Overview –

Modeling Assumptions
Metrics
Schedule
Preparing for the reporting of results

March 5, 2007

Scenario Analysis* – What is it?

Background

- ISO-NE-sponsored stakeholder process to explore long range electric energy alternatives for meeting an 8,000 MW incremental customer load in New England (total load of 35,000 MW)
- Simulation of different fuel and technology-based scenarios for a single future year
- Presentation of high level metrics for each scenario:
  - If a particular technology path is pursued, what are the reliability, transmission, economic, environmental impacts?
- Results designed to inform public policymakers of consequences of each scenario
- No judgment of "best" scenario will be made in this process

* "SA" = ISO-NE Scenario Analysis process

Scenario Analysis – Background: 7 Proposed Scenarios being analyzed

- **Market Mix of Resources "Queue Mix"**
- **Natural Gas Combined Cycle**
- **Clean Coal (IGCC) – with & without carbon capture and sequestration**
- **Nuclear**
- **Renewable Resources**
- **Imports: hydro and/or low emitting resources**
- **Energy Efficiency (EE) and Demand Response (DR)**
  - Both EE and DR are considered resources

Scenario Expansions and Sensitivities: Background

- **Assume a base expansion of 2,600 MW common to all scenarios based on the mix of resources in ISO interconnection queue**
- **The remaining 5400 MW will be comprised solely of the fuel/technology type for a given scenario**
- **Sensitivity cases will test changes in assumptions re:**
  - Fuel prices
  - EE and DR replacement of supply side resources
  - Retirements
  - CO_2 allowance prices
  - CO_2 sequestration
  - Increased imports

Scenarios & Sensitivity Analyses: Background

		A	B	C	D	E	F	G	H	I	J	K
	Scenarios – ***Incremental 8,000 MW Note: all cases have the same 2,600 MW of resources reflecting proposals in the ISO-NE Queue as of 10/31/06***	Common Assumptions	High Gas/ Oil Fuel Prices	Low Gas/Oil Fuel Prices	Replace 3,500 MW of the Scenario Technology with 1,750 MW of Energy Efficiency (EE) and 1,750 MW of Demand Response (DR)	Replace 2,700 MW of DR with 2,700 MW of EE	Replace 2,700 MW of EE with 2,700 MW of DR	Retire 3,500 MW and Replace with Scenario Technology	High Carbon Allowance Prices	Low Carbon Allowance Prices	For Coal: with Carbon Sequestration	Decreased Imports of Low-Emission Resources (- 7 TWh)
1	Mix of currently proposed resources (5,400 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 2,700 MW of DR and 2,700 MW of EE	X	X	X		X	X	X	X	X		
3	Nuclear – 5,400 MW	X	X	X	X			X	X	X		
4	Advanced Clean Coal – 5,400 MW without Carbon Sequestration	X	X	X	X			X	X	X	X	
5	Natural Gas (Combined Cycle) – 5,400 MW	X	X	X	X			X	X	X		
6	Renewables – 5,400 MW (including a combo of wind (on/off shore), hydro, biomass, landfill gas, Combined Heat and Power, fuel cells, Photo Voltaics 1/8 each)	X	X	X	X			X	X	X		
7	Increased Imports of Hydro and/or other Low Emission Resources (30 TWh of imports)	X	X	X	X			X	X	X		X

Types of Analyses used in Scenario Analysis – Background

- **Production Cost Simulation**
- **"Post-processing" calculation of capital costs**
- **Operable Capability analysis**
- **High-level analysis of infrastructure costs:**
  - – Electrical Transmission
  - – Electrical Distribution
  - – Natural Gas Delivery

