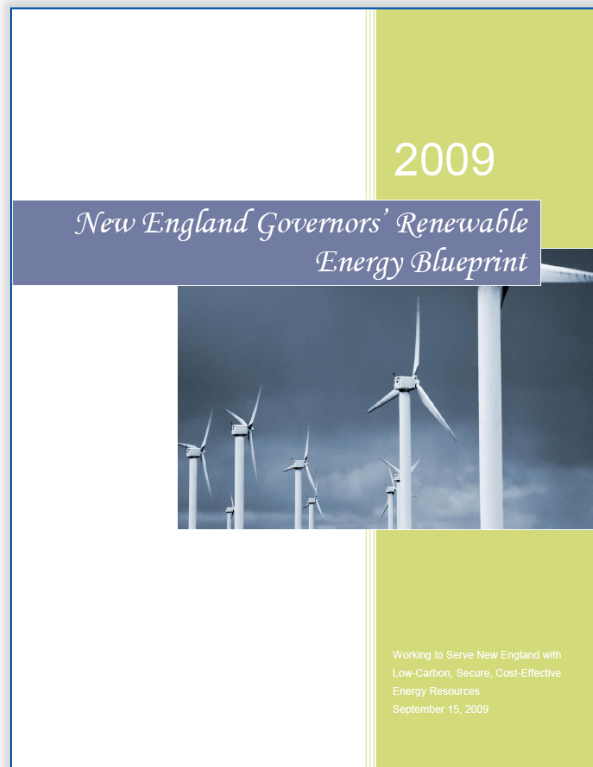


# 2030 Power System Study

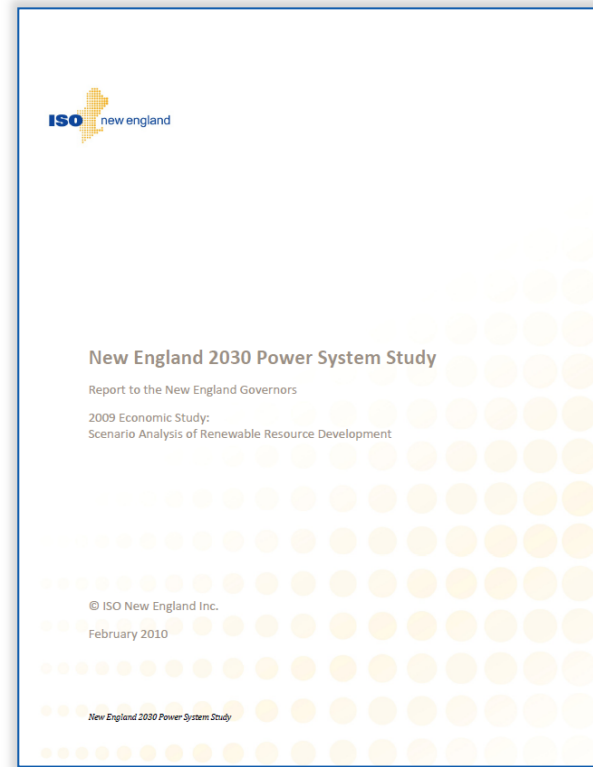
Report to the New England Governors

*2009 Economic Study: Scenario Analysis of Renewable Resource  
Development*

# New England Governors Adopt Long-term Renewable Energy Vision



**States' Blueprint as guiding policy and regulatory framework**



**ISO economic study as technical support**

# Economic Study: Approach

- ISO conducted “scenario analysis” for development of renewable resources, 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

