Scenario Analysis Update

May 24, 2007

ISO new england

Scenario Analysis Initiative: Objective

- Analysis of future “what if” scenarios
  - Metrics to compare scenarios:
    - Economic
    - Reliability
    - Environmental
- Analysis designed to inform stakeholders and policymakers for their own discussions of preferred outcomes
- Scenario Analysis did not attempt to:
  - Develop a least-cost plan
  - Prepare a multi-year present worth analysis
  - Develop consensus on a preferred approach

Stakeholder Input

- Plenary meetings
  - Review scope of work, assumptions, and results
  - Broad and diverse stakeholder representation

- Technical experts provided comments/information
  - Fuel forecasts
  - Need for additional natural gas infrastructure
  - Profiles of wind, photo-voltaic (PV), and energy efficiency resources

Stakeholder Input (continued)

- Open Stakeholder Meetings held to discuss detailed technical issues
  - Power Supply Planning 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
    - Type and format of Scenario Analysis information to be provided

Scenario Analysis Materials

- **Background Information**:
  - Final Modeling Assumptions: May 21
  - Preliminary Results: May 21
  - On/Offshore Wind Potential in New England: May 21
  - Long-term Fuel Price Forecast: April 30
  - Gas Infrastructure:
  - Resource Characteristics/Assumptions/Profiles: April 2

- **Report**:
  - Draft report posted for stakeholder comment: May 16
  - Stakeholder meeting to discuss draft report: May 21
  - Comment deadline: May 23
  - Final report: Mid June

Seven Resource Scenarios

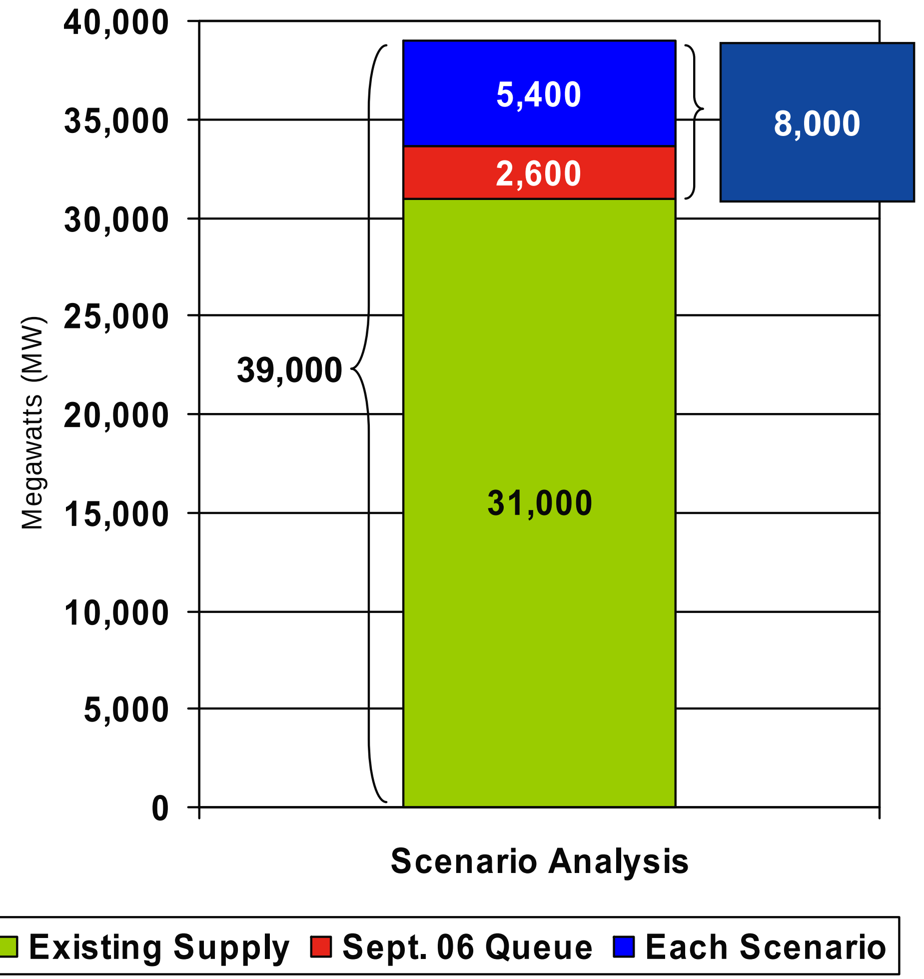
1. The "Queue" Mix
2. New Demand-side Resources
   – Energy efficiency and demand response viewed as resources
3. Expansion of Nuclear Plant Capacity
4. New Coal-fired Generation using IGCC Technology
5. New Natural Gas Combined Cycle Power Plants
6. New Renewable Projects
7. Increased Imports of Hydro and other Low-emission Resources

Seven Scenarios and Sensitivity Analyses

		A	B	C	D	E	F	G	H	I	J	K
	Scenarios — incremental 8,000 MW All cases have the same 2,600 MW of resources reflecting proposals in the ISO queue as of 9/30/06.	**Common Assumptions**	**Low Gas/Oil Fuel Prices**	**High 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**	**Low Carbon−Allowance Prices**	**High Carbon−Allowance Prices**	**For Coal with Carbon Sequestration**	**Decreased Imports of Low−Emission Resources (−7 TWh)**
1	**Queue Mix —** combination of currently proposed resources; 5,400 MW blend reflecting the fuel mix exhibited recently by the market	X	X	X	X			X	X	X		
2	**Demand-side resources —** an additional 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 technology coal (IGCC) —** 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 on− and offshore wind, hydro, biomass, landfill gas, combined heat and power, fuel cells, photovoltaics; 1/8 each	X	X	X	X			X	X	X		
7	**Increased imports of hydro and other low−emission resources —** 30 TWh of imports	X	X	X	X			X	X	X		X

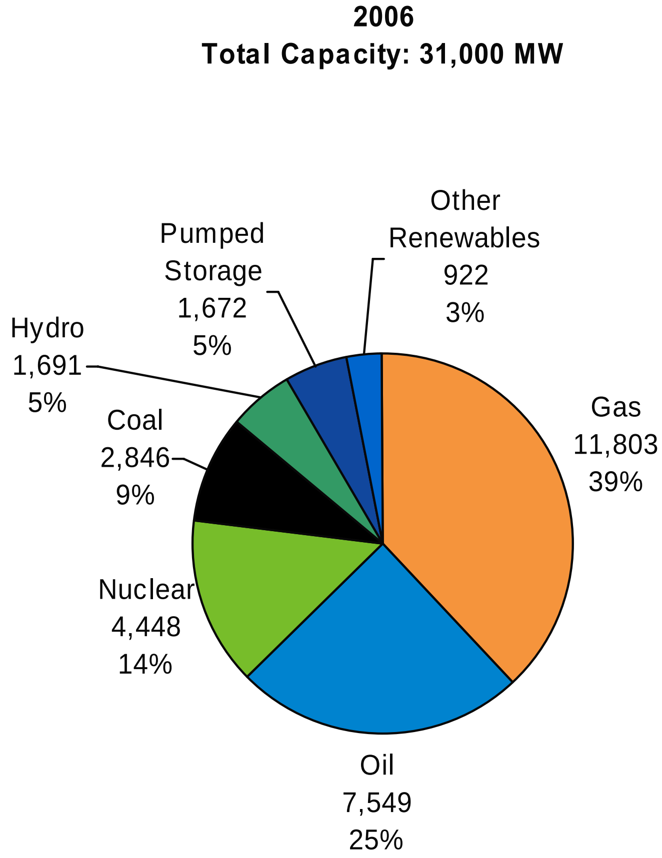
New England Scenario Analysis

- Each scenario considers an 8,000-MW system expansion based on:
  - A representative mix of the resources in the queue as of September 2006, *plus*
  - Seven different technologies/ types of resources
- Scenarios exaggerated to show differences
  - Actual expansion may result in a mix of resources