Process for Review of Assumptions – Background

- Working Group discussions
  - Detailed discussion of technical assumptions, methods
- Other technical experts provided comments / information
- Meetings held with:
  - Power Supply Reliability Committee
    - Assumptions and data inputs
    - Modeling characteristics, Capital and dispatch costs
  - Demand Response Working Group
    - Energy Efficiency and Demand Response Costs and Characteristics
  - Environmental Advisory Group
    - Emission modeling and rates, Environmental metrics
  - Transmission Owners Working Group
    - Transmission and Distribution Conceptual Costs
  - Metrics Working Group

Scenario Analysis Process – Update on Modeling Inputs and Assumptions

- **Today's meeting and follow-up**
  - Overview of the effort to date
  - More information on technical modeling and analysis issues
  - Opportunity for discussion of more technical detail (on appendix materials) at end of meeting
  - Opportunity for comments after the meeting – ASAP
  - Closure on modeling issues by end of week of March 5^{th} – in order to commence modeling

Scenario Analysis Process – Update on Modeling Process

Our Focus Today

- **Overview**
  - High-level presentation of modeling issues
  - Overview of fuel price inputs and gas infrastructure costs
  - Update on metrics
  - Preliminary thoughts on next steps (getting ready for presentation of results, by April)
- **Technical issues in inputs to modeling and analysis**
  - Power plant technology characteristics
  - Profiles for wind and PV and demand-side resources
  - Transmission and distribution costs (and savings)
- **Opportunity for side-bar discussion of detailed appendix materials for today's meeting**

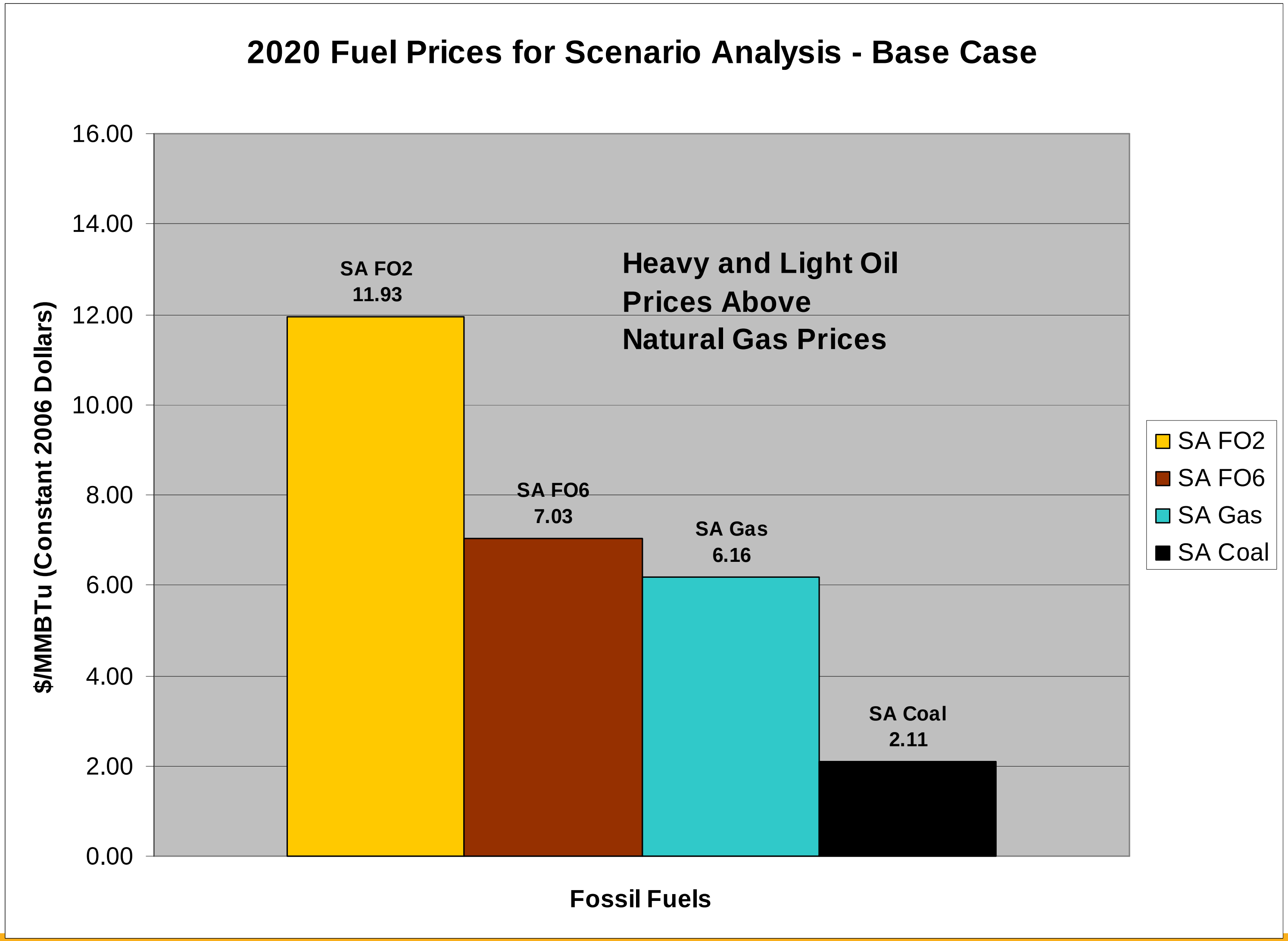
Overview of Fuel Price Forecast – For Modeling of Scenarios

