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2016 Economic Study (NEPOOL Scenario Analysis)

New England Restructuring Roundtable

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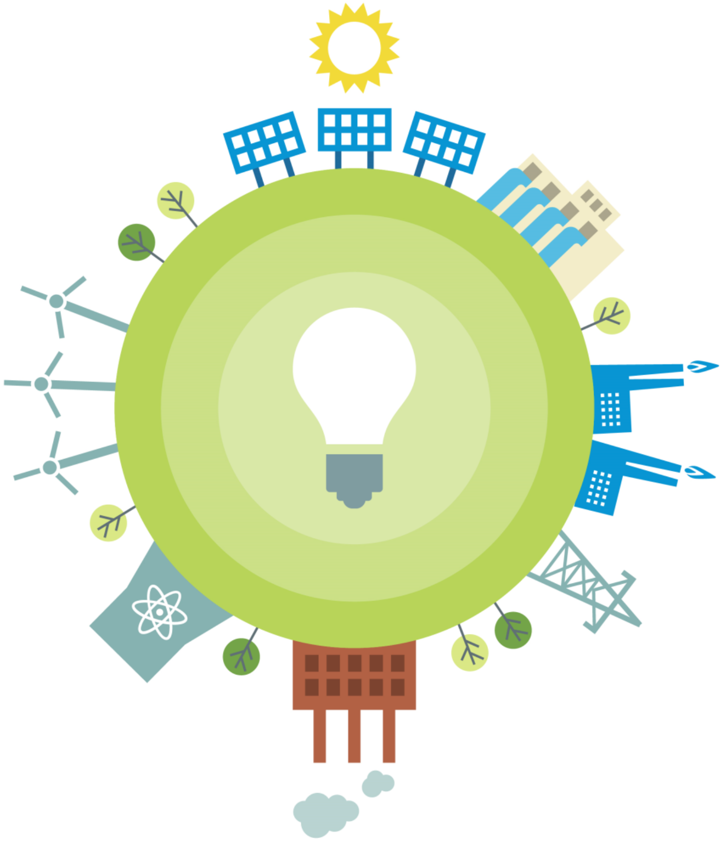
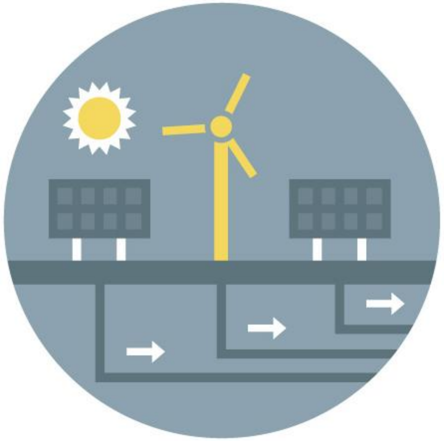
Overview of Presentation

- About the Study
- Study Scenarios
- Study Metrics
- Results Summary



About the Study

- The ISO is conducting a scenario analysis for NEPOOL to inform regional stakeholder discussions about the effects of public policies on the future electric power system
- What's *not* included in the study: recommendations, a transmission plan, resolution of technical or market issues



The ISO Has Organized the Study into Two Phases

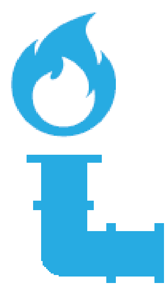
- ***Phase I*** – A traditional economic study analysis that utilizes assumptions provided by stakeholders and shows their effect on factors like the future resource mix and energy market prices (completed in 2016)
- ***Phase II*** – The ISO will supplement Phase I in 2017 by discussing additional market and operational issues, such as projected Forward Capacity Market prices, regulation, ramping and reserve requirements, and natural gas deliverability issues
- Study materials are available on the Planning Advisory Committee webpage: https://www.iso-ne.com/committees/planning/planning-advisory

