Proposed Scenarios

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Scenario Considerations

- Expansion scenarios should highlight differences across option cases, rather than “forecast reality”
  - Inform policy makers
  - Help frame policy issues
  - Develop policy in other venues
- Study results (metrics) will include
  - Reliability impacts
  - Production costs
  - Wholesale energy costs to consumers
  - Gross revenues to suppliers
  - Environmental emissions (NOx, SO2, CO2)

Assumptions

- Scenarios have many detailed technical data inputs and assumptions, e.g.
  - Heat rates
  - Fuel costs
  - Emission rates
  - Unit availability parameters
  - Interchange with neighboring systems
  - Load shape
  - Energy Efficiency is embedded in base forecast – over 1,500 MW
  - Others
- Many assumptions are common to other ISO-NE studies, e.g. RSP06
  - These have previously been reviewed with stakeholders, e.g. the PAC

Assumptions

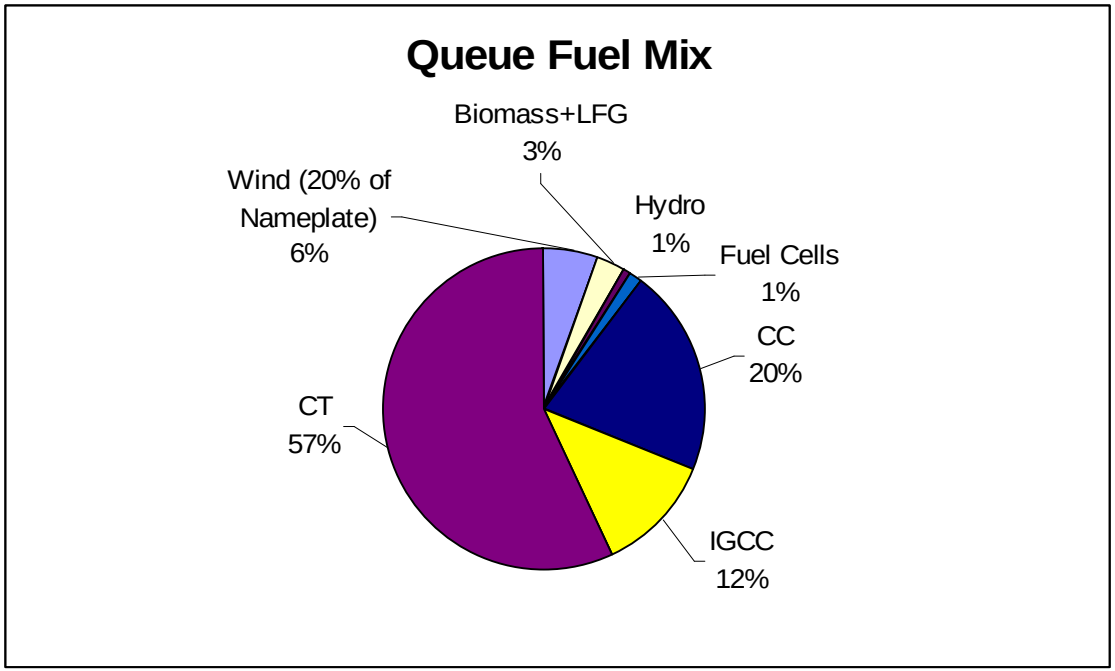
- Any new Scenario Analysis detailed technical assumptions will be reviewed with the appropriate technical committees
  - PAC
  - Power Supply Planning Committee
  - Environmental Advisory Group

Seven Scenarios – Modified Strawman

1. Each scenario = +8,000 MW of incremental resources (supply or demand)
2. Each includes 2,600 MW of same blend of resources in common
   - Reflects representative fuel mix from "The Queue"
3. Each will vary from the other resources for the rest of the 5,400 MW
   - Two "business as usual" cases
     A. Blend reflecting current mix of proposed resources
     B. Natural gas – combined cycle
   - Two base load supply-side characteristics
     A. Nuclear
     B. Clean coal
   - Three non-traditional options
     A. Imports of low-emissions resources (hydro and/or renewable)
     B. Renewable and localized supply-side resources (wind, biomass, landfill gas, photovoltaic, DG, CHP, fuel cells)
     C. Energy efficiency and demand response