- **Need to use a fuel price forecast for all scenarios**
  - Using Levitan & Associates, Inc. (LAI) *"Conventional Wisdom"* base case forecast, with key inputs including:
    - **Relative stability in OPEC nations**
    - **New oil supplies from Alberta tar sands, Former Soviet Union (FSU), and ultra-deepwater**
    - **Steady worldwide investment in exploration & production (E&P)**
    - **Gradual development of new gas reserves**
    - **Moderate worldwide oil demand growth**
    - **Development of new U.S. supplies in Alaska North Slope & Gulf offshore**
  - High and low fuel price cases used in ISO-NE scenarios:
    - Informed by "high" and "low" fuel price cases in Levitan's *"Peak Oil"* and *"LNG Overbuild"* cases
    - Reflects a deliberate attempt to model "what if" situations, where fuel prices diverge from normal patterns

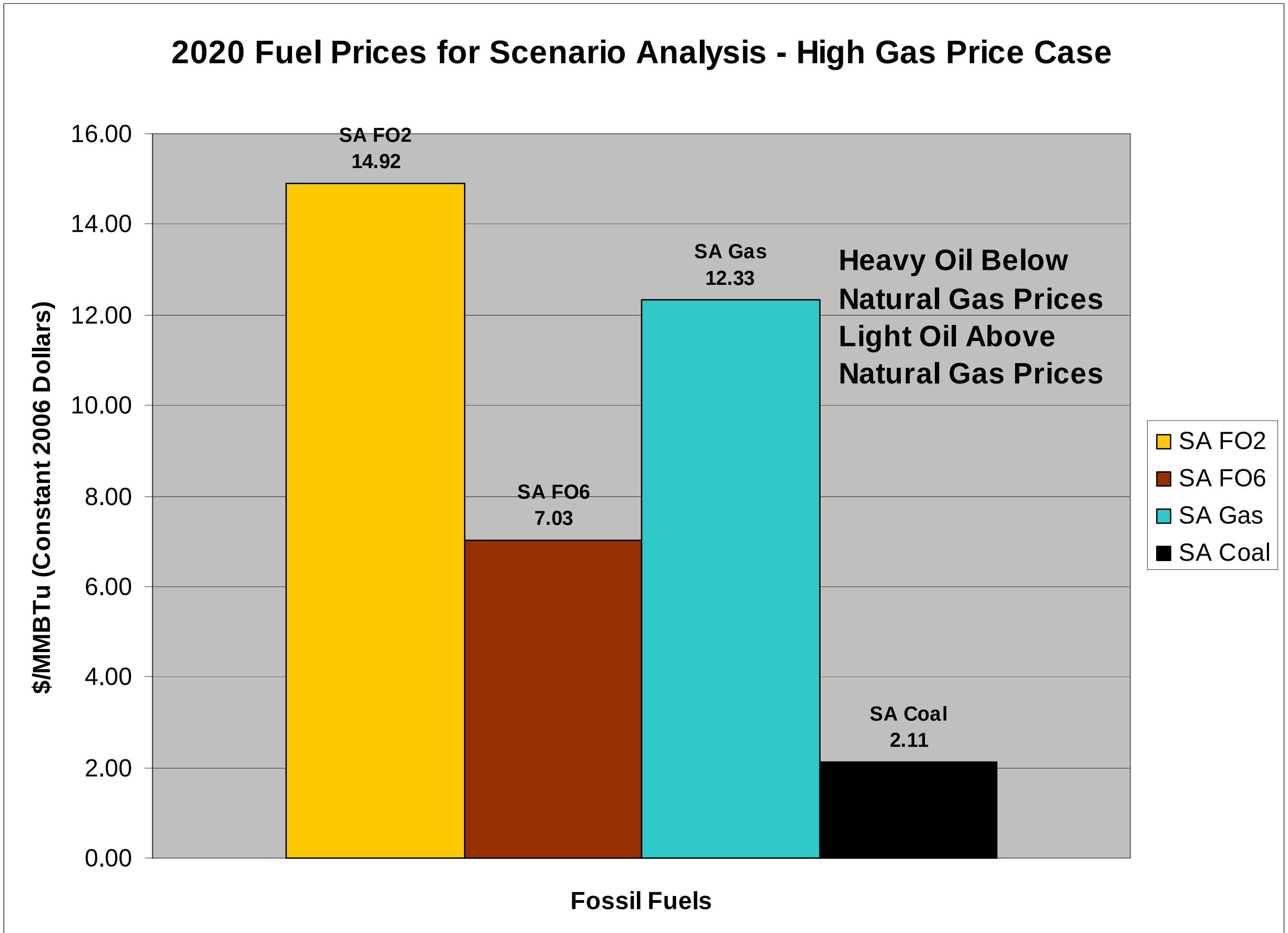
Overview of ISO-NE SA Fuel Prices – Inputs used in Modeling

- **"Base Case" Fuel Prices** – Used in power plant dispatch analysis
  - Levitan's *"Conventional Wisdom"* case
- **"High Gas Price Case" –** Sensitivity Analyses
  - Assume: natural gas price = 2 X base case price
  - Assume: light oil (FO2) price = 1.25 X base case price
  - Assume: heavy oil (FO6) and coal price = same as base case price
  - This results in using higher natural gas prices than projected in Levitan's *"Peak Oil"* case
- **"Low Gas Price Case"** – Sensitivity Analyses
  - Assume: natural gas price = 50% of base case price
  - Assume: light oil, heavy oil & coal prices = same as base case price
  - This results in using of lower natural gas prices than projected in Levitan's *"LNG Overbuild"* case

