Preliminary Assumptions for Economic Studies

Planning Advisory Committee
June 16, 2010

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Overview

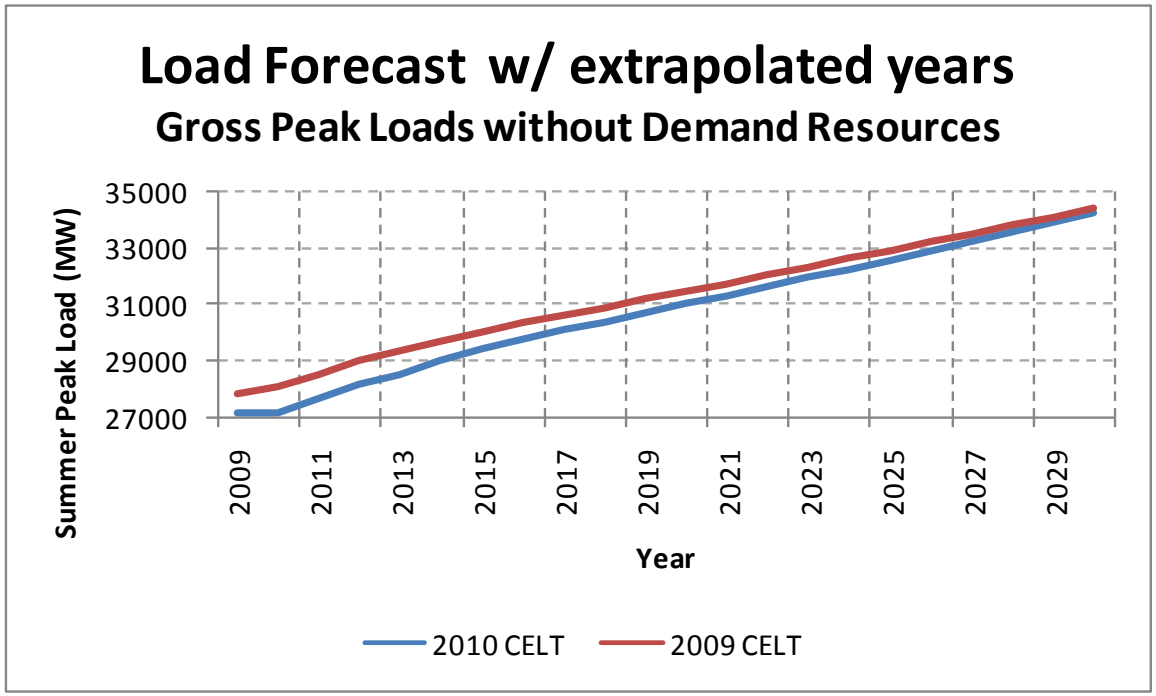
- Economic studies are performed under ISO New England's Open Access Transmission Tariff (OATT), Attachment K process (FERC Order 890)
  - ISO performs up to three economic planning studies each year
  - 2010 NESCOE request encompasses a breadth of requests
- Study Assumptions
  - Several "high level" scenarios were defined as the initial phase of the analysis
  - 2009 Governors' Study Assumptions adopted as the basic framework for base case
  - Refinement of assumptions developed as available

Framework for Analysis

- Build on the 2009 Governors' Study
  - Evaluate hypothetical New England system in 2030
- Supply resources considered
  - Energy Efficiency and Active Demand Resources
  - Wind based on ISO Queue and New England Wind Integration Study (NEWIS)
  - Combined-cycle (CC) resources
  - Canadian imports
  - Solar and biomass (states to identify targeted levels)
- Replace existing carbon-heavy resources

Load Forecast

- Summer peak load for (nominal) 2030 is 34,300 MW
  - Last year's estimate was 200 MW higher at 34,500 MW
  - With an 11.3% reserve margin, Installed Capacity Requirement (ICR) would be 38,200 MW



Areas Modeled

RSP Areas	Area Name
BHE	Bangor Hydro
BOST	Boston
CMAN	Central Massachusetts
CT	Connecticut
ME	Central Maine
NH	New Hampshire
N-NH	Northern New Hampshire
NOR	Norwalk
RI	Rhode Island
SEMA	Southeastern Masachusetts
SME	Southern Maine
SWCT	Southwestern Connecticut
VT	Vermont
WMA	Western Massachusetts

Internal Areas	Area Name
DRCT	WESTERN DEMAND RESPONSE
EECT	WESTERN ENERGY EFFICIENCY
EGCT	WESTERN EMERGENCY GENERATION
DRMA	EASTERN DEMAND RESPONSE
EEMA	EASTERN ENERGY EFFICIENCY
EGMA	EASTERN EMERGENCY GENERATION

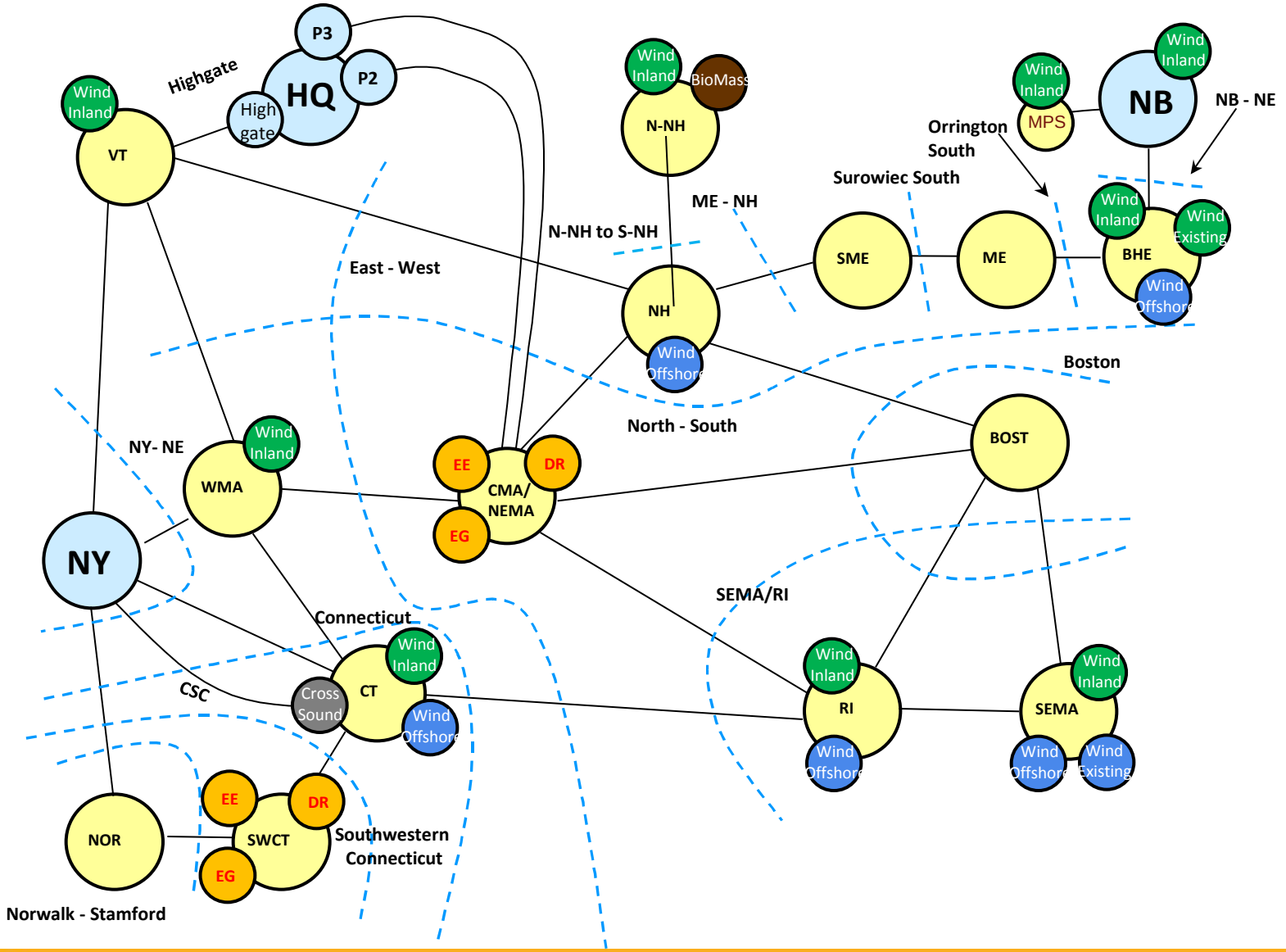
External Areas	Area Name
JCSP	JCSP INTERCONNECTION
HQHG	HQHG
HQP2	HQ PHASE II ECONOMIC MWH
HQP3	HQ PHASE III HYDRO OR ECONOMIC
XSND	CROSS SOUND CABLE
NY	NEW YORK
MARI	MARITIMES
MPS	MPS