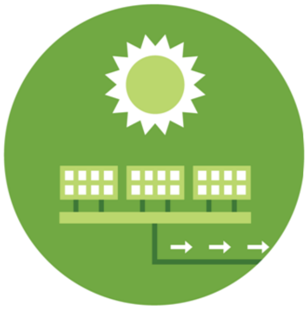
NEPOOL Identified Resource Scenarios

The scenarios include a range of potential futures to address system needs as generators retire or demand grows, and fall into two general categories:

1. Closer to current system and planned development of resources (Scenarios 1,4,5)

2. Effects of large amounts of renewable/clean energy resources (Scenarios 2,3,6)





NEPOOL's Six Base Scenarios

1. **RPS + Gas:** Physically meet Renewable Portfolio Standards (RPS) and replace generator retirements with natural gas (combined cycle units)
2. **ISO Queue:** Physically meet RPS and replace generator retirements with new renewable/clean energy
3. **Renewables Plus:** Physically meet RPS, add renewable/clean energy, EE, PV, PEV, storage, retire old generating units
4. **No Retirements (beyond FCA #10):** Meet RPS with resources under development and use RPS Alternative Compliance Payments (ACP) for shortfalls, add natural gas units
5. **Gas + ACPs:** Meet RPS with resources under development and use ACP, replace retirements with natural gas
6. **RPS + Geodiverse Renewables:** Scenario 2 with a more geographically balanced mix of on/offshore wind and solar PV

Highlights of Study Metrics

- Total energy production for each resource type (terawatt-hours)
- Relative Annual Resource Cost (RARC) encompassing all components (billions of dollars and cents per kWh)
  - Systemwide production costs ($M/year)
  - Capital costs of resource additions
  - Preliminary high-level, order-of-magnitude transmission-development costs ($ billion)
- Energy market contributions to fixed costs ($/kW-year)
- Carbon Dioxide (CO_2) emissions (Million tons)
- Full study contains additional metrics:
  - Load-serving entity (LSE) energy expense ($ million)
  - Average locational marginal prices (LMPs) ($/MWh)
  - Transmission interface flows (% of interface ratings)