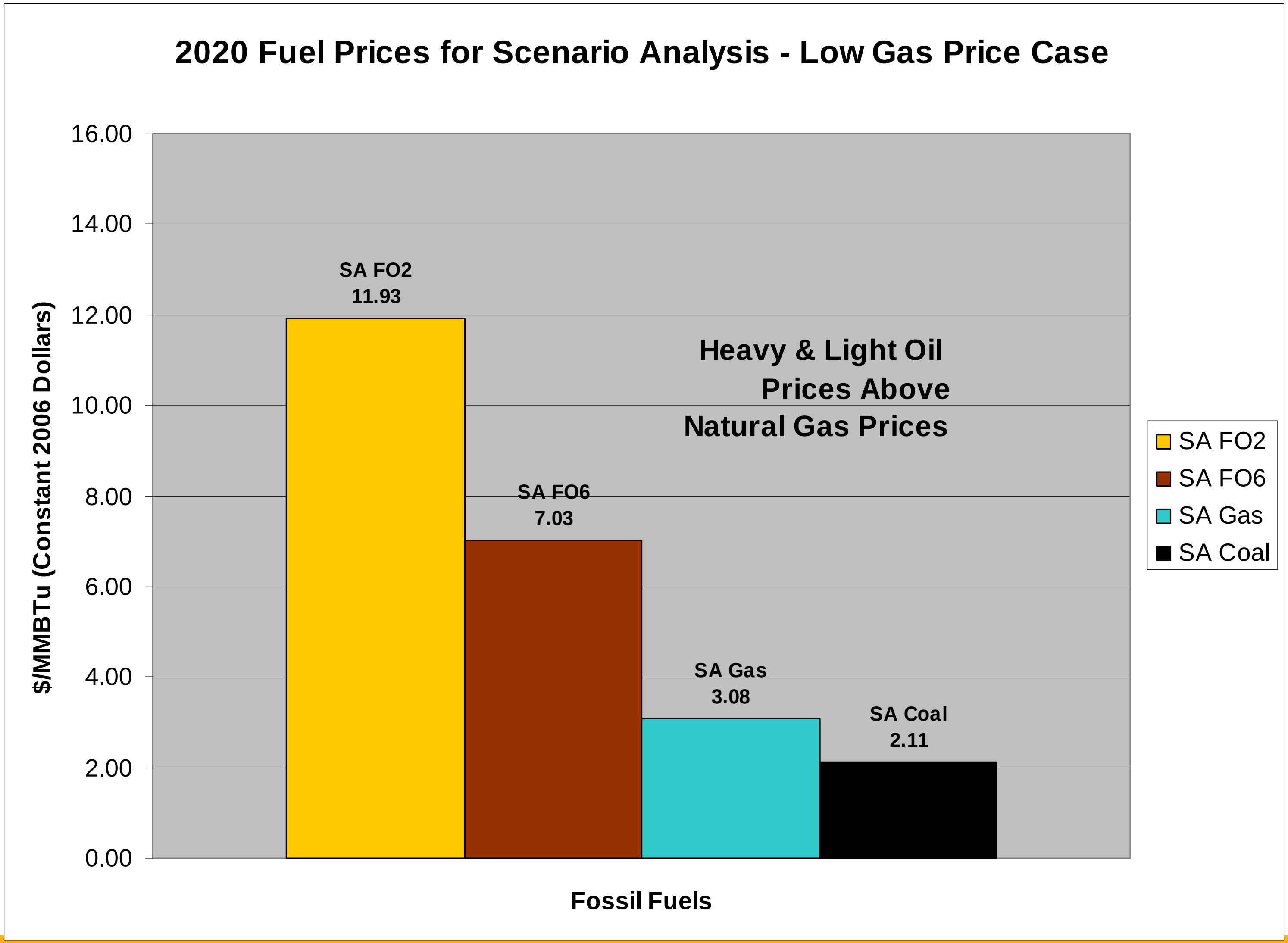
SA Fuel Prices – Base Case



SA Fuel Prices – High Gas Price Case



SA Fuel Prices – Low Gas Price Case



Overview of Gas Delivery Infrastructure – For Scenarios with High & Low Gas Needs

- Some scenarios require more or less natural gas utilization than other scenarios:
  - Gas-fired Combined Cycle Scenario – requires more gas
  - Renewable Scenario – requires less gas
- One metric of interest in interpreting the scenarios: the extent to which incremental gas delivery infrastructure would be needed in conjunction with a particular scenario
  - Levitan assessed the fuel requirements of various scenarios and identified the need (or not) for new, incremental gas-delivery infrastructure (e.g., expanded pipelines and/or LNG facilities)
  - A range of gas-delivery investment costs were developed to add to those "high gas utilization" scenarios