Interfaces

- Interfaces to be evaluated two ways
  - Constrained using 2009 Regional System Plan (RSP09) interface limit assumptions
  - RSP09 includes
    - New England East West Solution (NEEWS)
    - Maine Power Reliability Program (MPRP)
    - Remaining constraints likely to impede delivery of energy
  - Unconstrained transmission sensitivity case
    - Energy Initiatives Group (EIG) transmission expansion assumed to create unconstrained transmission system to new wind resources, Canadian imports and Joint Coordinated System Plan (JCSP) alternatives

Base Interface Limits

Single-Value Summer Peak Transmission Interface Limits for Use in Subarea Transportation Models									
Interface	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
New Brunswick-New England	1000	1000	1000	1000	1000	1000	1000	1000	1000
Orrington South Export	1200	1200	1200	1200	1200	1200	1200	1200	1200
Surowiec South	1150	1150	1150	1150	1150	1150	1150	1150	1150
Maine-New Hampshire	1600	1575	1550	1525	1500	1475	1450	1450	1450
Northern NH to Southern NH	9999	9999	9999	9999	9999	9999	9999	9999	9999
North-South	2700	2700	2700	2700	2700	2700	2700	2700	2700
Boston Import	4900	4900	4900	4900	4900	4900	4900	4900	4900
SEMA Export	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit	No Limit
SEMA/RI Export	3000	3000	3000	3000	3300	3300	3300	3300	3300
East-West	2800	2800	2800	2800	3500	3500	3500	3500	3500
Connecticut Import	2500	2500	2500	2500	3600	3600	3600	3600	3600
Southwest Connecticut Import	3200	3200	3200	3200	3200	3200	3200	3200	3200
Norwalk / Stamford	1650	1650	1650	1650	1650	1650	1650	1650	1650
Cross-Sound Cable (CSC) (Out)	330	330	330	330	330	330	330	330	330
Cross-Sound Cable (CSC) (In)	346	346	346	346	346	346	346	346	346
NY-NE Summer	1400	1400	1400	1400	1400	1400	1400	1400	1400
NY-NE Winter	1875	1875	1875	1875	1875	1875	1875	1875	1875
NE-NY Summer	1400	1400	1400	1400	1400	1400	1400	1400	1400
NE-NY Winter	1400	1400	1400	1400	1400	1400	1400	1400	1400
HQ-NE (Highgate)	200	200	200	200	200	200	200	200	200
HQ-NE (Phase II)	1400	1400	1400	1400	1400	1400	1400	1400	1400



Modeling External Areas

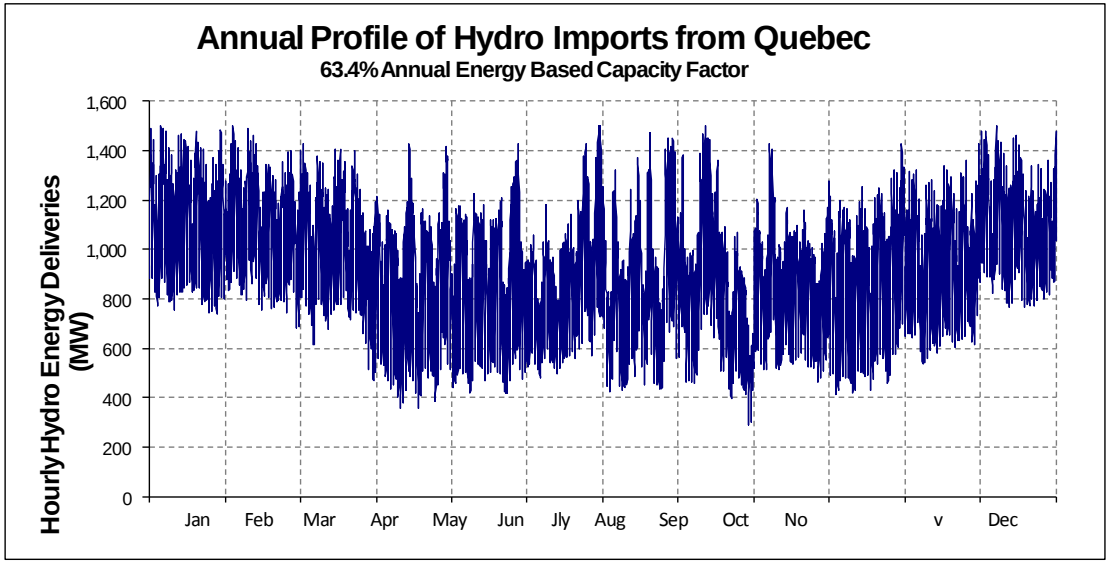
- Base Models for External Areas
  - No loads or resources modeled for New York, Maritimes, or Quebec
  - Existing Phase II modeled with economic opportunity blocks
    - Block 1: 300 MW at Natural Gas based on 8,400 Btu/kWh CC
    - Block 2: 300 MW at Natural Gas based on 10,349 Btu/kWh Steam
    - Block 3: 300 MW at Distillate Fuel Oil based 12,593 Btu/kWh Combustion Turbine (CT)
  - Maritimes bubble has no loads or resources
    - Sensitivity case will investigate the effect of Maritimes
  - Maine Public Service (MPS) modeled using a BHE load shape
    - Connected via the Maritimes bubble
    - Limited number of resource
    - 100 MW Cross Sound Cable export assumed
    - NYPA purchases assumed to continue
  - Vermont Joint Owners (VJOs) purchases assumed to continue