RESULTS SUMMARY

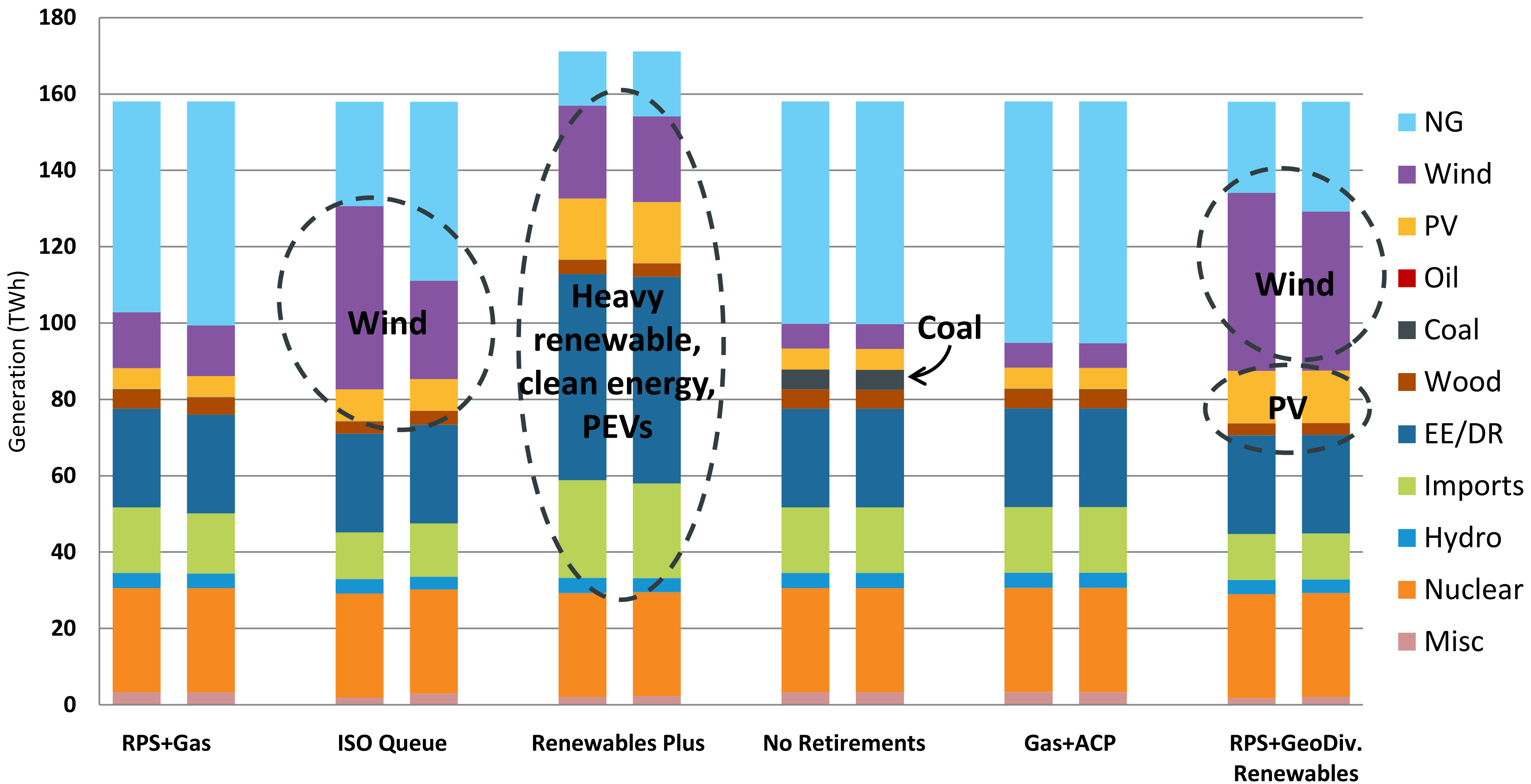
Key Findings

- Some scenarios yielded lower production costs and emissions, but higher relative annual resource costs
  - Would require significant transmission expansion and investment in new resources, particularly for wind power development in northern New England
- Across all scenarios, revenues from the energy market are insufficient to cover a new resource’s fixed costs
  - Would require other revenue sources to be economically viable



