Economic Study for the New England Governors: *Renewable Development Scenario Analyses*

July 22, 2009
Washington, D.C.

Governors' Request ISO Technical Support for Regional "Blueprint"

- States seek to identify: "***significant sources of renewable energy available to New England, the most effective means to integrate them into our power grid, and the estimated costs***."
  - New England States Committee on Electricity (NESCOE), March 2009
- Request economic study for 2009
- Initial economic and transmission analysis has been completed

Economic Study: Approach

- ISO conducted “scenario analysis” for renewable development, focused primarily on wind
- Up to 12,000 MW of wind in New England
  - 7,500 MW onshore and 4,500 MW offshore
    - Offshore distributed evenly between Maine, Massachusetts, Rhode Island
  - Incremental cases: 2,000 MW / 4,000 MW / 8,000 MW
  - Nameplate capacity ratings
- Other resources
  - Demand resources, plug-in electric vehicles (PEVs), energy storage, and expanded imports
  - Range of resource penetrations (low / medium / high)

Economic Study: Approach, *cont.*

- Timing and sensitivities
  - Evaluated long-term horizon: approximately 20 years into the future (around 2030)
  - Evaluated generator retirement and repowering scenarios for units in service for 50 / 60 / 70 years by the year 2030
  - Evaluated sensitivity of each scenario to higher fuel prices, transmission constraints
- States developed study assumptions with technical support from ISO

Study Results

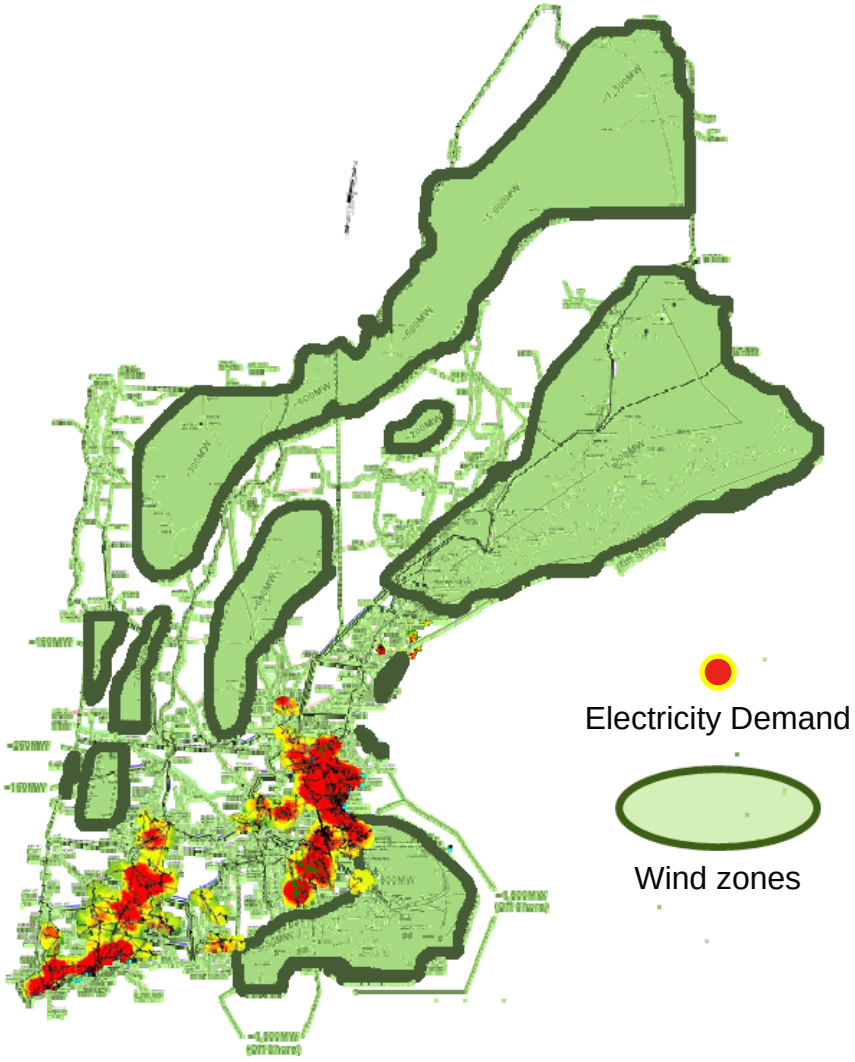
- Environmental metrics
  - Wind scenarios produce the lowest SO_2, NOx, and CO_2 emissions; retirement and repowering scenarios also produce significant SO_2, NOx, and CO_2 reductions
  - SO_2 emissions are higher in sensitivity cases with higher fuel prices as oil units run more often when gas prices are high
- Energy contribution from wind and hydro
  - Developing 5,500 MW of wind could supply 12% of New England's energy in 2030
  - Developing 12,000 MW of wind and expanding ties with Eastern Canada (assumed to be wind/hydro) could supply 26% of New England's energy in 2030