Incremental Gas Infrastructure Issues: Several Scenarios Require Gas Assumptions

- **Base case fuel forecast assumes commercialization of a new LNG import terminal - Canaport, which is now under construction in St. John, New Brunswick**
- **Several scenarios in SA will require new gas delivery capacity beyond base case requirements**
- **These scenarios will have incremental gas delivery costs added to their capital costs**
- **Incremental gas delivery costs are estimated as some combination of either pipeline expansion and/or new, regional LNG delivery capacity**

Incremental Gas Infrastructure Issues: Several Scenarios Require Gas Infrastructure

Relative to other scenarios, some require more/less gas:

- Scenario #5 (Gas-fired CCs) –assumes the need for considerably more gas
- Two Cases
  - **Base Case: 1.0 Bcf/d**
    - **From Queue: 530 MW CC + 38 MW Fuel Cell**
    - **Add'l Capacity: 5,400 MW CC**
  - **Plant Retirement Case: 1.6 Bcf/d**
    - **From Queue: 530 MW CC + 38 MW Fuel Cell**
    - **Add'l capacity: 5,400 MW CC**
    - **Retired capacity to be replaced with add'l 3,500 MW of CC**

- Scenario #6 (EE & Renewables) – assumes the need for considerably less gas
- Two Cases
  - **Base Case: 260 MMcf/d**
    - **From Queue: 530 MW CC + 38 MW Fuel Cell**
    - **Add'l Capacity: 675 MW Fuel Cell**
  - **Plant Retirement Case: 365 MMcf/d**
    - **From Queue: 530 MW CC + 38 MW Fuel Cell**
    - **Add'l capacity: 675 MW Fuel Cell**
    - **Retired capacity to be replaced with add'l 438 MW of Fuel Cells**

Notes:
CC = combined cycle, EE = energy efficiency
Gas requirements estimated by Levitan & Associates

Assumptions for SA Scenario #5 re: Gas Infrastructure Expansion Cost Estimates

- **If new delivery capacity is built to provide sufficient gas for 5,400 MW of new, gas-fired combined cycle power plants, then assumed range of costs:**

  $0.15 billion to 1.5 billion for base case

  (assumes some combination of pipeline and/or LNG expansion(s))

- **If there are retirements of existing generating capacity, combined with 5,400 MW of new, gas-fired combined cycle power plants, then assumed range of costs:**

  $0.45 billion to $3.0 billion for retirement case (CC)

  (based on combination of pipeline and/or LNG expansion(s))

Notes:
CC = combined cycle
Gas requirements estimated by Levitan & Associates

Assumptions for SA Scenario #6 - Gas Infrastructure Expansion Cost Estimates

- Assuming Canaport supplies are adequate to meet the increased demand in the Base and Retirement Cases
  - No additional LNG or mainline infrastructure is needed to serve fuel cell gas requirements
- Assume fuel cells are served by gas LDCs and may require expansion behind the LDC citygates
  - Assume fuel cells are dispersed throughout LDC service territory as needed to meet demand and reduce localized system strain
  - LDC expansions needed to serve fuel cell demand are covered under LDC transport-only rates (adjusted for inflation to 2020)
  - Range of "tariffed" delivery/distribution charges:

    $0.1/therm to $0.43/therm, Winter

Notes:
CC = combined cycle
Gas requirements estimated by Levitan & Associates

Overview of Power Plant Technology Assumptions: For Modeling & "Post-Processing" Analysis

- **Need to use a common set of operating and other parameters for different power plant technologies:**
  - **For production simulation:**
    - **Plant size, heat rate, variable fuel costs, availability factor, emissions rates, emissions allowance costs, capital cost for the power plant,**
  - **For "post-processing" calculations:**
    - **Plant capital cost**
    - **Certain environmental parameters (water use, land amount)**
- **Technical information to be presented later today**