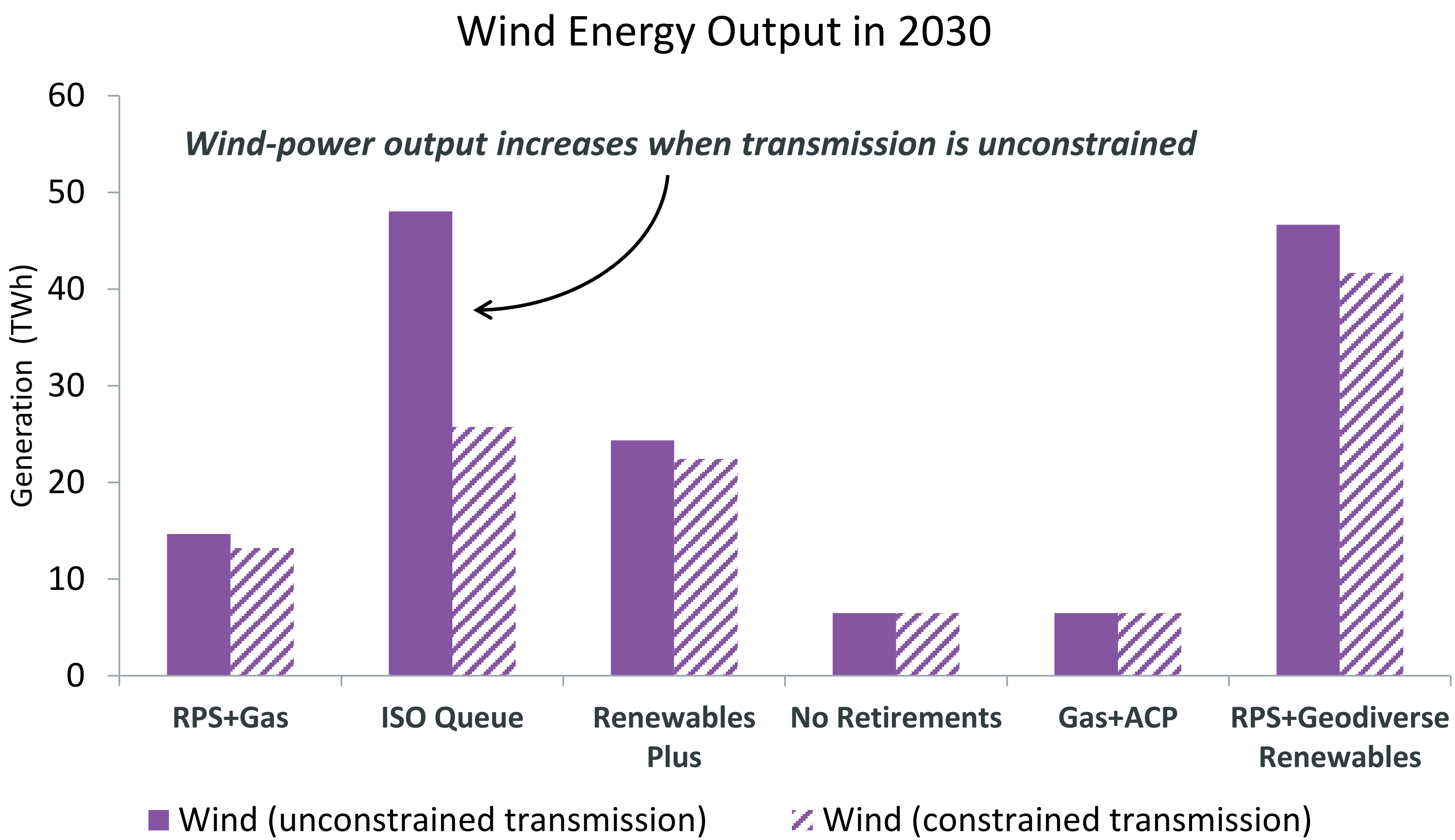
Energy by Source Varies Across Scenarios in 2030

Natural gas is on the margin most of the time across all scenarios



Notes: TWh: Terawatt-hours; Unconstrained transmission shown in left column; constrained transmission shown in right column