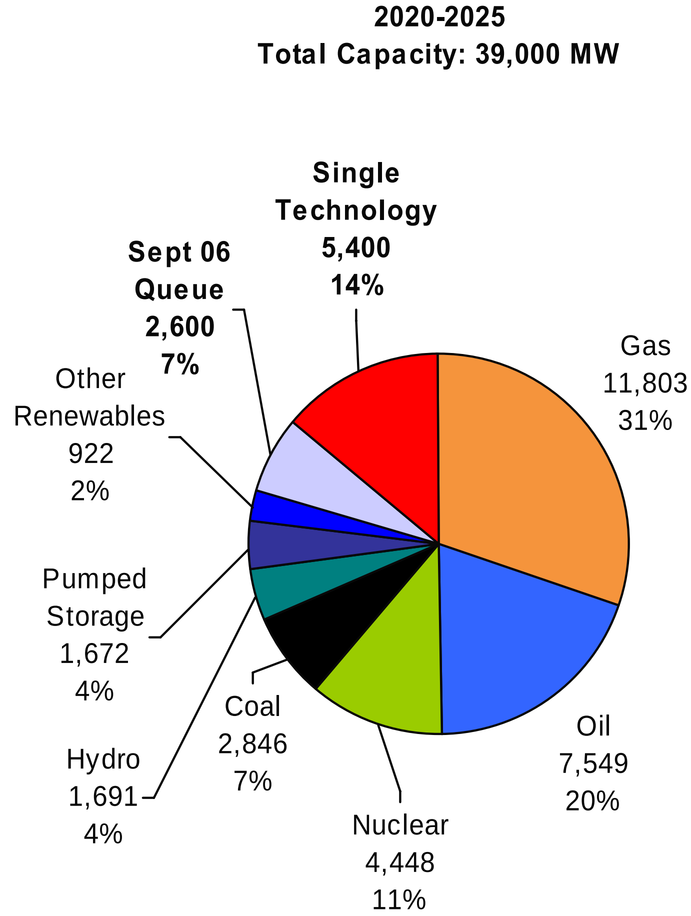


Fuel Mix: 2006 and 2020-2025 Timeframes

Existing System



Sample Scenario



Types of Analyses Performed

- Production Simulations
  - Provide individual and total production costs for resources
  - Calculate wholesale energy costs to consumers
  - Determine gross energy revenues to resources
  - Show air emissions
- Operable Capacity Analysis
  - Evaluate need for fuel diversity
  - Use methodology similar to RSP06
- Conceptual Electrical Transmission Needs
  - Develop cost for generic transmission expansion
  - Determine representative $/MW-mile for transmission expansion

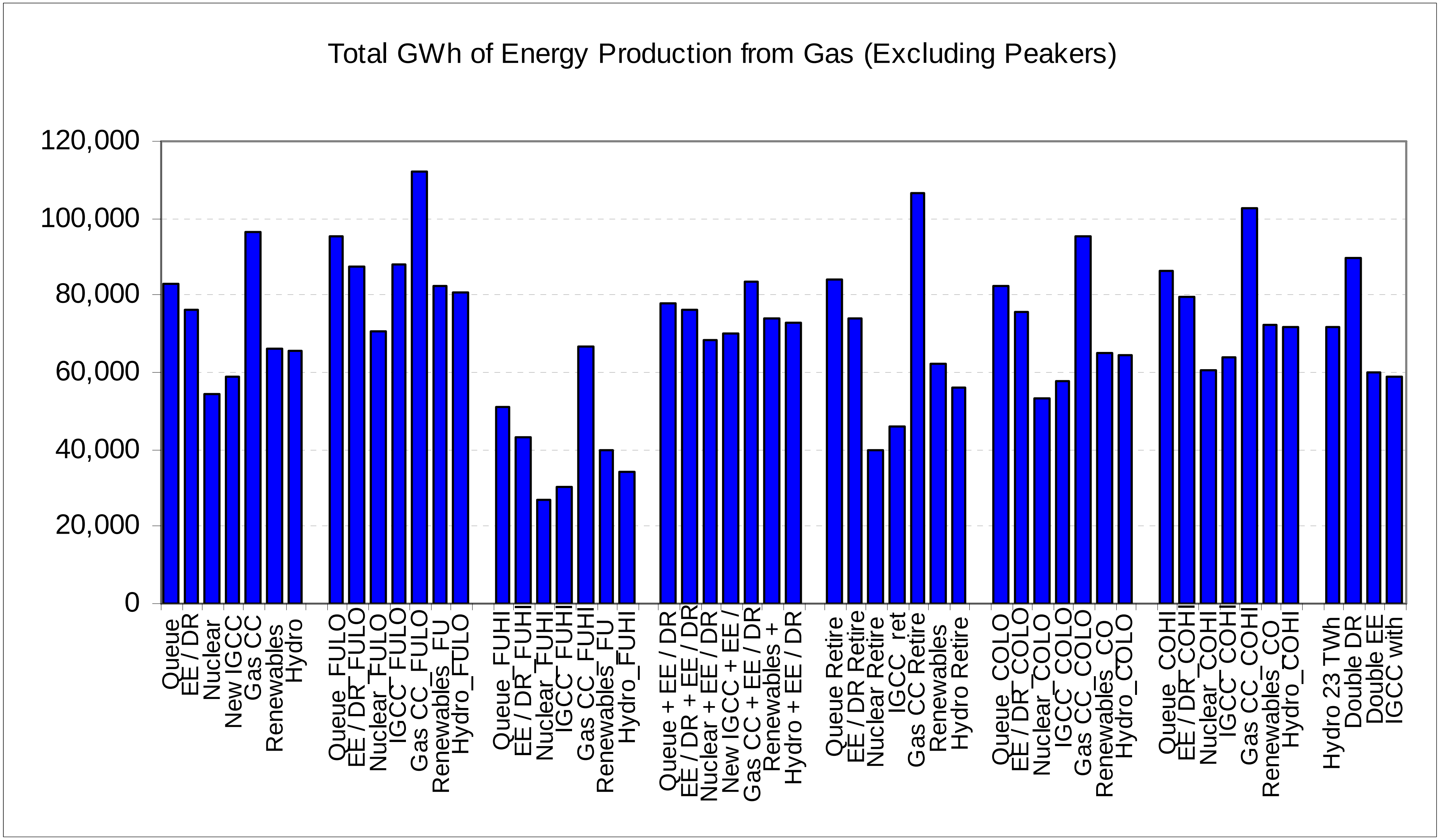
Types of Analyses Performed (continued)

- Conceptual Electrical Distribution Needs
  - Develop cost for generic distribution system expansion
- Conceptual Expansion of Wholesale and Local Distribution Natural Gas Delivery Systems
  - Develop cost for generic expansion of natural gas delivery system
- Physical Resource Needs for Land and Water Use
- Economic Analysis
  - Revenue support from energy markets in comparison to capital costs