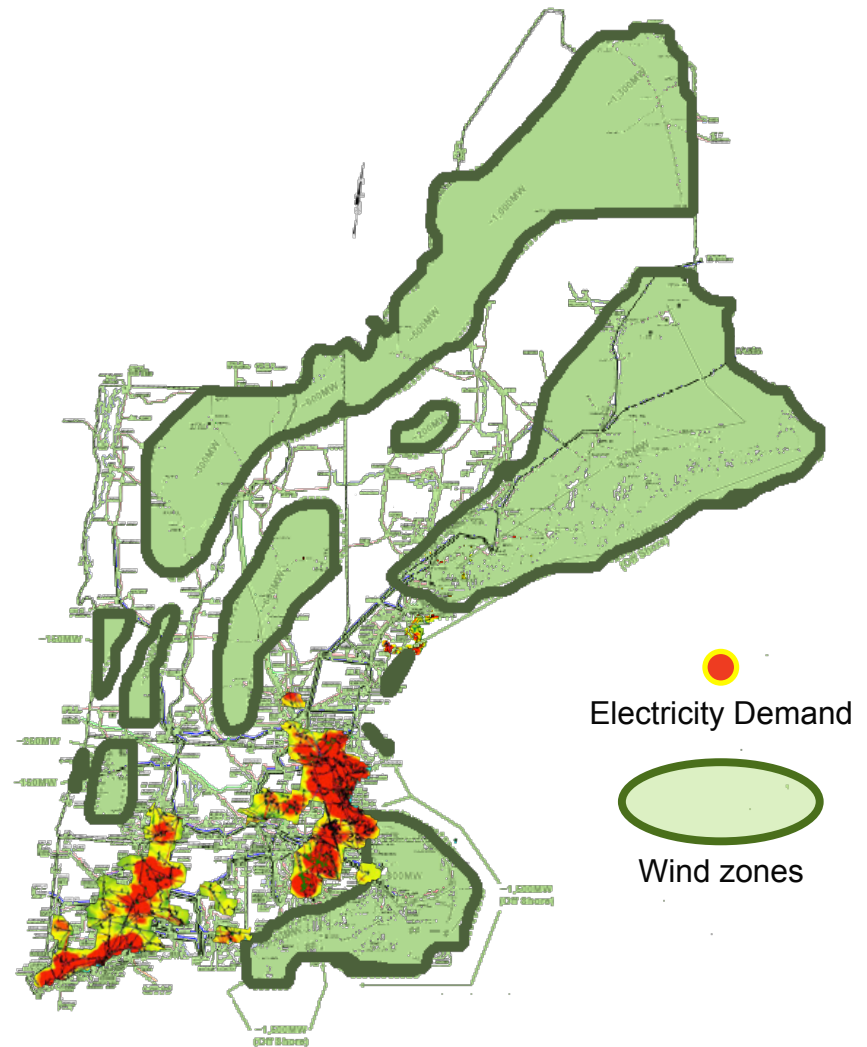
- Environmental metrics
  - Retirement and repowering scenarios produce the lowest SO<sub>2</sub>, NO<sub>x</sub>, and CO<sub>2</sub> emissions; wind scenarios also produce significant SO<sub>2</sub>, NO<sub>x</sub>, and CO<sub>2</sub> reductions
- Energy contribution from wind and hydro
  - Developing 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 and hydro) could supply 26% of New England's energy from wind and an additional 9% from hydro in 2030

# Study Results, *cont.*

- Wholesale Electric Energy Prices
  - Average annual prices are lower in scenarios that add low-cost 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
  - Some resources would retire if energy market revenues were reduced or would need to consider other sources of revenue
- Wholesale electric energy prices do not include capital costs of the resources and associated transmission

# Connecting Wind Energy to Load Centers

- Population and electric demand are concentrated along the coast in central and southern New England
- 12,000 MW of onshore 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



# Summary of Scenarios for Renewable Resources

*Offshore and near-shore wind and wind imports can achieve 15% of New England's energy*