Load Shape Modifiers

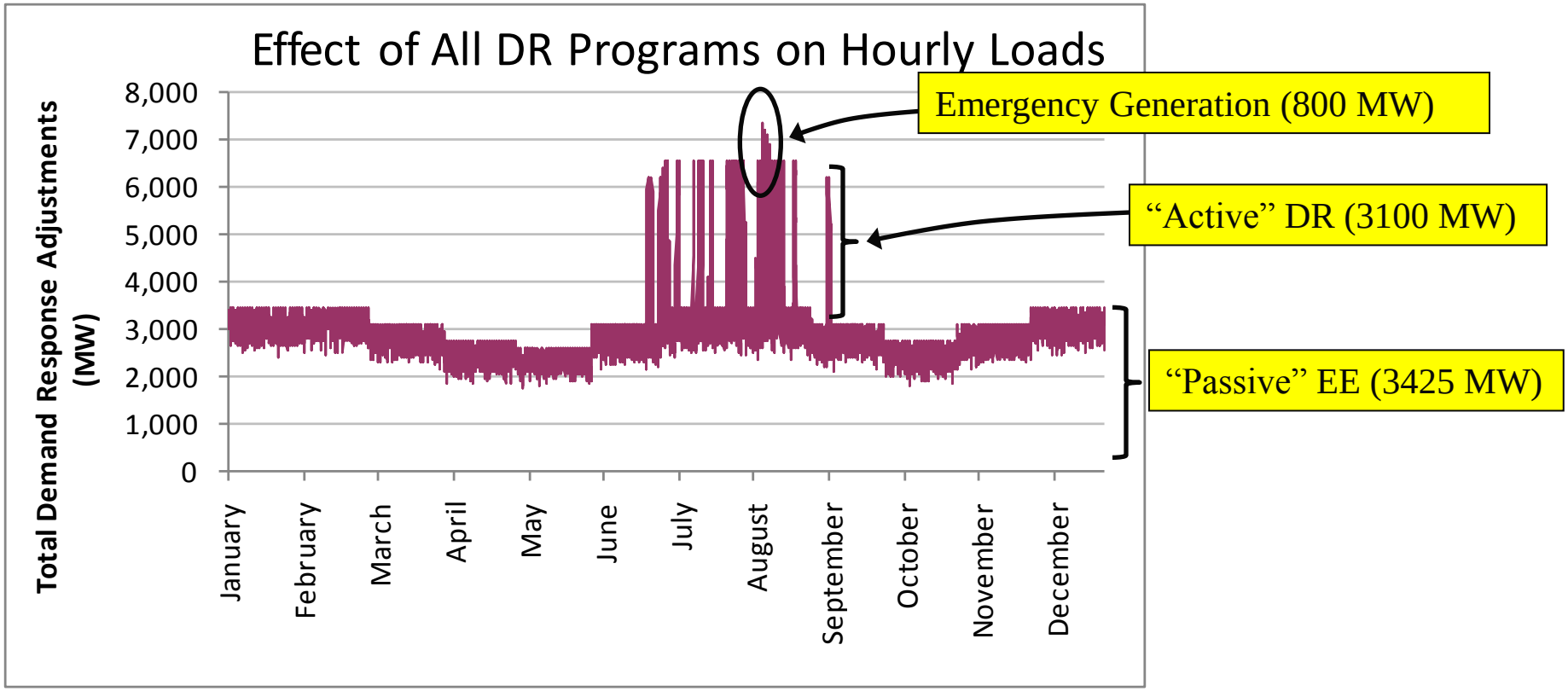
- Dispatch of resources are based on pre-specified profiles
  - Wind
    - Meteorologically co-occurring wind and loads based on data developed for NEWIS
      - ME-BHE (On-shore)
      - ME-CMP (On-shore)
      - NH (On-shore)
      - RI (Off-shore)
      - SEMA (Off-shore)
      - VT (On-shore)
      - WEMA (On-shore)
  - Canadian hydro imports
    - Assumed to have a capacity factor of 63%
- Energy Efficiency is a discrete “supply side” resource
  - 38% in west side of East / West interface (based on load share)
  - 62% in east side of East / West interface (based on load share)

Canadian Hydro Imports

- Assumed 63.4% capacity factor
  - Consistent with 2007 Scenario Analysis
  - Peak-shaving bias for energy deliveries
  - 8.3 TWh of energy is comparable to Firm Energy Contract (7 TWh)
  - Several lines (~1,500 MW each) added to supplement other resources required for the retirement of carbon-heavy resources



Energy Efficiency (EE) / Demand Resources (DR) / Real-Time Emergency Generation (RTEG) Load Modifiers (Base Case)



Wind Models

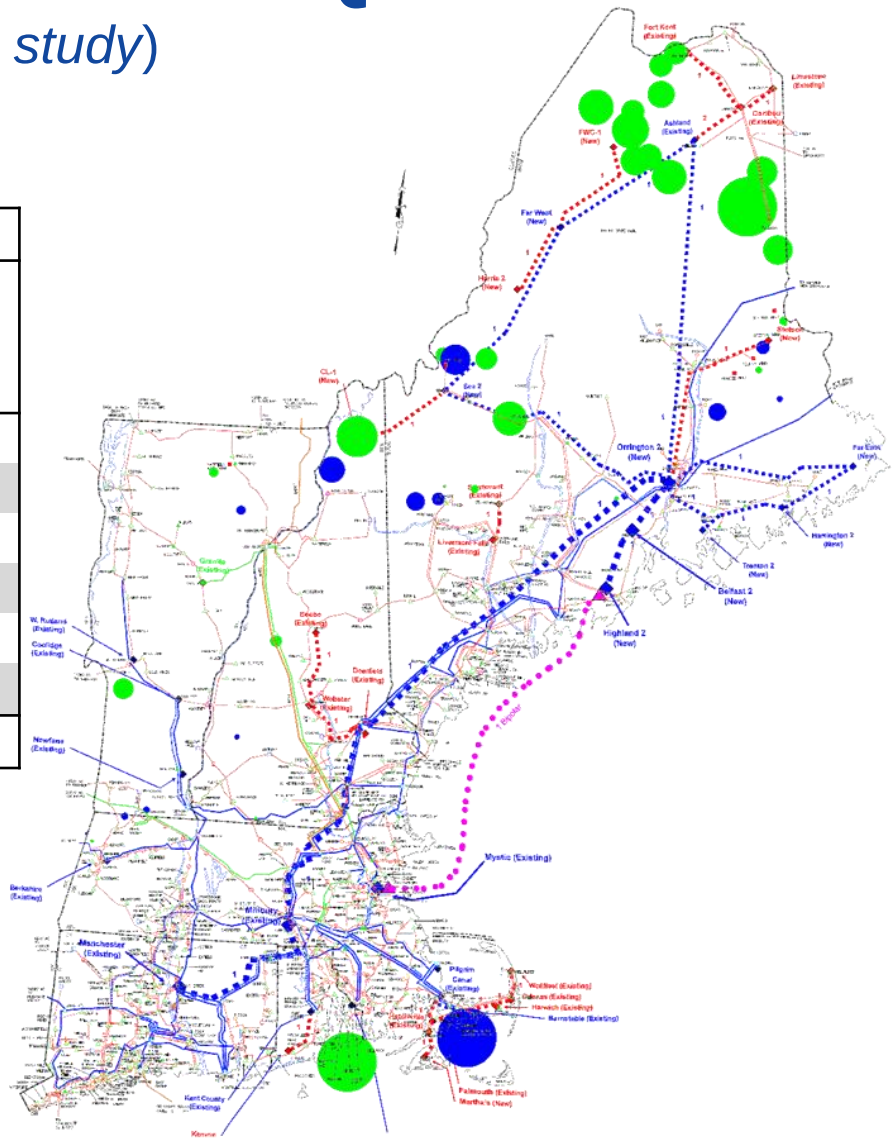
- Based on NEWIS
  - New England sites
  - Neighboring area sites
- Multiple wind models have been developed
  - Hourly granularity
  - Site specific (aggregated to an RSP bubble)
  - Correlated to meteorology present in the loads
  - Intention
    - Not intended to be estimates for specific project
    - Intended to be regional estimates

Full Build-out of Wind in the Queue

Total: 4.36 GW (*Base case for 2010 study*)

2 GW Transmission Overlay

State	Onshore			Offshore			Capacity Factor (%)		
	Site Count	Name Plate (GW)	Energy (GWh)	Site Count	Name Plate (GW)	Energy (GWh)	On shore	Off shore	Total
CT	-	-	-	-	-	-	0%	0%	0%
ME	30	2.888	8,043	-	-	-	32%	0%	32%
MA	2	0.044	135	1	0.460	1,615	35%	40%	40%
NH	5	0.400	1,290	-	-	-	37%	0%	37%
RI	-	-	-	1	0.360	1,295	0%	41%	41%
VT	5	0.209	584	-	-	-	32%	0%	32%
Total	42	3.541	10,053	2	0.820	2,910	32%	41%	34%