Key Themes

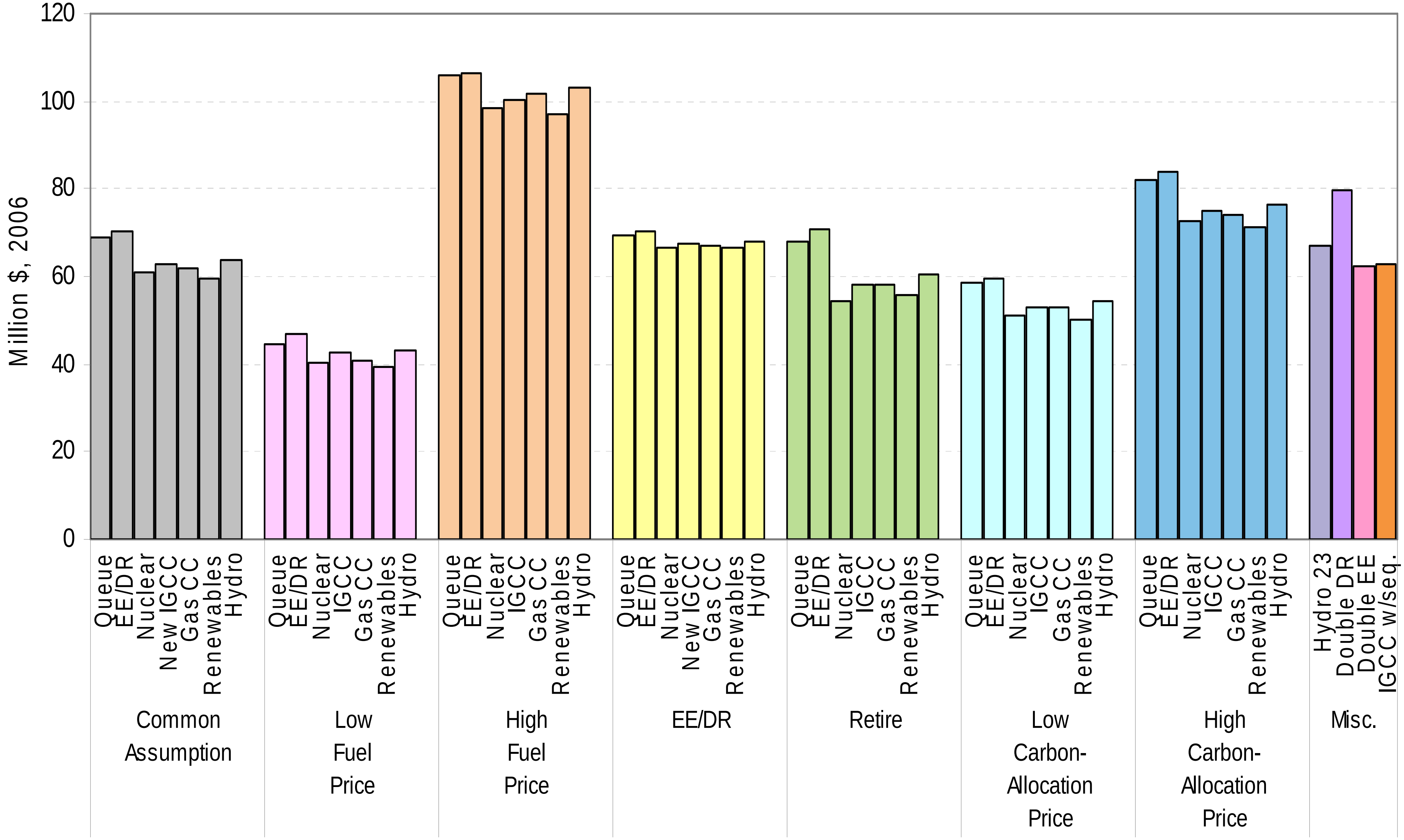
- Under all the scenarios, New England will continue to depend on natural gas to supply electricity.
- The prices of fossil fuels, particularly natural gas, drive the region's electric energy mix, costs, electric energy prices, and level of emissions.
- Across all the scenarios and sensitivity cases, gas-fired power plants tend to be among the last plants dispatched (the so-called marginal units) in New England to meet demand.
- Gas-fired plants tend to set electric energy clearing prices in the wholesale electricity markets in most hours of the year, approximately 90% of the time.

All Scenarios: New England Continues to Depend on Natural Gas to Supply Electricity



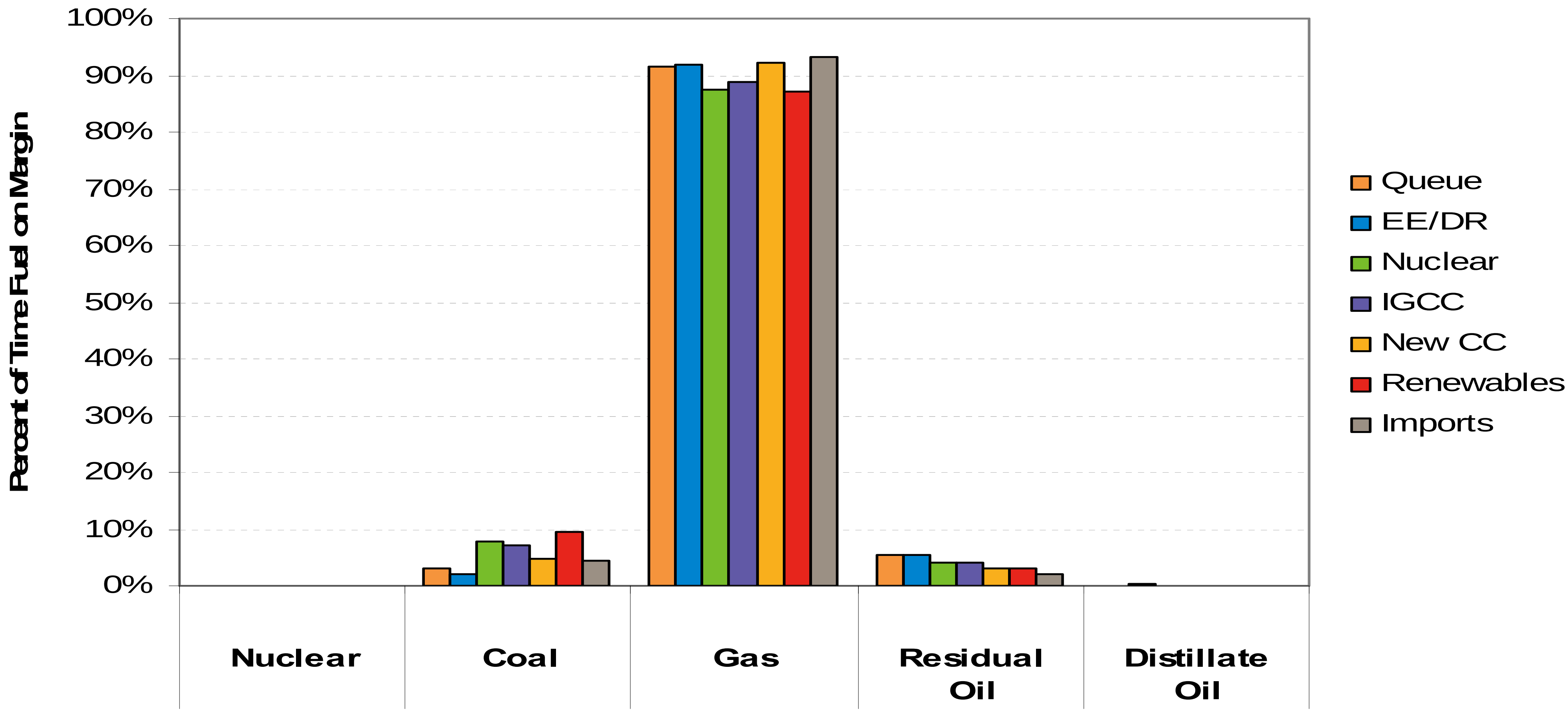
Fossil Fuel Prices Drive NE's Electric Energy Mix, Costs, Prices, and Level of Emissions

Figure 3: Average clearing price for wholesale electric energy, grouped by sensitivity case, $/MWh.