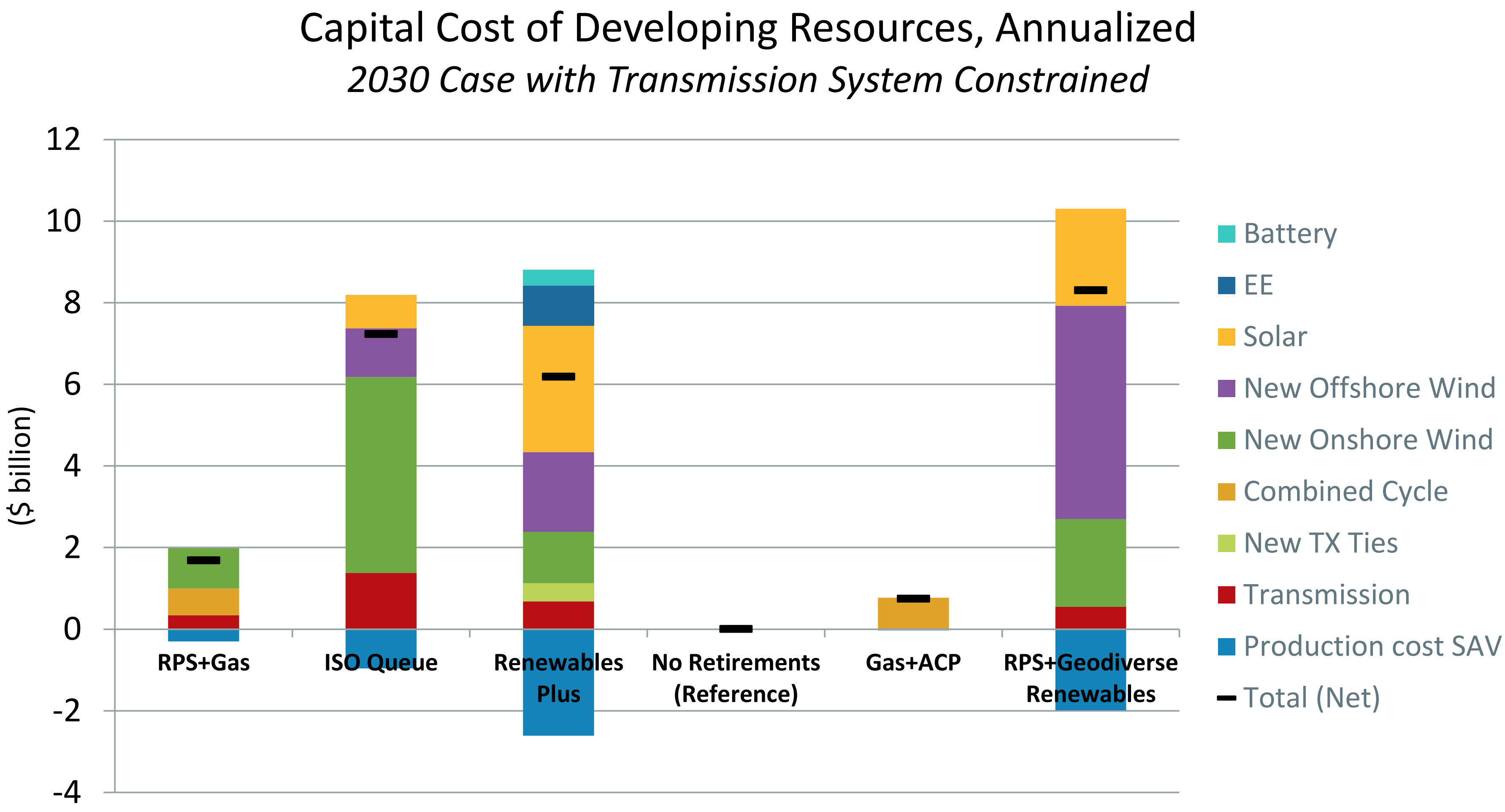
Transmission Constraints Have a Noticeable Impact in Scenarios with Heavy Onshore Wind