Study Results, *cont.*

- Wholesale Electricity Prices
  - Average annual electricity prices are lower in scenarios that add energy to the system (such as higher wind penetration) or remove energy from the system (such as higher demand resource penetration)
  - Retiring large amounts of fossil fuel generators and replacing them with advanced natural gas units also produces lower prices
  - For some resources, the reduction of energy market revenues could result in retirement and may require consideration of the need for other sources of revenue

Connecting Wind Energy to Load Centers

- Region's population and electricity demand are concentrated along the coast
- ISO identified 12,000 MW of on- and offshore wind potential
  - Preliminary screening eliminated wind sites near urban areas and sensitive geographic locations (e.g. Appalachian Trail)
- Transmission will be required to connect potential wind resources to load centers in New England



Transmission Scenarios

- ISO developed nine conceptual transmission scenarios:
  - Six scenarios to connect wind in New England, and
  - Three scenarios to expand ties to neighboring regions
  - Transmission scenarios developed as robust, workable solutions with cost estimates based on actual project experience
  - More detailed transmission studies would be required if the region pursues specific projects
  - New voltage classes may be needed for higher wind penetration scenarios (345 kV is the backbone of the existing system)

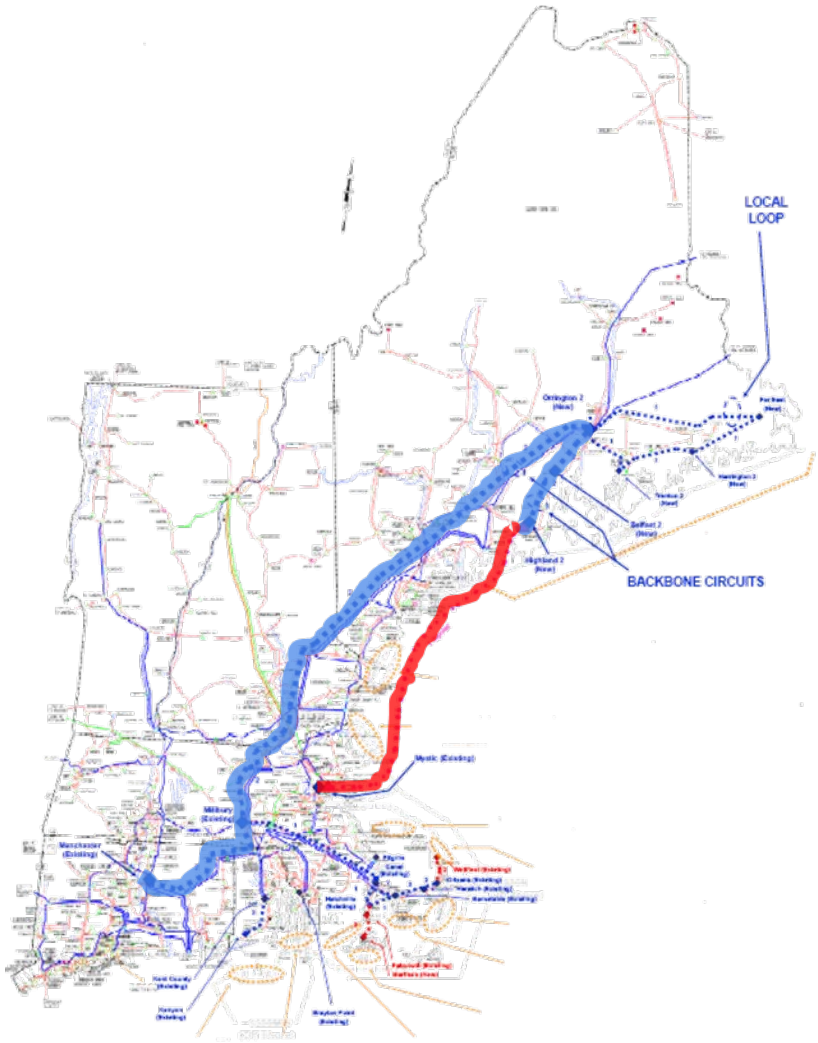
New England has Options for Developing or Accessing Renewable Resources