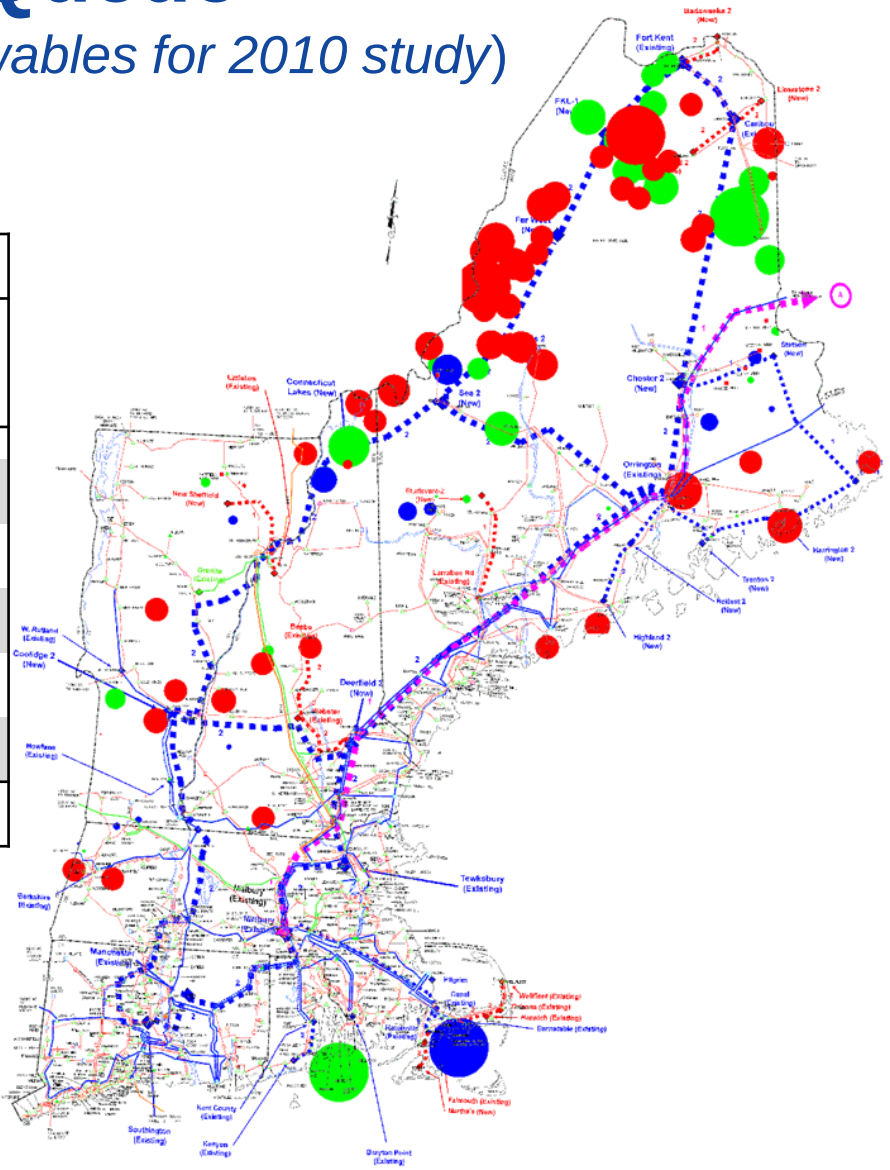


Best Onshore + Full Queue

Total: 9.77 GW (*New England renewables for 2010 study*)

4 GW Transmission Overlay

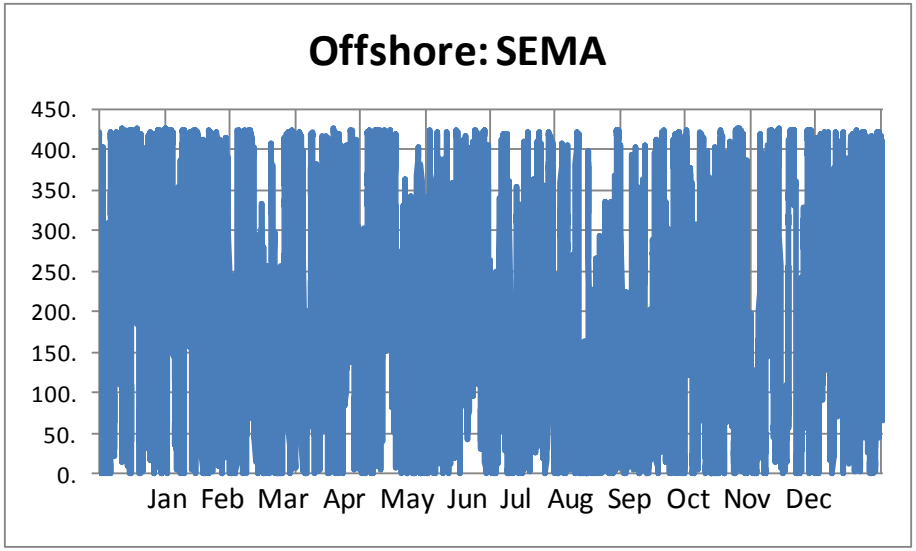
State	% Energy by State	Onshore			Offshore			Capacity Factor (%)		
		Site Count	Name Plate (GW)	Energy (GWh)	Site Count	Name Plate (GW)	Energy (GWh)	On shore	Off shore	Total
CT	0%	-	-	-	-	-	-	0%	-	0%
ME	157%	63	7.006	20,274	-	-	-	33%	0%	33%
MA	4%	4	0.244	696	1	0.460	1,615	33%	40%	37%
NH	30%	12	1.064	3,335	-	-	-	36%	0%	36%
RI	10%	-	-	-	1	0.360	1,295	0%	41%	41%
VT	23%	11	0.635	1,845	-	-	-	33%	0%	33%
Total	20%	90	8.949	26,150	2	0.820	2,910	33%	41%	34%



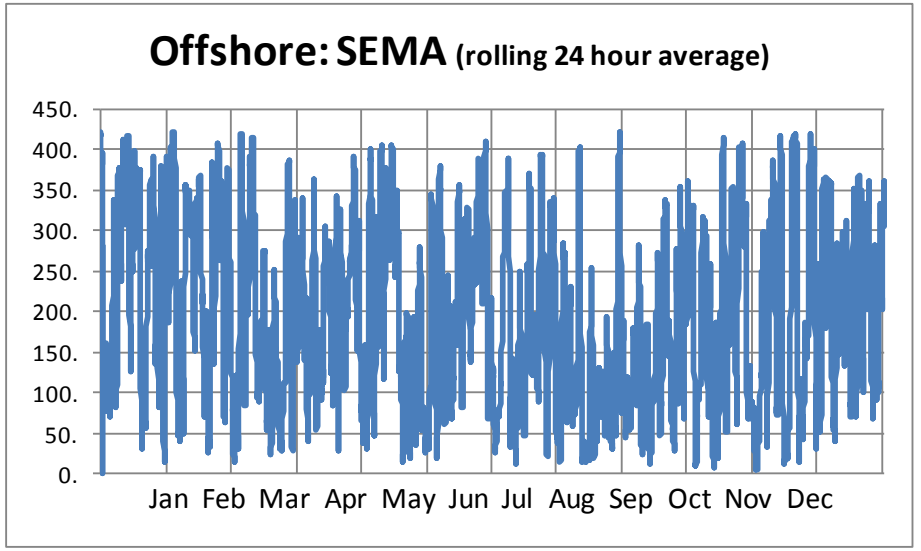
- Partial Queue
- Additional Queue
- Additional to 20% Energy

Wind Profiles Based on NEWIS Profiles

Hourly Profile (to be used in the simulations)

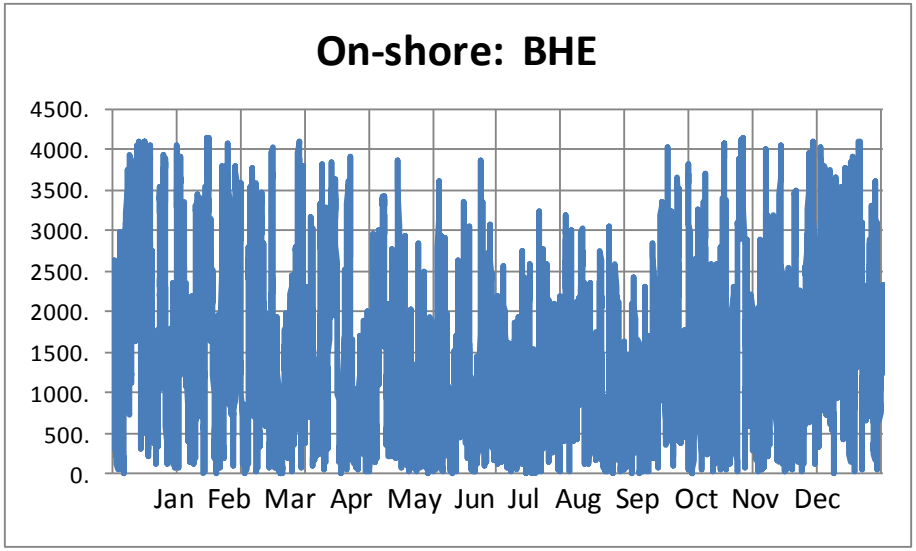


Smoothed Hourly Profile (conceptual visualization)