Gas-fired Power Plants Still Tend to be "Marginal Units"

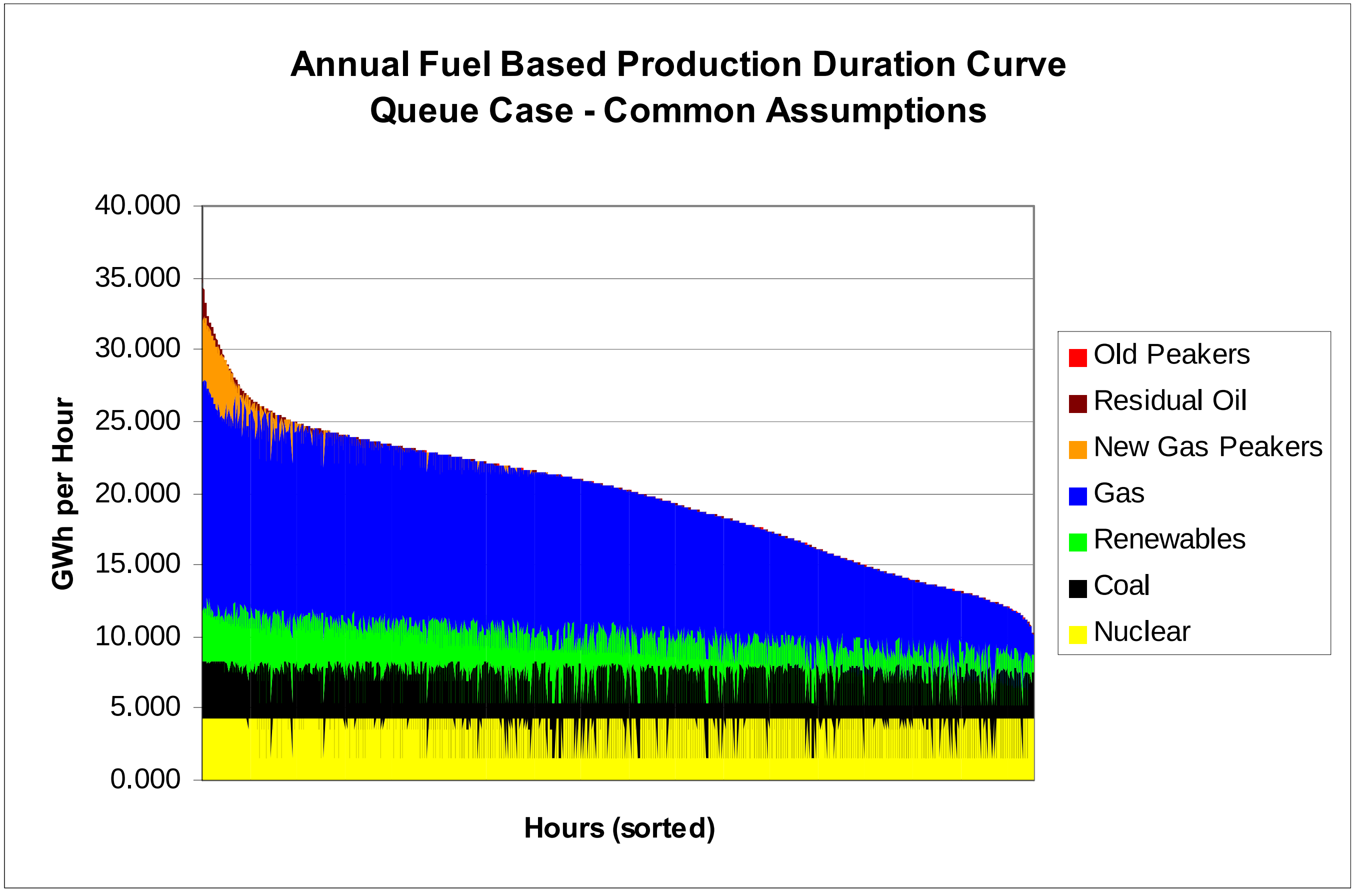
Figure 4: Percent of time fuel is on the margin.



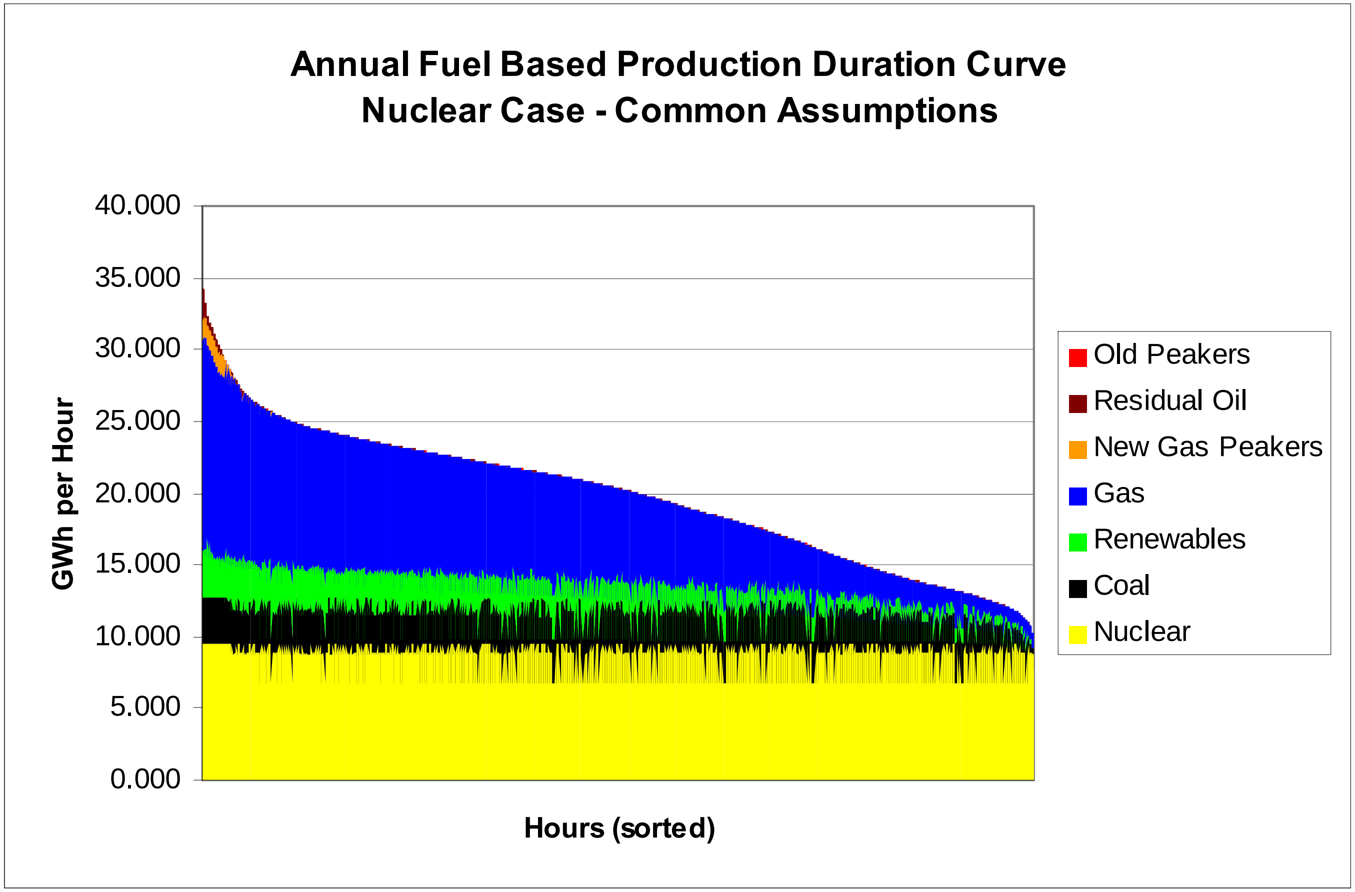
Key Themes (continued)