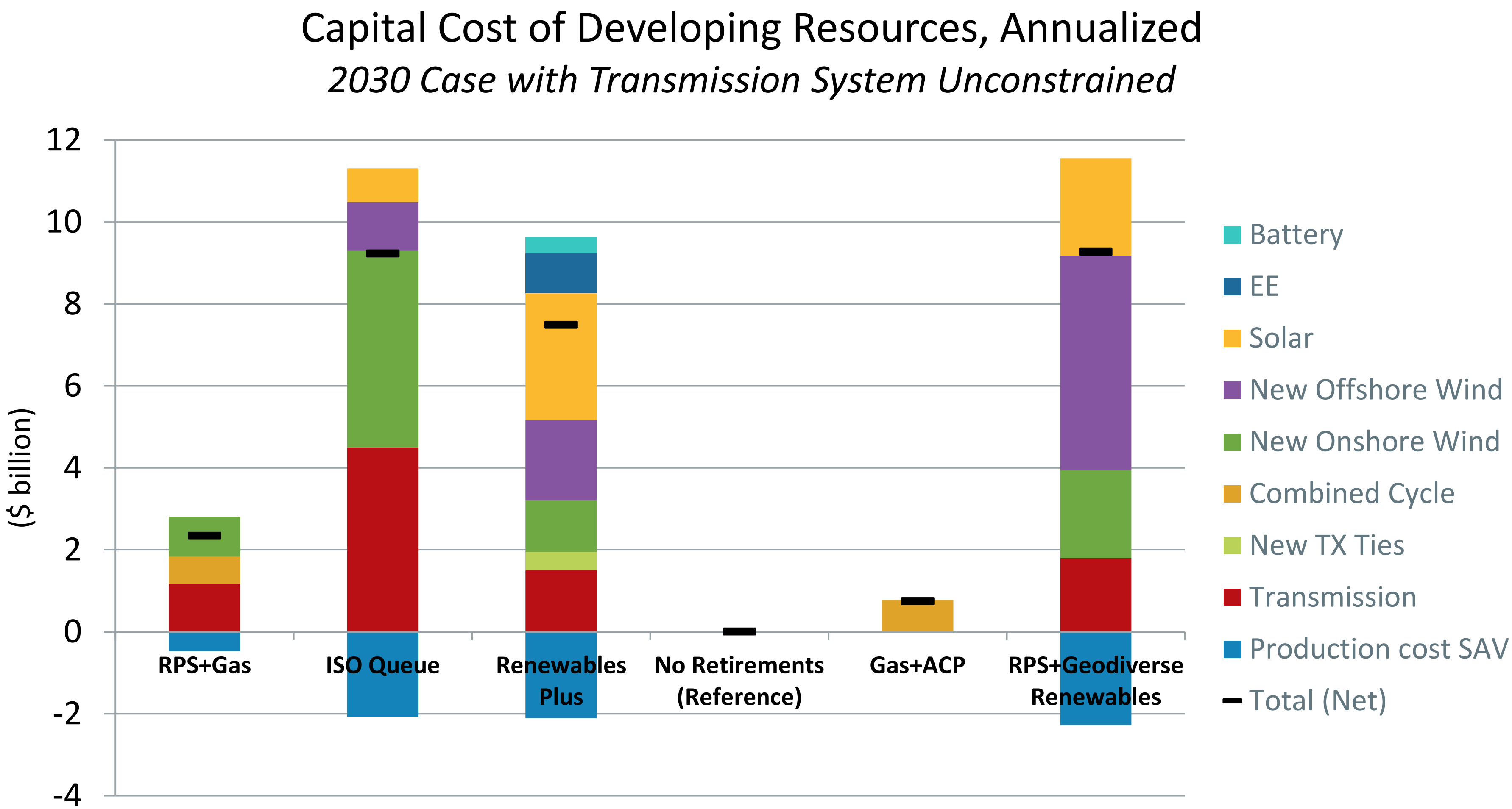
Comparing Total Costs of All Scenarios

- The Relative Annual Resource Cost (RARC) metric is a means of comparing the total costs of all six scenarios
- RARC compares the annualized carrying costs assumed for new resource additions, order-of-magnitude transmission costs for integrating resources, and production-cost savings for each scenario
- Scenarios with more onshore wind see higher increases in transmission costs
- Scenarios with more PV and offshore wind see higher increases in new resource development costs

Renewable Resources Have *Lower* Production Costs, but *Higher* Relative Annual Resource Costs



