
C&I (Rate 30 &35)	Peak	0.069	0.138	0.650	1.601	0.650	1.601
	Off-Peak	-0.031	-0.062	0.000	0.000	-0.020	-0.049

AMI & Dynamic Pricing: Impacts on Peak Demand

AMI coupled with dynamic pricing (CPP and PTR) had the largest impact on peak demand reductions. Customers with access to enabling technology demonstrated larger reductions

Demand Impact Results of CL&P Pilot Program

		TOU		PTR		CPP	
Customers	**Period**	High Diff.	With Tech	High Diff.	With Tech	High Diff.	With Tech
Residential (Rate 1 &5)	Peak Load Reduction	-3.1%		-10.9%	-17.8%	-16.1%	-23.3%
	Monthly consumption change	-0.1%		-0.2%		+0.2%	
C&I (Rate 30 &35)	Peak Load Reduction	0%		0%	-4.1%	-2.8%	-7.2%
	Monthly consumption change	0%		0%		0%	

Findings: Emerging Technologies

- Because of the growing commitments to plug-in electric vehicle (PEV) manufacturing and charging infrastructure on the part of vehicle manufacturers and electric utilities, PEVs appear poised to achieve an uncertain but potentially significant fleet penetration over the next decade.

- A 5 percent level of fleet penetration by 2020 represents an optimistic view of PEV vehicle sales over the next decade, but one that is worth exploring for its potential impact on the New England electricity system.

- Even an optimistic view of PEV penetration in New England over the next two decades is unlikely to pose any unmanageable issues for maintaining reliable electric service.

Findings: Emerging Technologies (continued)

- An optimistic view of PEV penetration in New England is likely to produce a modest environmental benefit, with net CO_2 and NO_X emissions decreasing and only a negligible increase in SO_2 emissions.

- Widespread implementation of advanced metering infrastructure (AMI) has the potential to decrease peak loads. The magnitude of the decrease will depend on customer participation rates in dynamic pricing programs and their responsiveness to near-term price signals.

- Enabling technologies can help customers respond more effectively to price signals, and AMI programs that encourage these technologies are more likely to yield more pronounced responses.