- ***The scenarios that have low variable cost, low emissions, and medium-to-high energy output (e.g., double energy efficiency, nuclear, hydro imports) will produce electricity more efficiently (i.e., with less overall fossil fuel consumption and lower emissions).***
- ***New England's CO_2 emissions from the power sector vary considerably across the scenarios.***
- ***The demand-side resources provide capacity and energy to the system at low capital costs and emissions, relative to other resources simulated*.**

Annual Energy Duration Curves: Queue



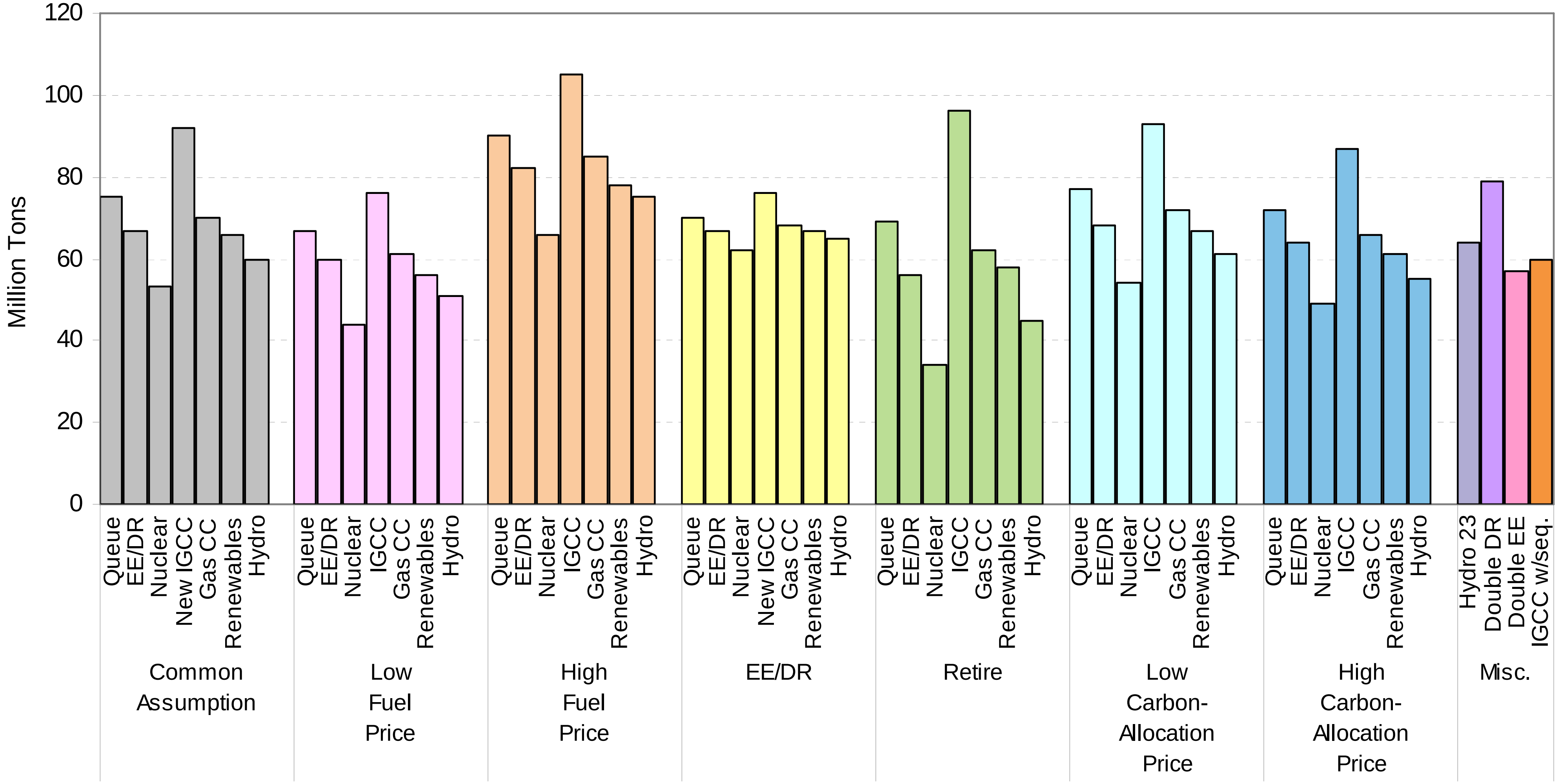
Annual Energy Duration Curves: Nuclear



New England's CO_2 Emissions from Power Sector Vary Considerably Across Scenarios

Figure 11: Total annual CO_2 emissions, grouped by sensitivity case.

Note: Table includes emissions from some small units not covered by RGGI requirements.



Comparing Scenarios and Cases with RGGI Allocation to New England States

Scenario	Cases with Emissions Below New England's RGGI CO_2 Allocation (50.2 million tons)
1. Queue	None
2. EE/DR	None
3. Nuclear	All cases except the high fuel-price case and the case to replace 3,500 MW with EE and DR
4. IGCC	None
5. NGCC	None
6. Renewables	All except the high fuel-price case
7. Imports	Low fuel-price case; the case to retire 3,500 MW; and the case with the high CO_2-allowance price

Summary of Metrics for Comparing Scenarios

Economic	Reliability	Environmental
Systemwide production costs[a] (billion $)	Systemwide energy mix (MWh; % MWh by fuel)	Total systemwide emissions of SO_2 and NO_X (1,000 tons) and CO_2 (million tons)
Energy supply duration curves for marginal clearing price	Systemwide capacity mix (MW by fuel)	Total systemwide NO_X emissions for the 10 highest peak-load summer days (tons)
Annual revenue requirements (ARR) for expansion resources[b] (billion $; $/kW-year)	Total units of fossil fuel burned (Quadrillion Btus consumed; MWh of production)	Total systemwide emissions of CO_2 (million tons)
Net wholesale electric energy market revenues for expansion resources (million $; $/kW-year)	Exposure to fuel-supply disruption (MW) (operable capacity analysis)	CO_2 emissions compared with Regional Greenhouse Gas Initiative allocation[c] (million tons; compliance/ noncompliance)
Load-serving entity expenses for wholesale electric energy based on hourly New England marginal clearing prices (billion $; $/MWh)		Mercury emissions (lbs)
Generic capital costs for expansion ($/kW)		Cooling water use (gal/minute)
Generic transmission expansion costs ($/scenario; $/MW-hour)		Amount of incremental land used (acres)
Generic distribution expansion costs ($/MW-hour)		Renewable energy contribution (MWh;% MWh)
Costs for generic expansion of gas-delivery system ($)		

(a) The systemwide production cost is the sum of the annual production costs (i.e., the fuel and emissions-related operating costs) for every resource to produce power in each hour of the simulated year.
(b) The annual revenue requirement (capital cost X the annual revenue requirement rate) captures all non-fuel-related costs including the recovery of capital costs, other operating costs, taxes, and other expenses.