Wind Profiles Based on NEWIS Profiles, *cont.*

Hourly Profile (to be used in the simulations)



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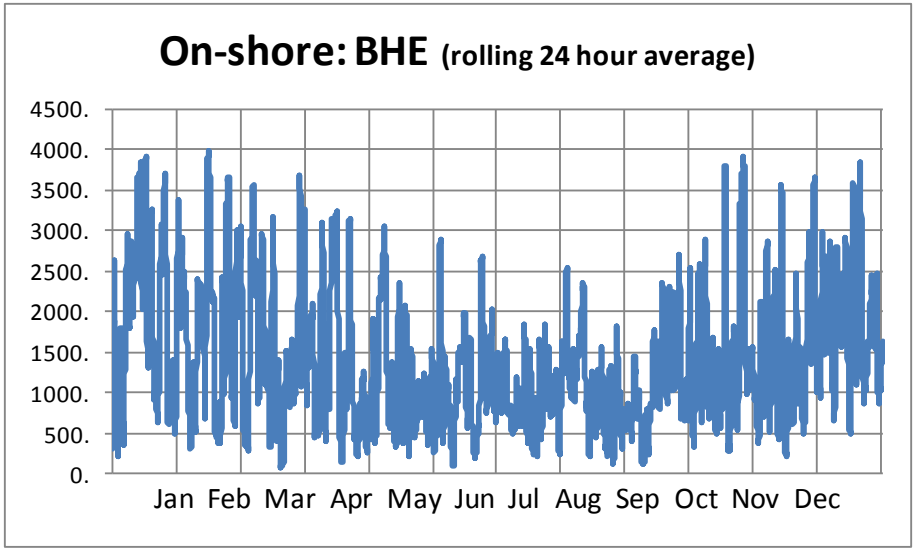
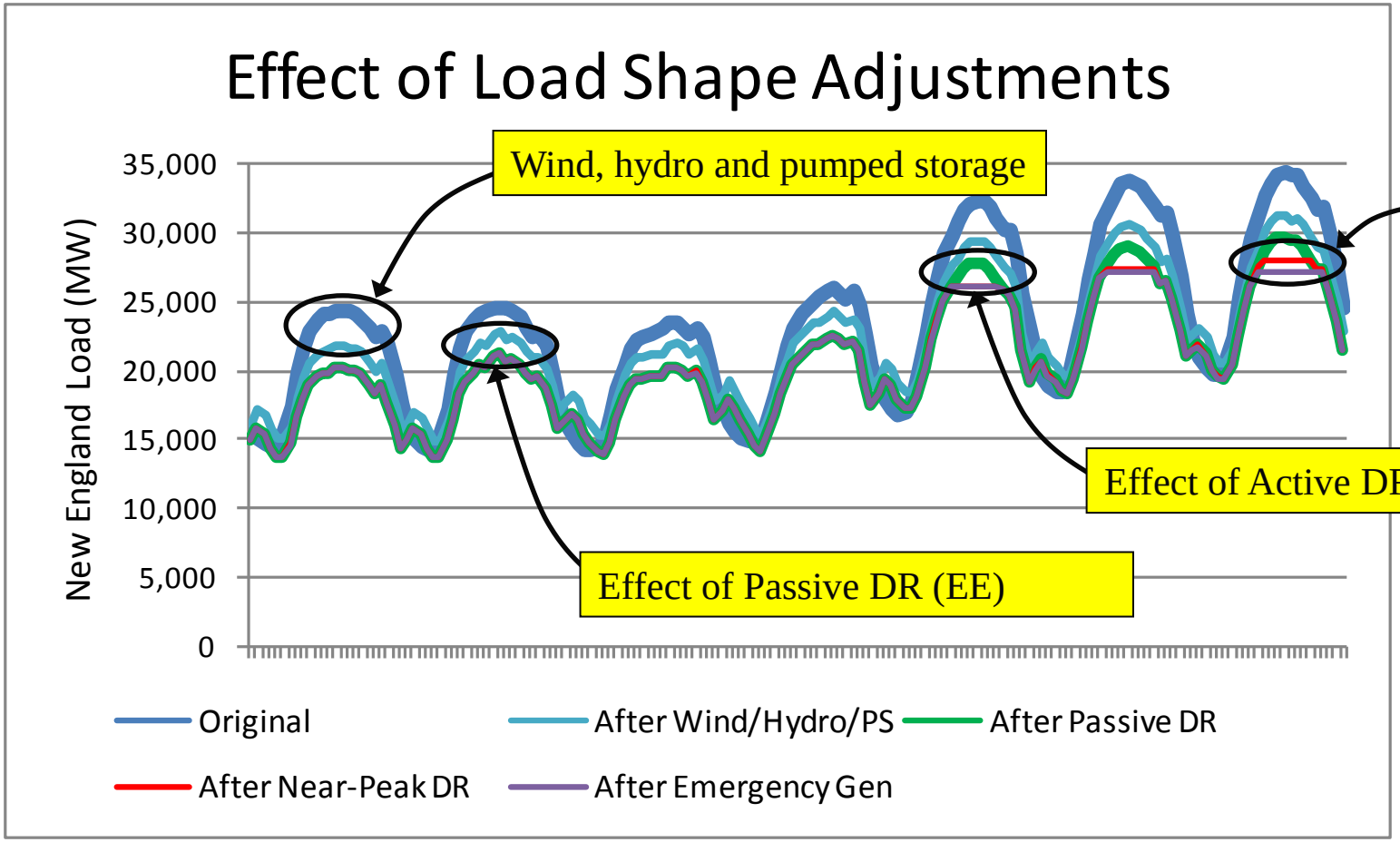
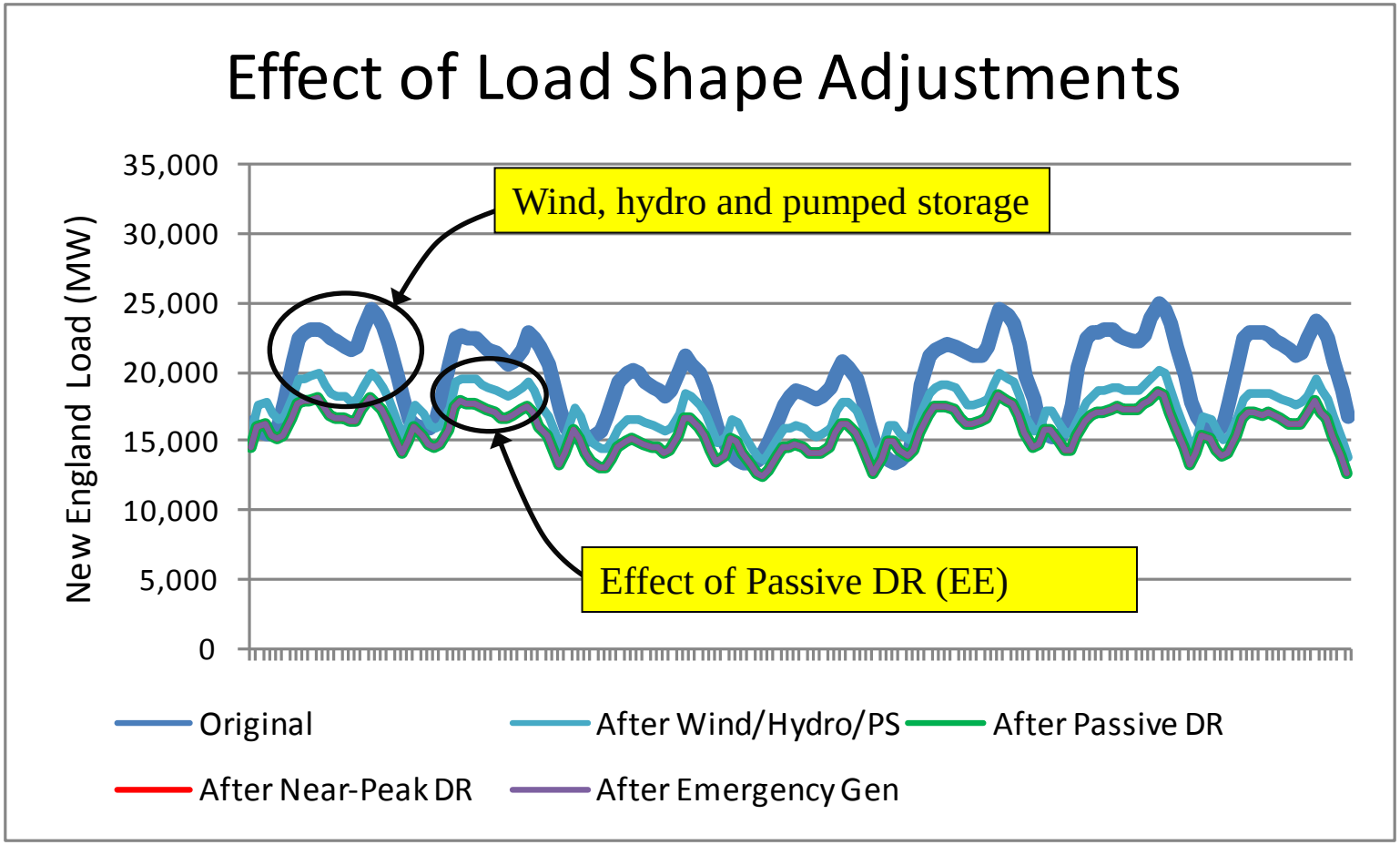