Description *Partial list of scenarios*	**New Capacity** (Megawatts)	**Percent of New England Energy** (%)	**Preliminary Transmission Cost Estimates** (Billions)
***From New England**:*			
4,000 MW of offshore wind *plus* 1,500 MW of inland wind	5,500 MW	12%	$6 B
12,000 MW of wind	12,000 MW	23%	$19 B to $25 B
***From New England and Eastern Canada**:*			
5,500 MW of wind (from above) *plus* 3,000 MW of additional imports from Québec and New Brunswick*	8,500 MW	15%	$10 B
12,000 MW of New England wind *plus* 3,000 MW of additional imports from Québec and New Brunswick*	15,000 MW	26%	$23 B to $29 B
From the Midwest: 10,000 MW of wind	10,000 MW	19%	$6 B to $9 B**

* Estimate does not include facilities in Québec and New Brunswick; only includes cost of potential transmission in New England.
** Estimate does not include New England's share of the cost of building transmission from the Midwest to the New York-New England border; only includes cost of integrating energy from the NY-NE border to load centers in New England.

Transmission for 5,500 MW of Wind

- Potential transmission to connect 4,000 MW of offshore and 1,500 MW of onshore wind
- New transmission paths:
  - New 345 kV line from Maine to Connecticut
  - New HVDC underwater cable from Maine to Boston
- Local loops to collect wind in Maine
- Preliminary cost estimate: $6 billion



Transmission for 3,000 MW of Imports

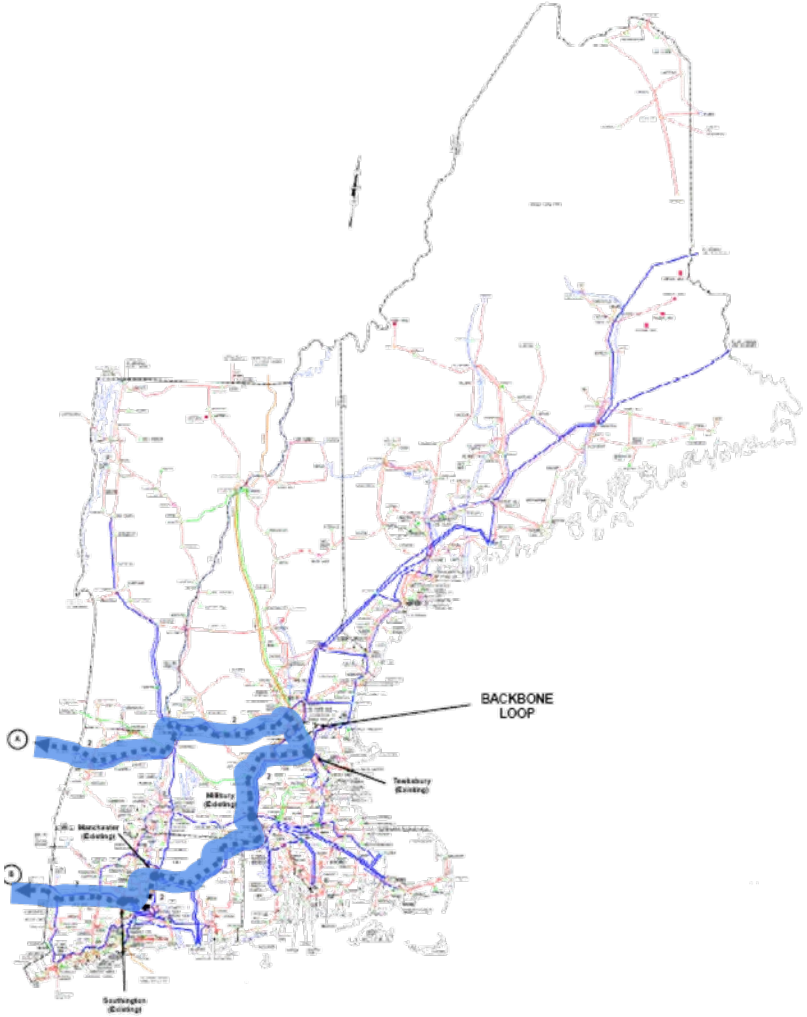
- Potential new transmission ties to Quebec and New Brunswick
  - Import 1,500 MW via new +/-450kV high voltage direct current (HVDC) line from Des Cantons substation in Québec to Millbury, MA
    - Preliminary cost estimate: $1.6 billion
  - Import 1,500 MW via new +/-450kV HVDC line from Keswick in New Brunswick to Millbury, MA
    - Preliminary cost estimate: $2 billion
  - Cost estimates represent only the cost of potential transmission facilities in New England

Transmission for 12,000 MW Wind Case

- New higher voltage backbone loop around New England
  - Local loops to collect wind in Maine
- Preliminary cost estimates:
  - 500 kV: $19 billion
  - 765 kV: $25 billion