Economic Metrics

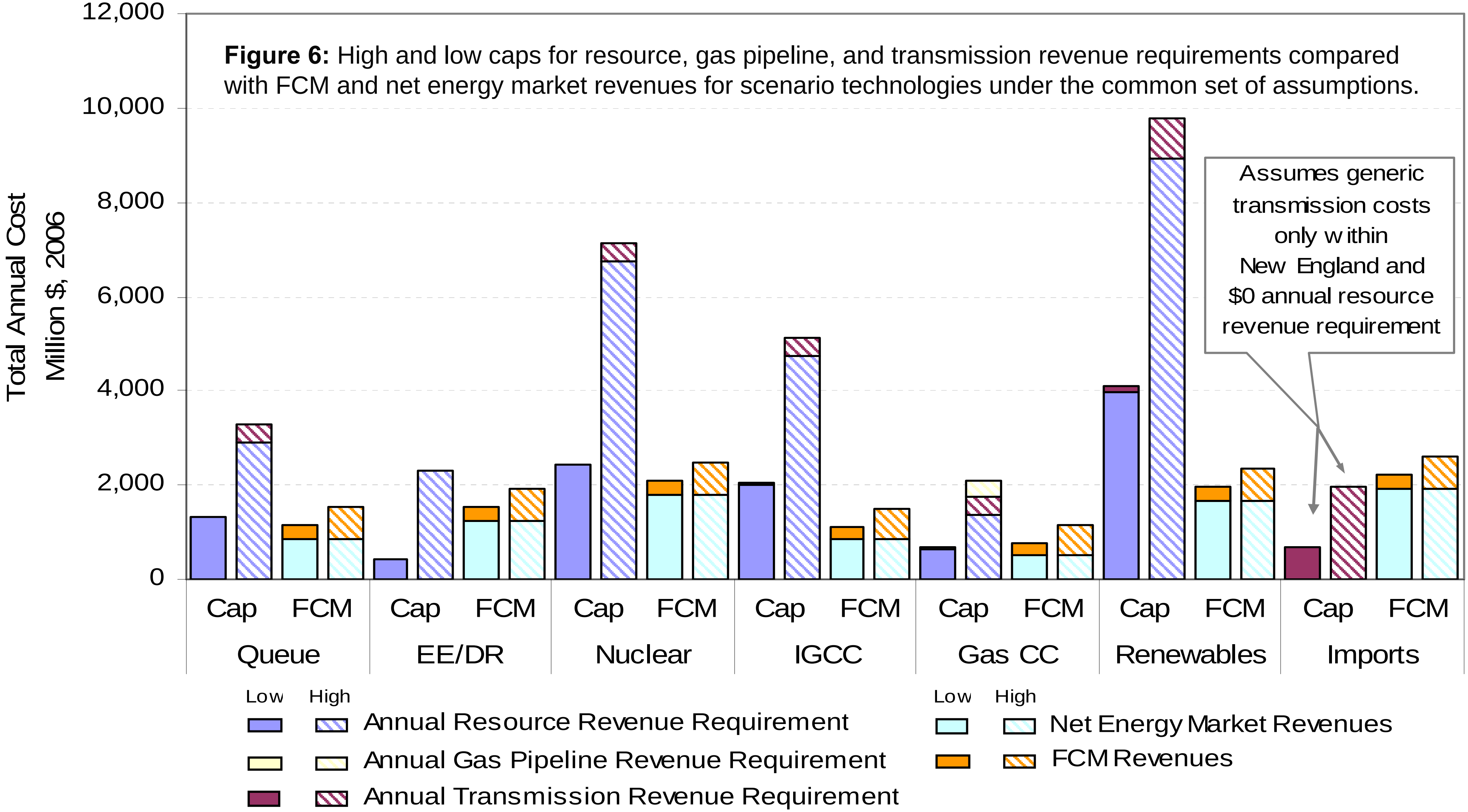
Themes of Economic Results

- *Adding resources with large amounts of electric energy production, low operating, costs, and low emissions will reduce production costs, energy prices, and emissions.*
  - Electric energy clearing prices in all cases except Scenario #2 (demand-side) are lower than the queue case.
  - The simulation results do not reflect dynamic changes, such as lower gas prices that could materialize in a scenario that reduces the demands for natural gas, such as the energy-efficiency cases.

Themes of Economic Results

- *Adding resources,* continued
  - The new gas-fired resources on the margin are more efficient than in the past and are thus likely to reduce marginal clearing prices compared with existing marginal gas-fired resources that have set average clearing prices in the past.
  - Scenarios, such as Scenario #1 (the queue), which largely depend on peaking and fast-start resources, are likely to lead to higher average marginal energy costs.
- Natural gas appears to remain the marginal fuel.

Demand-side Resources Provide Capacity and Energy at Relatively Low Capital Costs and Emissions



Themes of Economic Results

- *The price for fossil fuels (natural gas and oil) is the most dominant factor affecting the costs and emissions for each of the scenarios.*
- *The economic evaluation of expansion technologies must give full consideration to capital and operating costs as well as sources of revenues for the expansion technologies.*
- *Alternatively, energy efficiency and demand response show sufficient revenues from the electric energy and capacity markets to economically justify investment.*

Reliability Metrics

Reliability Results

- Energy mix and fuel-use patterns
  - Natural gas use and power production use
    - Varies with relative fuel prices
    - Is displaced by energy provided by other types of new resources
    - Stays about the same level in retirement cases
    - Increases for high carbon allowances
  - Residual fuel oil use
    - Increases only for retirement cases or when gas prices are high
  - Distillate fuel use increases for
    - The retirement case
    - More demand response
  - Energy response displaces natural gas and oil-fired units

Themes of Reliability Results

- *The system capacity mix would not alter a high dependency on natural-gas-fired capacity under any scenario.*

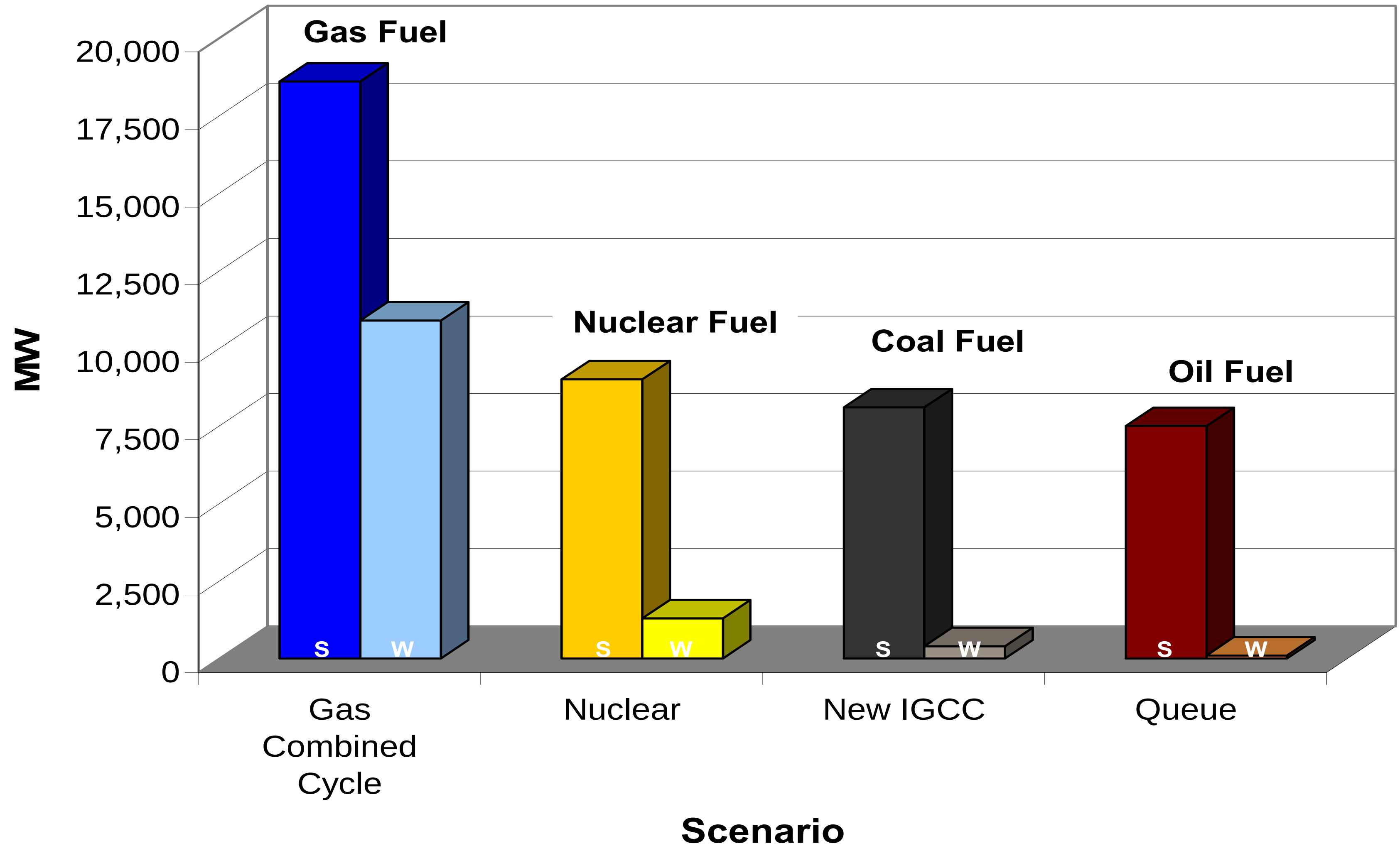
- *The greatest changes in the capacity mix tend to occur in the sensitivity cases that assumed that the oldest 3,500 MW of generating capacity in the region would retire and be replaced with that scenario's core technology.*