August Peak Week: RTEG and Active DR



First Week of March: RTEG and Active DR



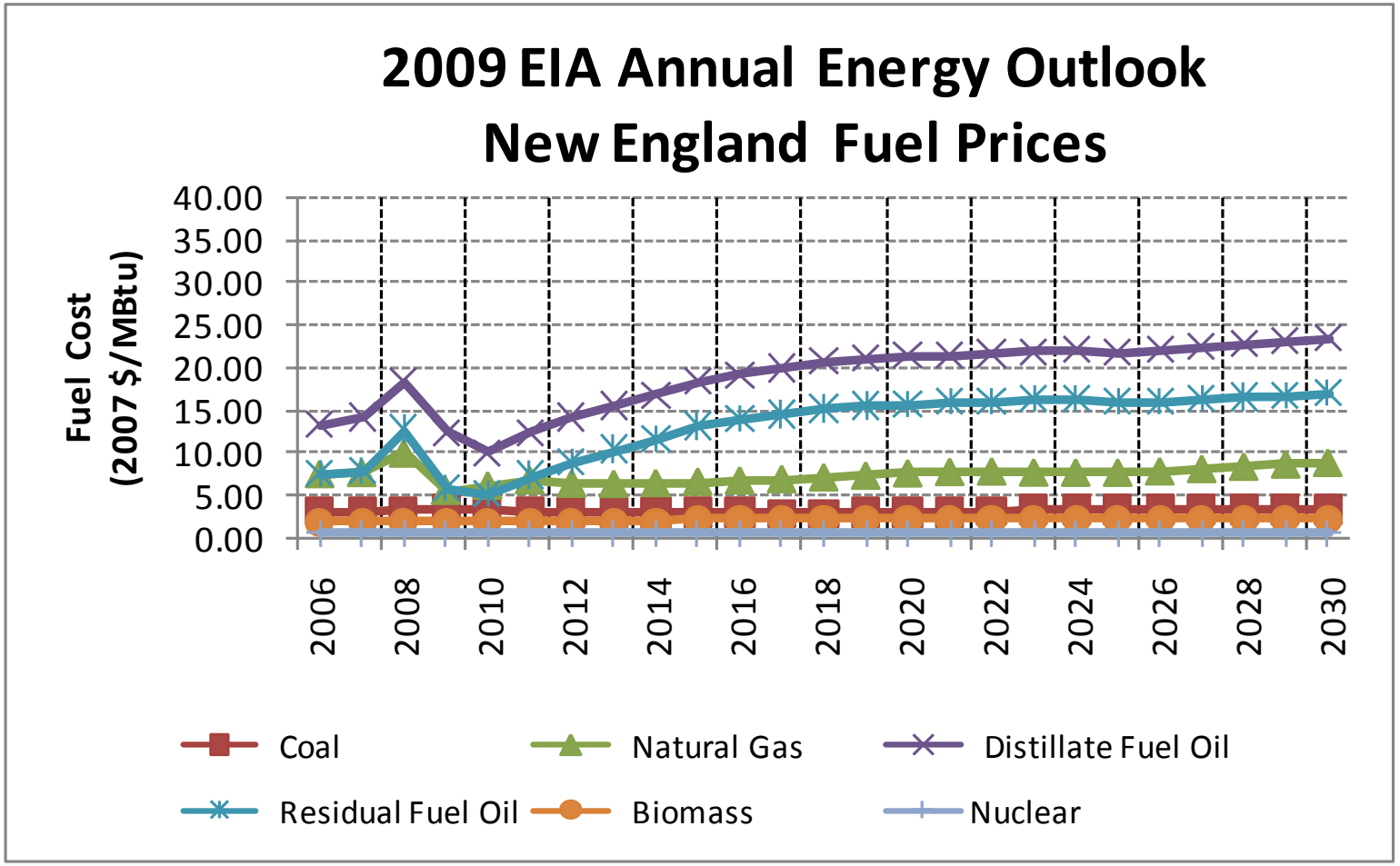
Retirement Scenarios

- Resource retirement assumptions
  - Approach to coal unit retirements
    - Retirement of all coal units over 50 years old as of 2030
  - Approach to oil unit retirements
    - Retirement of all oil units over 50 years old as of 2030
  - Approach to “carbon-heavy” coal and oil unit retirements
    - Retire of all coal and oil units over 50 years old as of 2030
  - Retirement scenarios with replacement use advanced CC
    - Heat Rate of 6500 Btu/kWh
    - Low NOx emission rate of 0.001 lb/MWh
  - Specific case with replacement by wind, solar and biomass from New England and imports from Eastern Canada