Greater Transmission Investment Is Required to Unlock Onshore Wind in Maine



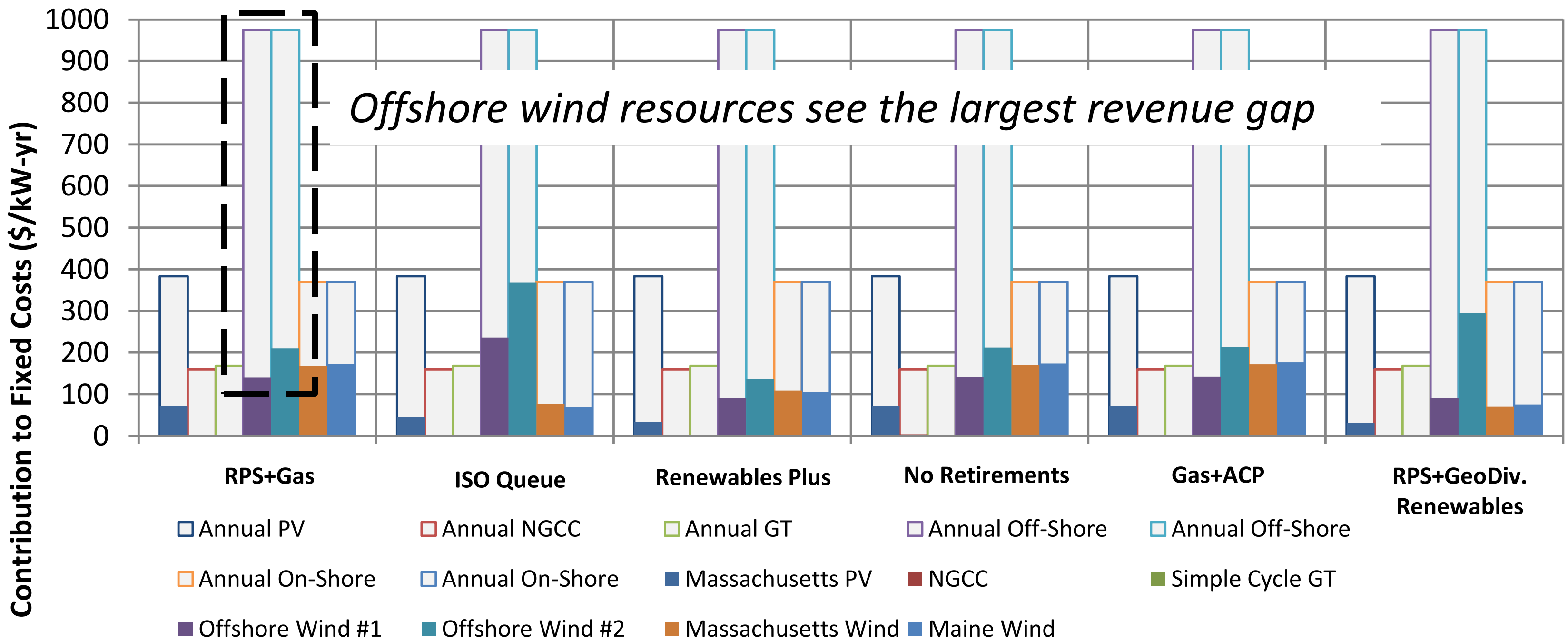
Energy Market Revenues Are Insufficient to Cover a Resource's Fixed Costs; Other Revenues Are Needed for Economic Viability

- Energy market revenues are depressed by:
  - Zero-cost resources
  - Competition of natural gas units
  - Low capacity factors of fossil units

Key:

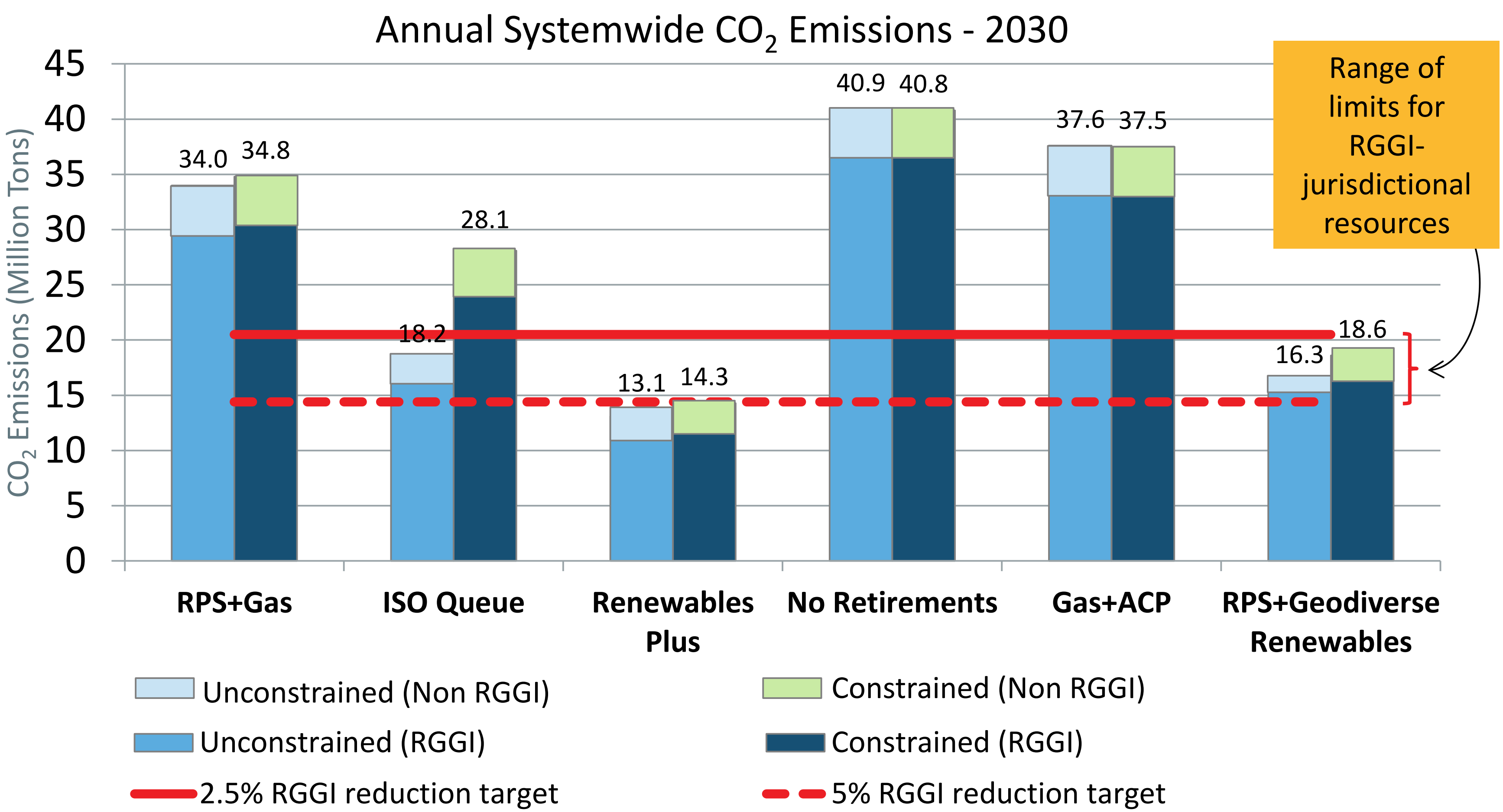
Revenue needed from other sources

Contribution to fixed costs



CO_2 Emissions Vary with Amount of Zero-Emitting Resources

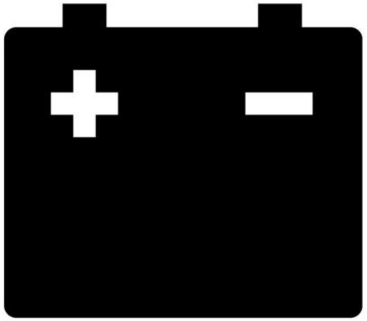
Renewable-heavy scenarios would fall below or within the range of RGGI goals, but transmission constraints could pose a challenge



Note: "Non RGGI" includes smaller resources not subject to the Regional Greenhouse Gas Initiative

Challenges and Solutions for Large-Scale Renewable Integration

- Lack of traditional spinning resources (and addition of asynchronous resources including EE, PV, wind, and HVDC imports) may pose physical challenges
  - Issues include need to address system protection, power quality, voltage regulation, regulation, ramping, and reserves
- Special control systems may be required, especially to stabilize the system and provide frequency control
- Efficient storage technologies would help facilitate the integration of variable resources



Questions