- *Adding thousands of megawatts of demand-response capacity, as assumed in this Scenario Analysis, could lead to trade offs.*

Major Results – Operable Capacity Analysis

- Operable Capacity Analysis (OCA) examines the ability to operate the system under peak-load conditions.
- Similar to RSP06 analysis, OCA was used to show the system-wide dependence on various types of capacity.
- Results show that natural gas-fired generation is the largest source of capacity across all scenarios.
- This suggests a continued need for:
  - Alternate sources of capacity and energy
  - Firm natural gas contracts and enhanced natural gas and liquefied natural gas (LNG) infrastructure
  - Dual-fuel capability of natural gas units

Summer and Winter Operable Capacity Needed by Fuel Source, MW

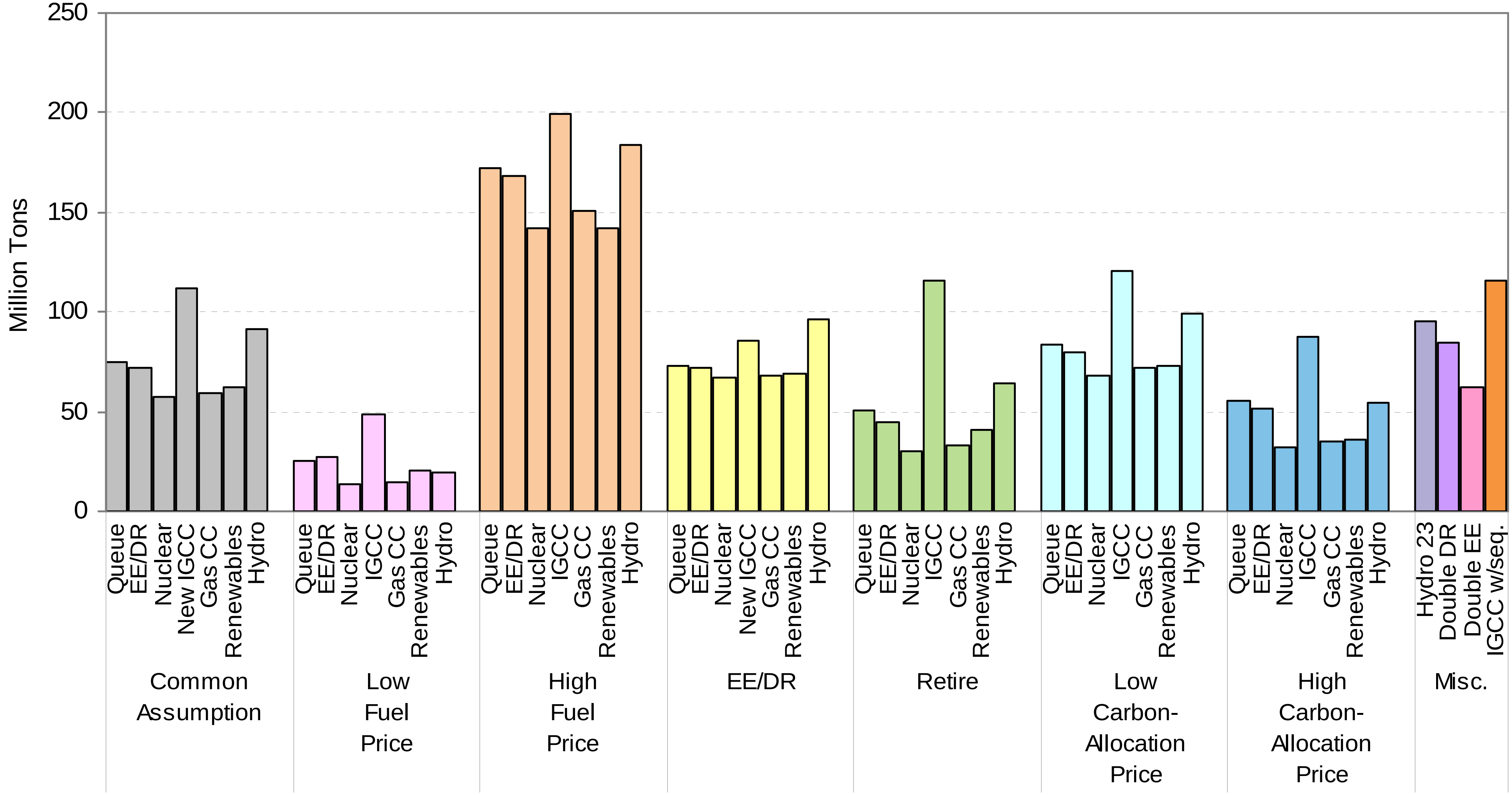


Environmental Metrics

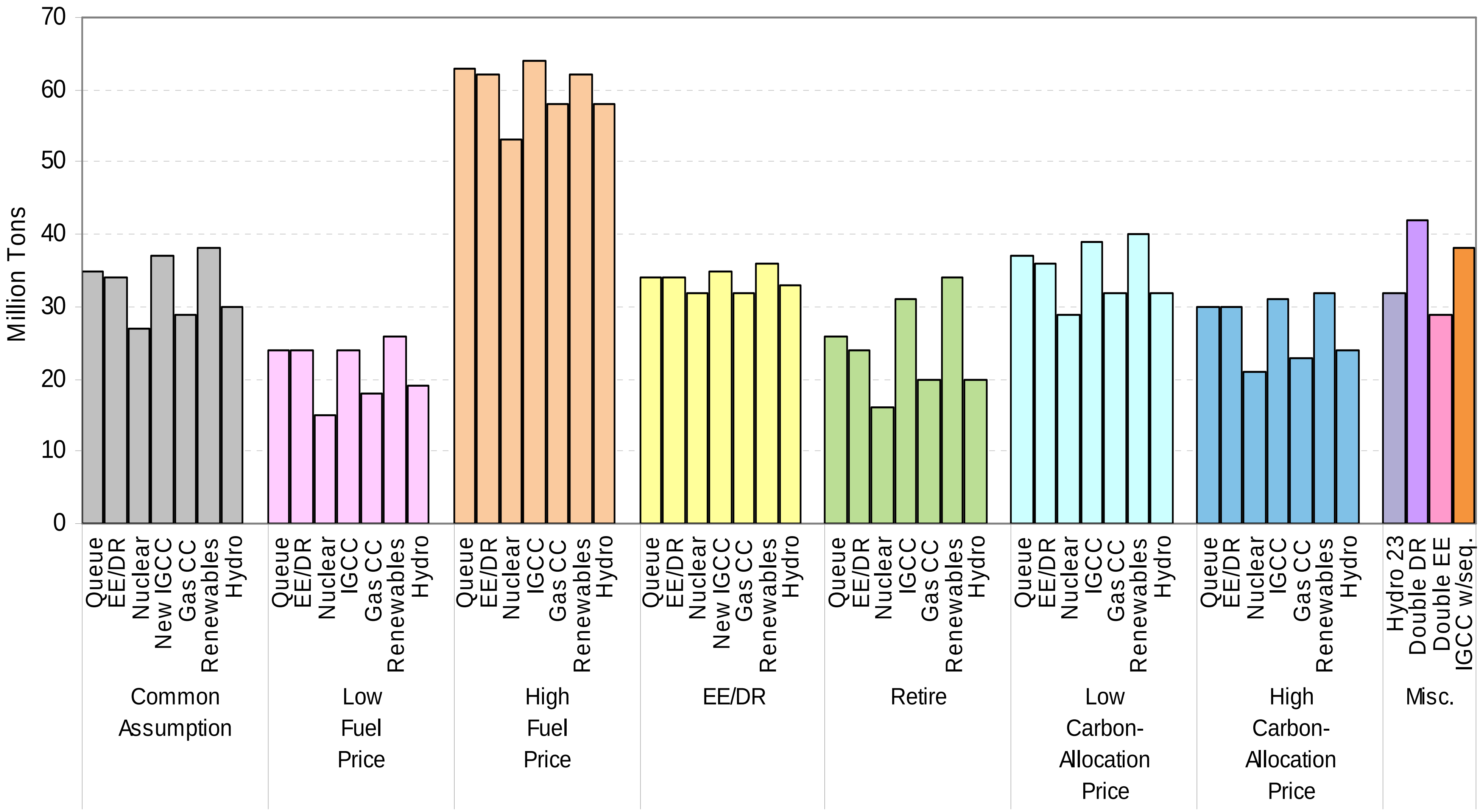
Themes of Environmental Results

- *With the exception of Scenario #4 (IGCC), the retirement case results show lower emissions.*
- *Relatively high reliance on fossil-fuel-based peaking resources, even in combination with some form of emission-free demand response, can result in an overall increase in air emissions.*
- *Because CO_2 emissions vary across the scenarios, regional compliance with RGGI will also vary.*

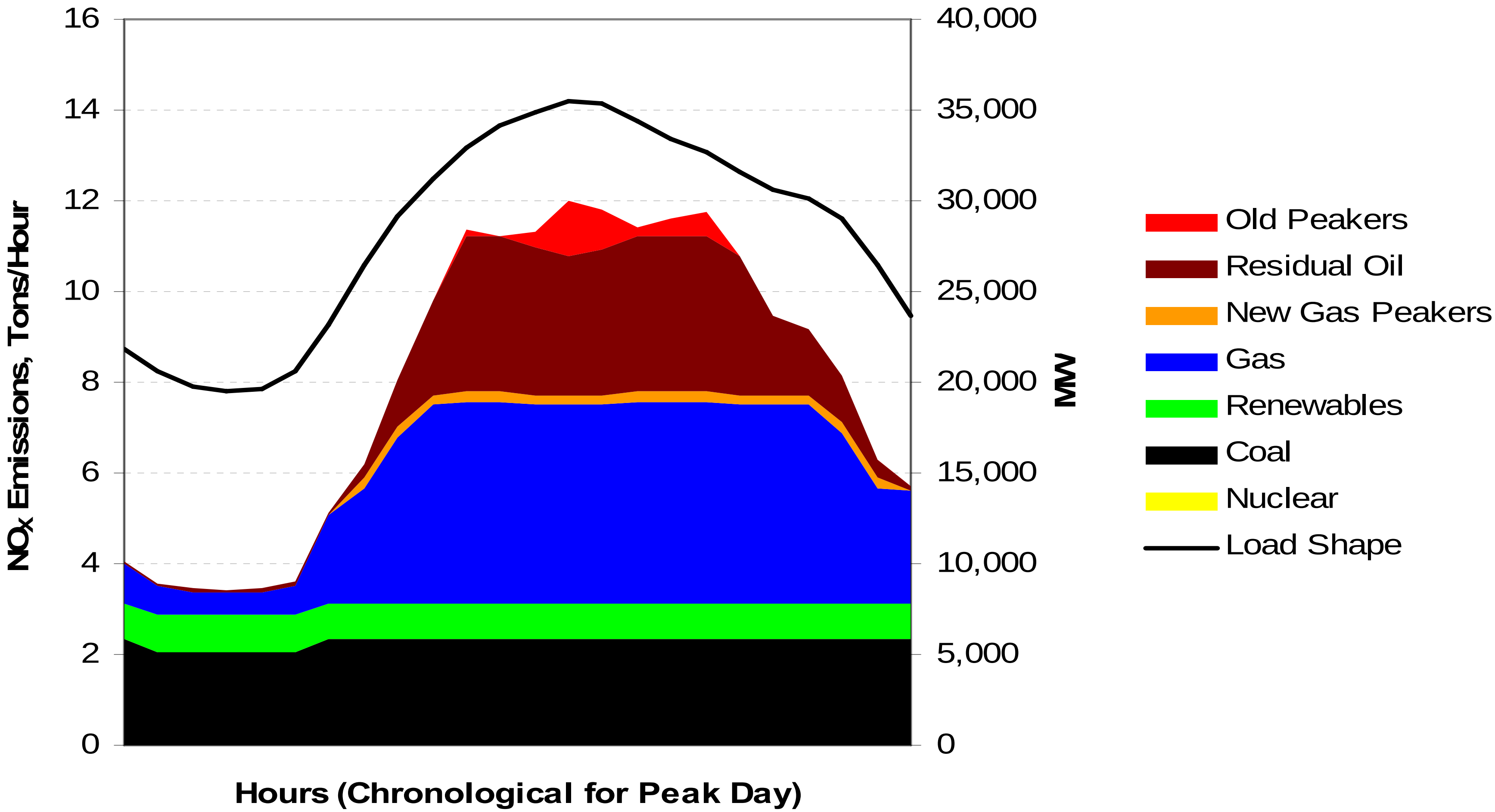