"Business as Usual" – "The Queue" Mix of Currently Proposed Resources

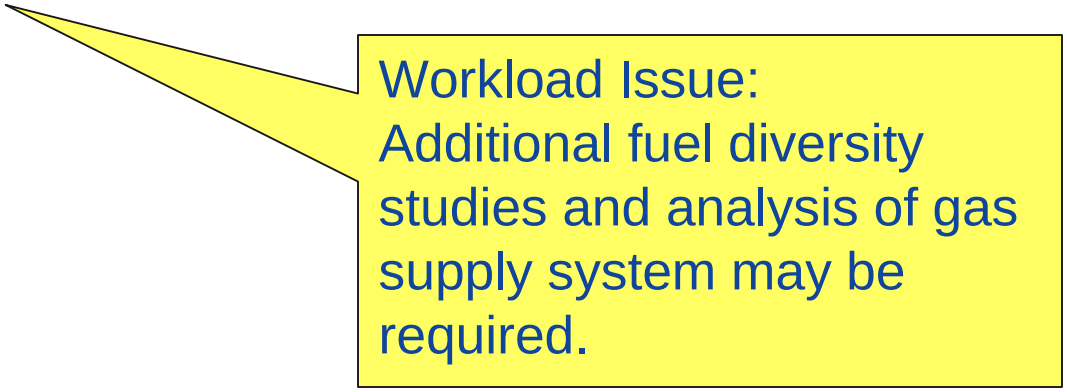
- "The Queue Mix"
  - Current resource "plan" as brought to the table by the today's market
  - Representative mix of resources
  - Provides a good baseline for comparing other scenarios



Workload Issue: Obtaining and analyzing wind data as input to model.

"Business as Usual"
Natural Gas – Combined Cycle

- Recent "resource of choice" in NE's wholesale market
- Low emissions
- Subject to high prices and high price volatility
- Dependent upon delivered natural gas and LNG
  - Would likely require expansion of natural gas infrastructure
  - Potential reliability concern, especially without dual fuel capability



“Low Emissions/Base Load” Characteristic – Nuclear*

- Simulate power production with relatively low variable fuel costs, base load operations, zero emissions
- Captures new nuclear technology – assume:
  - capacity expansions of existing plants, and/or
  - purchase from outside New England, and/or
  - new plant(s) built within New England
- Provides many technical insights for a relatively easy model

* The same simulation can be used to explore the baseload EE scenario

"Low Emissions Emissions/Base Load" Characteristic – Advanced Coal (with sequestration)

- New clean coal technologies have been proposed
  - May be possible to sequester carbon emissions
  - Advanced coal with sequestration is base case assumption
- Sensitivity analysis will explore "what if "without" carbon sequestration?"
- Characteristics of the resource scenario
  - Low energy production costs
  - Higher air emissions than the Nuclear Scenario and Energy Efficiency scenario
  - Technically easy to model

Low-Emissions/Imports
Hydro and Renewable Imports

- Captures resources that are energy limited, but have low emissions
  - Hydro imports from Canada
  - Photo-voltaic
  - Wind
  - Others
- Assume 14 TWHr limitation

Work load issue:
• Will require development of conceptual transmission costs for imports; detailed transmission plan is beyond scope
• Moderately difficult to model energy constraint

Low-Emission Options
Increased EE and DR

- Both EE and DR viewed as resources which work to decrease energy and/or capacity requirements of consumers.
- Demand Side Management
  - Energy Efficiency –
    - amount of energy reduction varies over time of day and season for different efficiency actions
  - Demand Response –
    - Amount and frequency varies as a function of price
  - Use of true load response versus distributed generation results in different emissions

Lots of technical issues for analysis →

Low-Emission Options
Increased EE and DR

- Technical issues – examples where will need to pick key assumptions for the analysis
  - Energy Efficiency
    - Assume proportionate to load during peak hours
    - Assume 50% of “resource” addition
  - Demand Response
    - Assume shaves top # of hours of load
    - Assume 50% of “resource” addition
    - Assume true load response in the simulation – and then decide which DG technology supported

ISO-NE to develop table of emission rates for different types of distributed generation technologies.

Low-Emission Options
Renewable and Local Supply Resources

- Mix of Resources – with different characteristics
  - Wind
    - Intermittent resource
      - operating characteristics vary with location and time
      - power system limit on acceptable amount that can be added?
  - Photovoltaic
  - Biomass
  - Landfill Gas
  - Fuel cells
  - Distributed generation (including Combined Heat and Power (CHP))
- Fuel type, amount, costs

Many technical issues for modeling this scenario

Low-Emission Options
Renewable and Local Supply Resources

- Option 1: Model as a mix of RE
  - E.g., assume equal proportional share of all RE and DG resources
    - Wind
    - Photovoltaic
    - Biomass
    - Landfill gas
    - Distributed generation
    - CHP
    - Fuel cells
  - Assume 50% of wind is on-shore and 50% is off-shore
- Option 2: Model resources implicitly
  - Assume that resources as a whole have a characteristic that is similar to 50% Energy Efficiency and 50% base load

Starting point is 50/50, but will be examined

Challenges in Carrying Out Analyses

Scenario	*Character*	*Comment –* *Process will need to address….*
Mix ("the Queue")	Base case	Wind data is difficult to obtain and reflect as an input assumption; will need to make simplifying assumptions – and may cause this scenario's results to be delayed
Natural gas	Consistent with recent history	Moderate - Requires additional studies of operable capacity analysis and gas fuel supply, which could delay results of this case.
EE	Base load & low emissions	Easy to model and provides key information
Nuclear	Base load & low emissions	Easy to model and provides key information

Challenges in Carrying Out Analyses (cont.)