Overview of Operating Profiles for Certain Renewable and Demand-Side Resources

- Certain renewable projects have constraints on "resource" availability at various times:
  - **Is the wind blowing?**
  - **Is the sun shining?**
  - **At what time of day does a demand-reduction measure reduce use?**
- The availability of the "fuel" (resource) thus affects how much energy (or energy savings) can be produced
- Dispatch modeling needs account for these issues
- ISO sponsored inquiries to inform these "operating" profiles for wind, PV, energy-efficiency, demand-response
- Studies informs treatment of these resources in modeling of various scenarios
- Technical information to be presented later today

Overview of Electric Delivery Infrastructure – For Various Scenarios

- Some scenarios require more or less incremental electric delivery capacity to connect the power generation technology to load center(s), e.g.:
  - Import case – requires more incremental transmission
  - Wind – requires more incremental transmission
  - Energy efficiency – requires less incremental transmission
- One metric of interest in interpreting the scenarios: the extent to which incremental electric delivery infrastructure would be needed in conjunction with a particular scenario
  - ISO-NE worked with Transmission Owners to develop “conceptual” “high level” “generic” estimates of # of miles and costs for transmission and delivery infrastructure
  - Used in “post-processing” analysis of costs of various scenarios
- Technical information to be presented later today

Metrics – Overview

- **To provide helpful results to stakeholders, there will be various means to compare Scenarios:**
  - Economic metrics (system-wide production cost, system-wide average prices, etc.)
  - Reliability metrics (exposure to loss of fuel source, dependence on imported fossil fuel, etc.)
  - Environmental metrics (emissions of various air pollutants, water consumption, etc.)
  - Other metrics (associated fuel delivery or transmission infrastructure requirements, etc.)
- **ISO-NE worked with stakeholders to develop set of metrics to use in comparing scenarios**

Metrics – Overview

Economic	Reliability	Environmental
System-wide Production costs	System-wide energy mix (% by fuel)	System-wide emissions of SOx, NOx, CO2
LSE Expense for wholesale energy based on hourly New England LMP	System-wide capacity mix (% by fuel)	Total system-wide NOx emissions for the fifteen highest peak load summer days
Average wholesale LSE expense for wholesale energy	Total units of fossil fuel burned	CO2 emissions compared to RGGI cap
Capital cost net of energy revenues	Exposure to fuel supply disruption	Mercury emissions – total and compared to regulations
Price duration curve for LMP		Water use
Conceptual incremental transmission infrastructure cost		Amount of land used
Conceptual incremental distribution infrastructure cost		% renewable energy
Conceptual incremental gas delivery infrastructure cost		Renewable compared to RPS % requirements

Preparing for Publishing Results – In a Future Stage of SA Process

- Some simulation modeling is getting ready to be underway by the end of week of March 5th
- “Post-processing” calculations not yet performed
- Schedule is to prepare preliminary results over next month – for presentation in April
- Work commencing to determine most useful way(s) to present preliminary and final results for policy makers, stakeholders
- Suggestions welcome

Preliminary Perspective: Presenting Results Once They're Ready

Show results in several ways:

1. To see how a scenario "performs:"
   - **for each scenario, list all metric results on a single page, with additional pages listing metric results of sensitivity analyses performed**
2. To compare scenarios in terms of how they "rank" on a particular metric:
   - **for individual metric of interest, provide chart (and/or table) showing results for all of the scenarios**

Illustrative Example: Reporting Results for Individual Scenario

SCENARIO "X"
Economic metrics:
System-wide production cost = xxx
Average LMP = xxx
Total capital cost = xxx
Etc.
Reliability metrics:
of units of fossil fuel = yyy
Energy mix = x%
Capacity mix = x%
Etc.
Environmental metrics:
System-wide Tons of NOx, SO2, CO2 = x, y, z
Renewables as % of total generation = z
Etc.

Illustrative Example: Reporting Results Across Scenario for a Metric