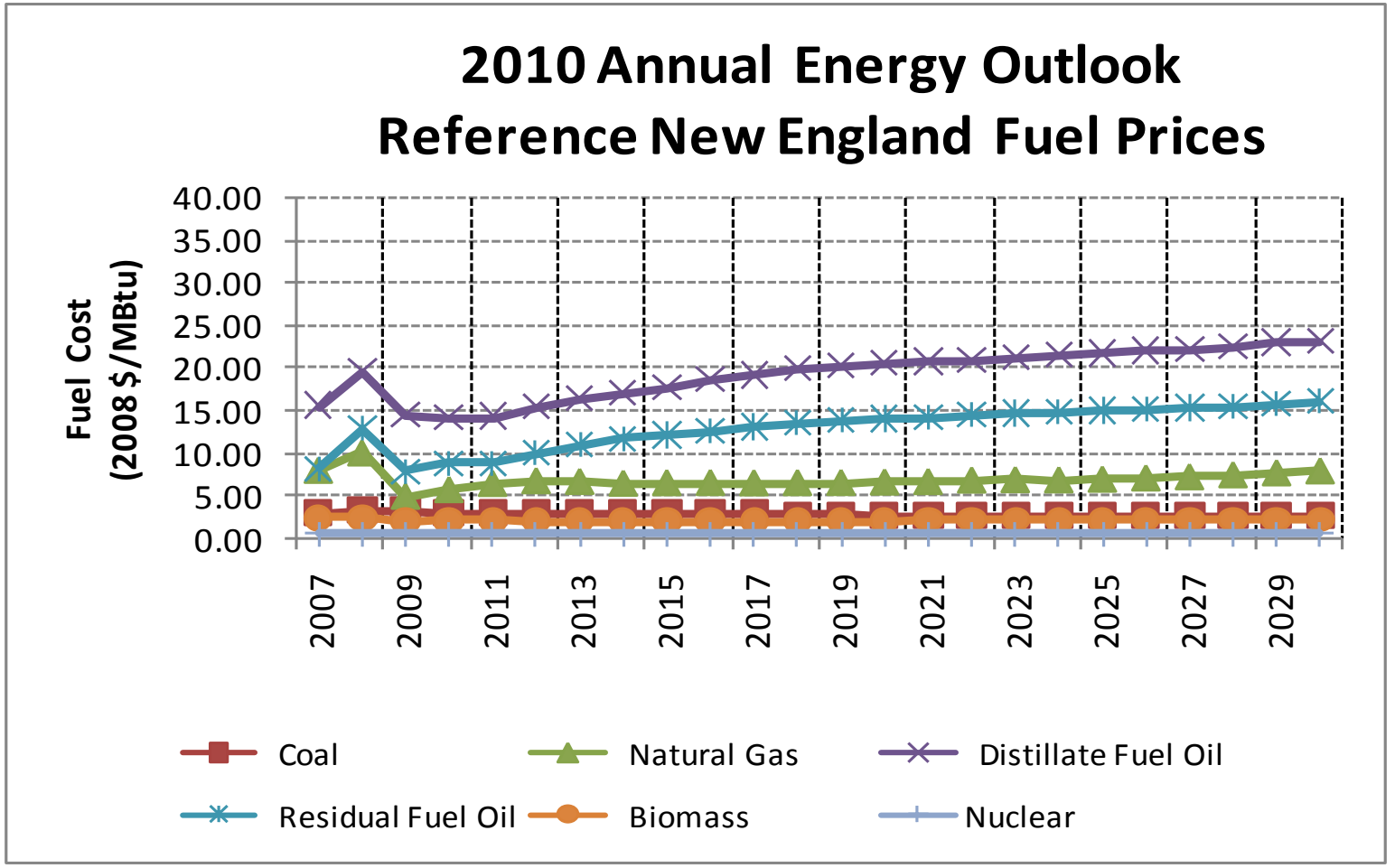
Carbon-Heavy Resources Assumed to be Replaced

ASSET ID	Year	Generator Name	Summer (MW)	Coal-or-Not	Primary Fuel Category	Alternate Fuel Category	Decade Total	Fuel Total
551	1952	SALEM HARBOR 1	82.0	Coal	BIT	FO6		
552	1952	SALEM HARBOR 2	80.0	Coal	BIT	FO6		
556	1952	SCHILLER 4	47.5	Coal	BIT	FO6		
558	1957	SCHILLER 6	47.9	Coal	BIT	FO6		
553	1958	SALEM HARBOR 3	149.8	Coal	BIT	FO6		
577	1959	SOMERSET 6	109.1	Coal	BIT		516.3	
498	1960	MT TOM	143.6	Coal	BIT			
489	1961	MERRIMACK 1	112.5	Coal	BIT			
350	1963	BRAYTON PT 1	228.2	Coal	BIT	NG		
351	1964	BRAYTON PT 2	225.8	Coal	BIT	NG		
340	1968	BRIDGEPORT HARBOR 3	380.0	Coal	BIT	FO6		
490	1968	MERRIMACK 2	320.0	Coal	BIT			
352	1969	BRAYTON PT 3	591.5	Coal	BIT	NG	2001.6	2517.9
493	1954	MONTVILLE 5	81.0	Not-Coal	FO6	NG		
1694	1957	WEST SPRINGFIELD 3	94.3	Not-Coal	NG	FO2		
639	1957	YARMOUTH 1	51.8	Not-Coal	FO6			
480	1958	MIDDLETOWN 2	117.0	Not-Coal	FO6	NG		
640	1958	YARMOUTH 2	51.1	Not-Coal	FO6		395.2	
519	1960	NORWALK HARBOR 1	162.0	Not-Coal	FO6			
	1961	BRIDGEPORT HARBOR 2	130.5	Not-Coal	FO6			
520	1963	NORWALK HARBOR 2	168.0	Not-Coal	FO6			
481	1964	MIDDLETOWN 3	236.0	Not-Coal	FO6	NG		
641	1965	YARMOUTH 3	115.5	Not-Coal	FO6			
365	1968	CANAL 1	550.4	Not-Coal	FO6		1362.4	
494	1971	MONTVILLE 6	407.4	Not-Coal	FO6			
554	1972	SALEM HARBOR 4	436.8	Not-Coal	FO6			
482	1973	MIDDLETOWN 4	400.0	Not-Coal	FO6			
353	1974	BRAYTON PT 4	422.0	Not-Coal	FO6	NG		
508	1974	NEWINGTON 1	400.2	Not-Coal	FO6	NG		
502	1975	MYSTIC 7	577.6	Not-Coal	NG	FO6		
513	1975	NEW HAVEN HARBOR	447.9	Not-Coal	FO6	NG		
366	1976	CANAL 2	553.0	Not-Coal	FO6	NG		
642	1978	YARMOUTH 4	603.5	Not-Coal	FO6		4248.4	6006.0
			8523.9				8523.9	8523.9

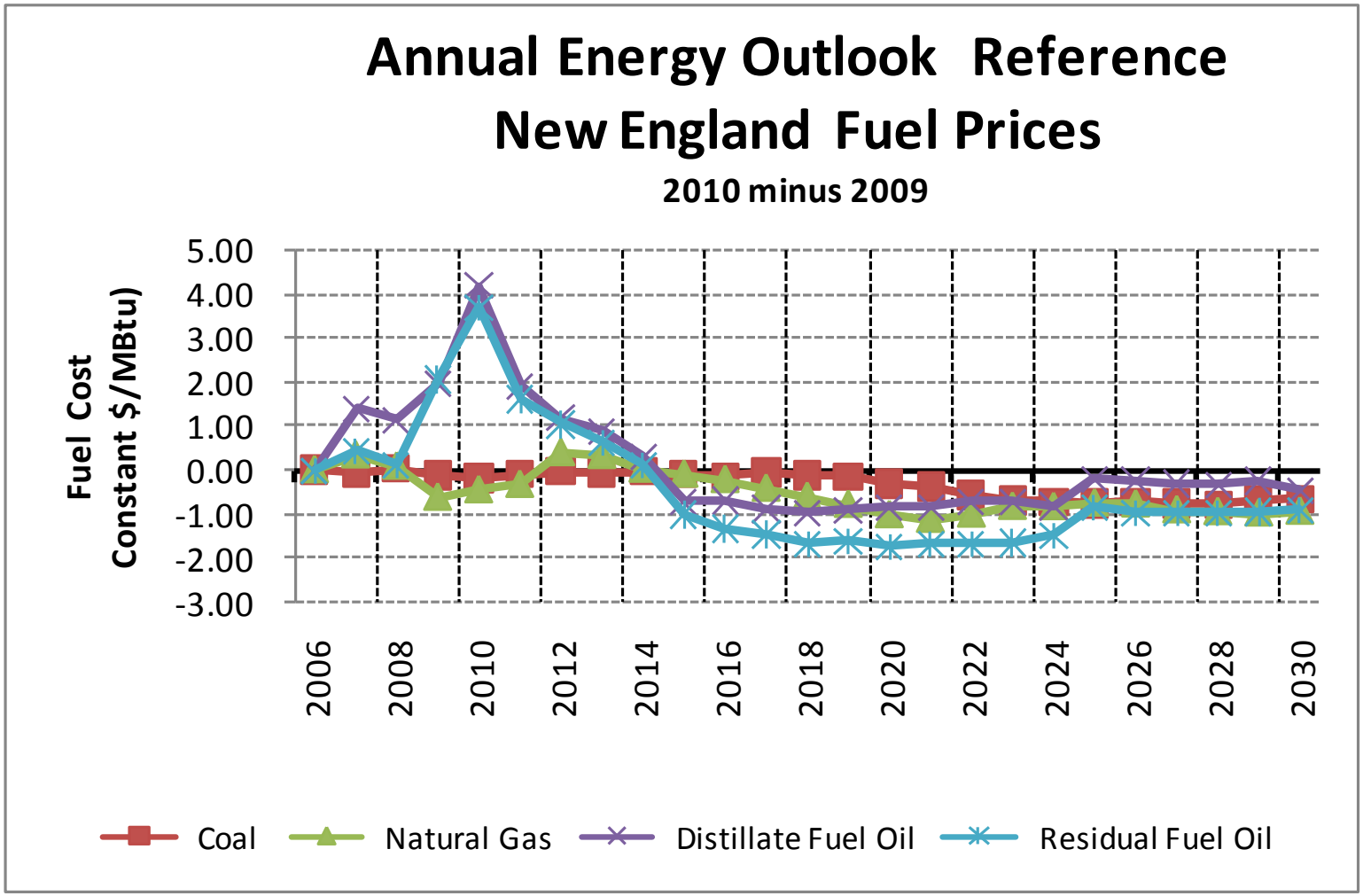
Fuel Price Forecast – 2009 Annual Energy Outlook (AEO) Base