Transmission for 10,000 MW via Midwest

- New 500 kV or 765 kV backbone loop from New York-New England border to load centers in southern New England
- Preliminary cost estimate: $6.3 billion
  - Does **not** include New England share of cost of building transmission from Midwest to NY-NE border
  - Costs to access Midwest wind are unknown at this time, but are expected to add substantially to this scenario



Distances to Access Renewable Resources

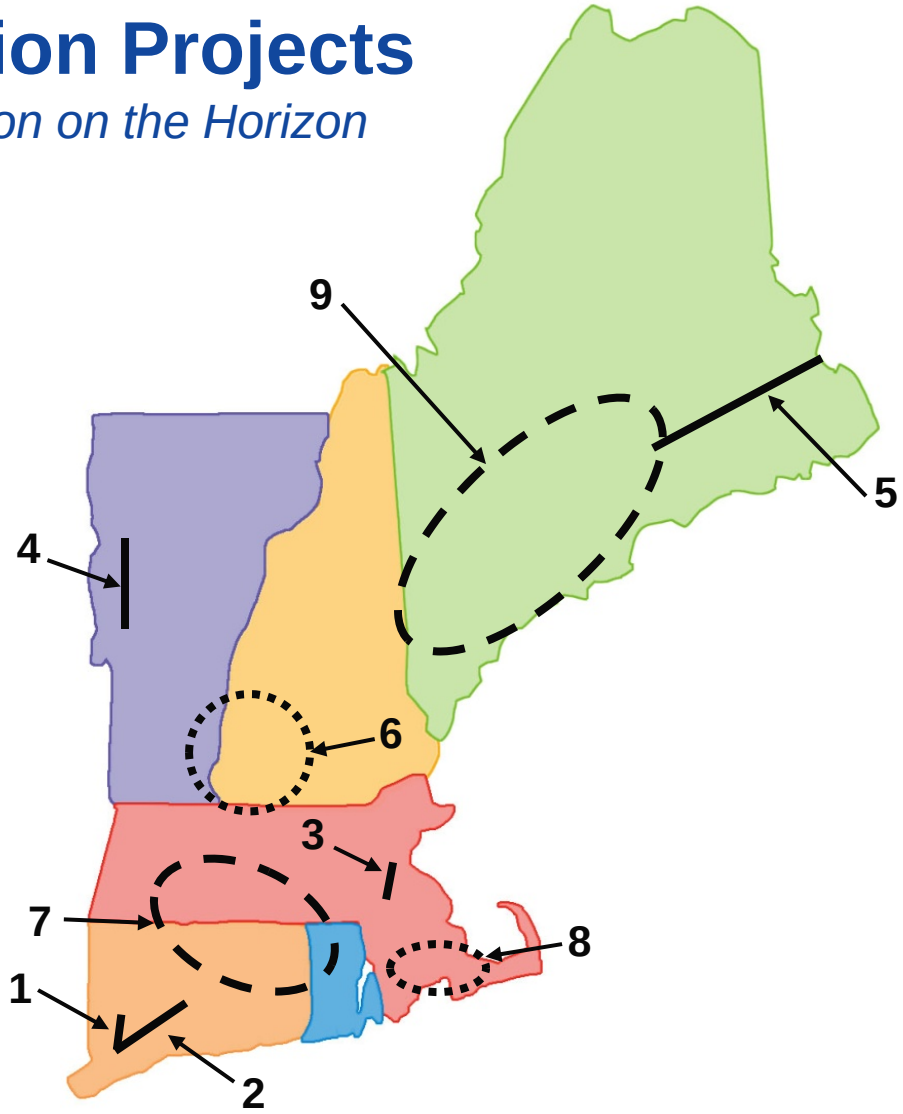
Economic Study: Highlights

- **Region has significant renewable options, nearby**
  - New England has significant potential to develop onshore and offshore renewable resources and to expand trade with nearby Eastern Canada
- **Transmission investment will be needed**
  - Transmission will be needed to integrate renewable resources into the electric grid and deliver energy from remote areas to load centers
- **Region has success building transmission**
  - New England's success developing major reliability projects is a solid platform for studies to evaluate additional transmission scenarios
  - ISO, New England transmission owners, and state officials play critical roles in transmission development

New England has Demonstrated Ability to Tackle Major Transmission Projects

Approx. $4 Billion in Investment, $5 Billion on the Horizon

1. Southwest CT Phase I
2. SWCT Phase II
3. NSTAR 345 kV Project, Phase I and II
4. Northwest Vermont
5. Northeast Reliability Interconnect
6. Monadnock Area
7. New England East-West Solution
8. Southeast Massachusetts
9. Maine Power Reliability Program



Next Steps

- Update New England stakeholders in August
- Submit report to New England Governors in August
- Meeting of New England Governors and Eastern Canadian Premiers in September