Scenario	*Character of scenario*	*Comment*
Clean Coal	Scenario using fuel with stable prices, but emissions	Technically easy to model
Imports of Low Emissions (Hydro & RE)	Allows exploration of facilities with energy (e.g., fuel) limits	Moderately difficult to model
Renewable & Local	Shows implications of RPS	Very difficult to model, could delay results. Can be simplified by base assumptions
EE & DR	Shows implications of EE & DR	Very difficult to model, could delay results. Can be simplified by base assumptions.

Sensitivity Analysis – Overview

Most of these will be applied to all scenarios

- Fuel prices ✓
- Additional energy efficiency and demand response ✓✓
  - Also includes Load Factor sensitivity ✓ ✓
- Retirements
- Emission allowance prices ✓✓
- Carbon sequestration ✓
- Amount of energy purchases ✓

✓✓✓ = level of technical difficulty of analysis

Sensitivity Analysis – More details

- Change in fuel prices
  - Higher natural gas prices relative to oil
  - Lower natural gas prices relative to oil
- Change in potential retirements
  - Retire 3,500 MW of the oldest non-hydro generators and replace the capacity with the same mix as the addition of the 5,400 MW

Sensitivity analysis is designed to show changes in outcomes (metrics)

Sensitivity Analysis – More details

- Increased penetration of EE and DR
  - Add 1,750 MW of EE and 1,750 MW of DR
- Increase different combination of EE with DR, and to examine (among other things) effect on load factor (to be derived from EE/DR case)
  - Instead of 50-50 split in EE and DR
    - Add 5,400 MW of EE and 0 MW of DR
    - Add 5,400 MW of DR and 0 MW of EE

Sensitivity analysis is designed to show changes in outcomes (metrics)

Sensitivity Analysis – More details

- Change allowance prices
  - Base case assumption of $5/ton for CO2 allowances
  - Change to $20/ton for CO2 emissions
  - Change to $0/ton for CO2 emissions
- Remove carbon sequestration from coal case:
  - (Recall base case is with carbon sequestration)
  - Simulate addition of clean coal plants with carbon sequestration
- Change in amount of energy constrained resources
  - Decrease hydro and renewable energy purchases from 14 TWHrs to 7 TWHrs

Sensitivity analysis is designed to show changes in outcomes (metrics)

7 Scenarios, and Sensitivity Analyses

	Scenarios – *Incremental 8000 MW* *Note: all cases have the same 2600 MW of resources reflecting proposals now in the ISO-NE Queue*	Base Case Conditions	High Fuel Price (Which fuel Gas of Gas and Oil)	Low Fuel Prices (Which fuel Gas of Gas and Oil)	Additional 1750 MW EE and 1750 MW of DR	Additional EE and DR with 0 MW of DR and 5400 MW of EE	Additional EE and DR with 5400 MW of DR and 0 MW of EE	Retire 3500 MW of Oldest non-hydro	High Carbon Allowance Prices **	Low Carbon Allowance Prices ***	For coal: remove Carbon Sequestration	Increased imports of low-emission resources (7 TWh)
		Sensitivities										
1	Mix of currently proposed resources (5400 MW blend reflecting the fuel mix exhibited recently by the market (i.e., "the Queue")	X	X	X	X			X	X	X		
2	Additional EE and DR with 2700 MW of DR and 2700 MW of EE	X	X	X	X	X	X	X	X	X		
3	Nuclear – 5400 MW	X	X	X	X			X	X	X		
4	Advanced clean coal – 5400 MW With Carbon Sequestration	X	X	X	X			X	X	X	X	
5	Natural Gas (Combined Cycle) – 5400 MW	X	X	X	X			X	X	X		
6	Renewables and EE – 5400 MW (including a combo of wind, biomass, landfill gas, DG, CHP, fuel cells, PV.)	X	X	X	X			X	X	X		
7	Increased Imports of Hydro and/or other Low Emission Resources (14 TWh of imports)	X	X	X	X			X	X	X		X

Notes:

* 35,000 MW system

** SO2, at X1, CO2 at Y1 and NOx at Z1 dollars per ton

*** SO2, at X,2 CO2 at Y2 and NOx at Z2 dollars per ton

Discussion