Fuel Price Forecast – 2010 AEO Base



Difference in Fuel Prices: Relatively Small



Cases and Sensitivities

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Cases Considered

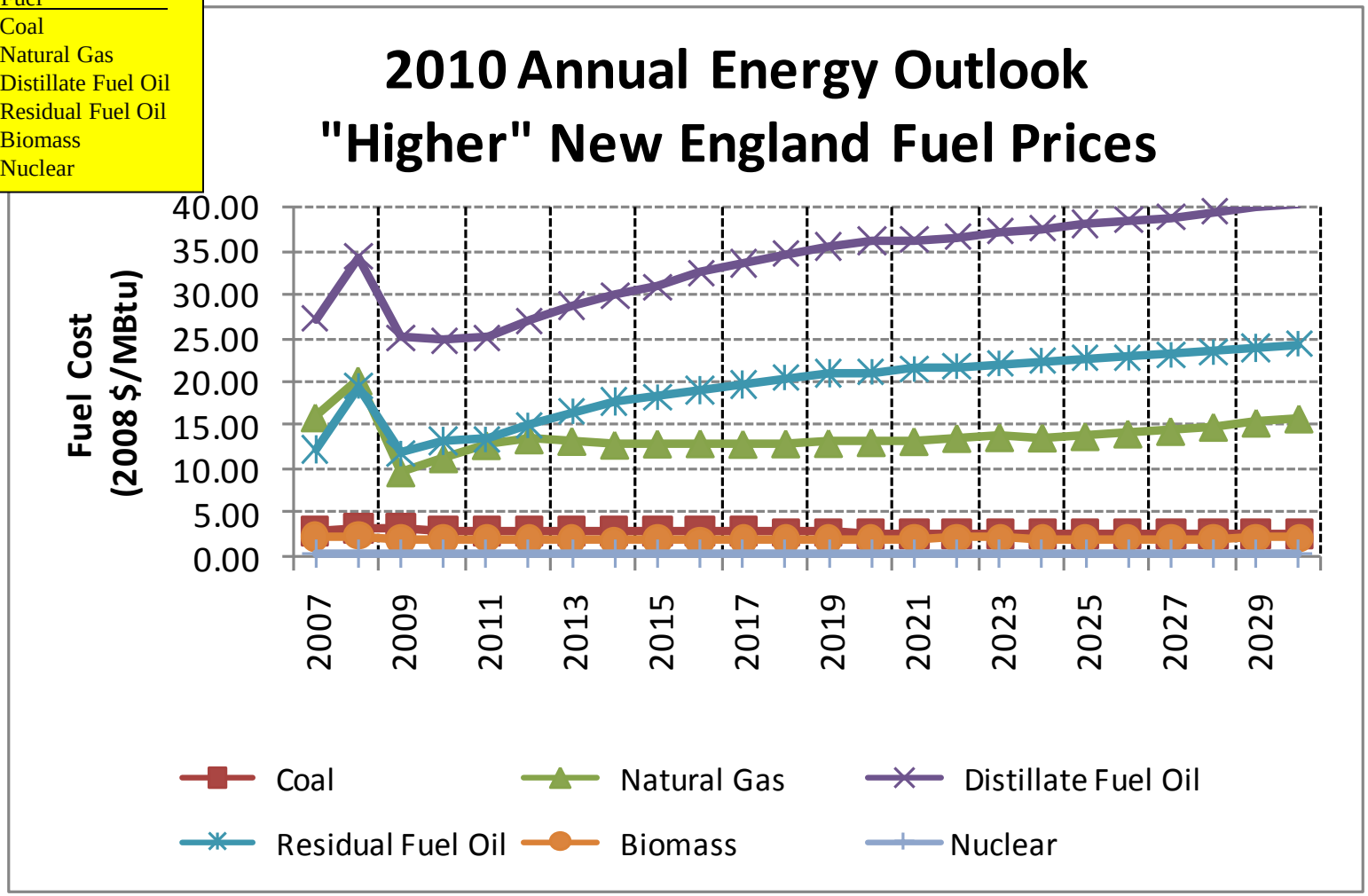
	Case	Description
1	Base	One Year 2030 Only; All resources in with no retirements • All resources in with no retirements • Passive Demand Resources (EE) of 3,425 MW • Active Demand Resources of 3,100 MW • Real Time Emergency Generation of 800 MW • No Additional purchases from Canada or New York • No Additional purchases from assumed EIPC renewable resources • Wind expansion from NEWIS "Full Queue Build-Out"
2	Base – Natural Gas	Same as Base Case except add 1,500 MW of new efficient natural gas combined cycle (CC) units in place of the NEWIS "Full Queue Build-Out" wind capacity. This replaces the energy from those wind resources
3	Retire All Coal	Same as Base Case except 2518 MW of coal units older than 50 years old will be retired and replaced with an equal amount of new efficient gas combined cycle (CC)
4	Retire All Residual Oil	Same as Base Case except 6,006 MW of residual oil units older than 50 years old will be retired and replaced with an equal amount of new efficient gas combined cycle (CC)
5	Retire all Carbon-Heavy	Same as Base Case except 8,523 MW of carbon heavy older than 50 years old will be retired and replaced with an equal amount of new efficient gas combined cycle (CC)
6	New England Renewables and Imports	Same as Base Case except 8,523 MW of carbon heavy units older than 50 years old will be replaced by additional New England wind (Best On-Shore plus Full Queue), state specific photovoltaic and biomass estimates plus imported energy from Canada (several new 1,500 MW DC transmission lines)

Sensitivity Cases

- Base Case
- “Higher” fuel prices
  - U.S. DOE *2009 Annual Energy Outlook* fuel price as base price
  - ISO doubled natural gas and increased oil-based fuels
- Unconstrained transmission sensitivity
- Inclusion of Maritimes loads and resources

Fuel Price Forecast – High Sensitivity

Multiplier	Fuel
1.00	Coal
2.00	Natural Gas
1.75	Distillate Fuel Oil
1.50	Residual Fuel Oil
1.00	Biomass
1.00	Nuclear



Maritimes Resource and Load Model

- A limited model has been implemented for the Maritimes
  - Approximately equal to existing capacity plus wind resources
  - No energy interchange between Quebec and Maritimes
  - Resources added to maintain 15% reserve margin
  - 50% distillate fuel-fired combustion turbines
  - 50% natural gas combined cycle

Evaluation Metrics

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Preliminary Results for Additional Cases

- Metrics
  - Economic (Production Cost, LSE Energy Expense, Congestion)
  - Environmental
  - Fuel consumption/energy by fuel type
  - Revenues from the Energy Market
- Sensitivities modeled to show impact of
  - Transmission constraints
  - High fuel prices
  - Maritimes energy flows (Labrador Hydro and Maritimes Nuclear could be considered to be part of the several new 1,500 MW DC lines)

Fuel Consumption Metric

- Generation (GWh and percent) by fuel type
  - Wind and Demand Resources have no associated MBtus
  - Shows amount of energy assumed to be served by
    - Energy Efficiency
    - Active Demand Resources
    - Wind
    - Hydro / Pumped Storage
    - Coal
    - Nuclear
    - Gas