Total Annual SO_2 Emissions



Total Annual NO_X Emissions



NO_X Emissions by Fuel Category on the 35,000 MW Peak-load Day for Scenario #2



Land Requirements (Acres)

Scenario	Generation	Transmission	Total
1. Queue	9,134 – 54,008	238 – 6,019	9,371 – 69,398
2. EE/DR	0	0	0
3. Nuclear	1,038 – 2,025	238 – 6,019	1,276 – 9,320
4. IGCC	378-2,700	238 – 6,019	631 – 9,350
5. NGCC	128 – 128	238 – 950	365 – 1,443
6. Renewables	127,449 – 232,727	2,257 – 13,781	129,706 – 246,507
7. Imports	0	11,880 – 29,462	11,880 – 29,462

Cooling Water Use for Large Power Plants

- Queue scenario (#1)—12,100 gal/min
- Nuclear scenario (#3)—85,200 gal/min
- IGCC scenario (#4)—65,900 gal/min
- NGCC scenario (#5)—20,700 gal/min
- Other technologies – Little to no cooling water

Conclusion

- Results show differing impacts across the scenarios between economic, environmental and fuel diversity
- ISO results help identify scenarios that have low energy costs and low emissions
  – Nuclear, renewable and imported hydro scenarios produce the lower carbon emissions across the cases
  – Energy efficiency reduces emissions, but appears to require other low-emitting resources and additional compliance measures to meet RGGI requirements
- ISO's role is to facilitate discussion, not to recommend any particular scenario.

Questions?