Description <i>Partial list of scenarios</i>	New Capacity (Megawatts) Est. Circuit Miles of Transmission	Percent of New England <i>Wind</i> Energy (%)	Preliminary Transmission Cost Estimates (Billions)
<b><i>From New England:</i></b>			
4,000 MW of offshore wind <i>plus</i> 1,500 MW of near-shore onshore wind*	5,500 MW (1,430 miles)	12%	\$4.7 B to \$7.6 B
12,000 MW of wind	12,000 MW (4,320 miles)	23%	\$19 B to \$25 B
<b><i>From New England and Eastern Canada:</i></b>			
5,500 MW of wind (from above) <i>plus</i> 3,000 MW of additional imports from Québec and New Brunswick**	8,500 MW (2,100 miles)	15%	~\$7 B to ~\$12 B
12,000 MW of New England wind <i>plus</i> 3,000 MW of additional imports from Québec and New Brunswick**	15,000 MW (5,000 miles)	26%	~\$17 B to ~\$36 B

\* Offshore wind was assumed to have a capacity factor of 40.7 percent. Onshore wind outside of Maine was assumed to have a capacity factor of 35.4 percent, while onshore wind in Maine and New Brunswick was assumed to have a 29.3 percent capacity factor

\*\* Estimate does not include facilities in Québec and New Brunswick; only includes cost of potential transmission in New England

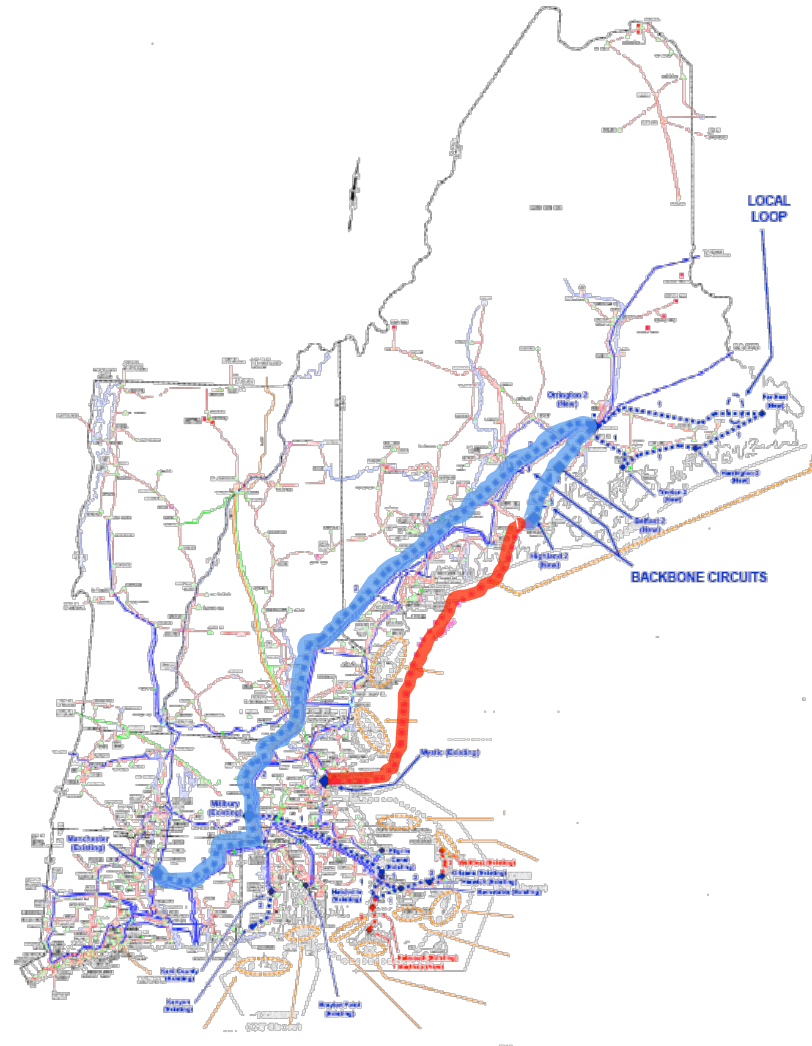


# Transmission Scenarios

- ISO developed 16 conceptual transmission scenarios
  - 13 scenarios to connect wind in New England, and
  - 3 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)

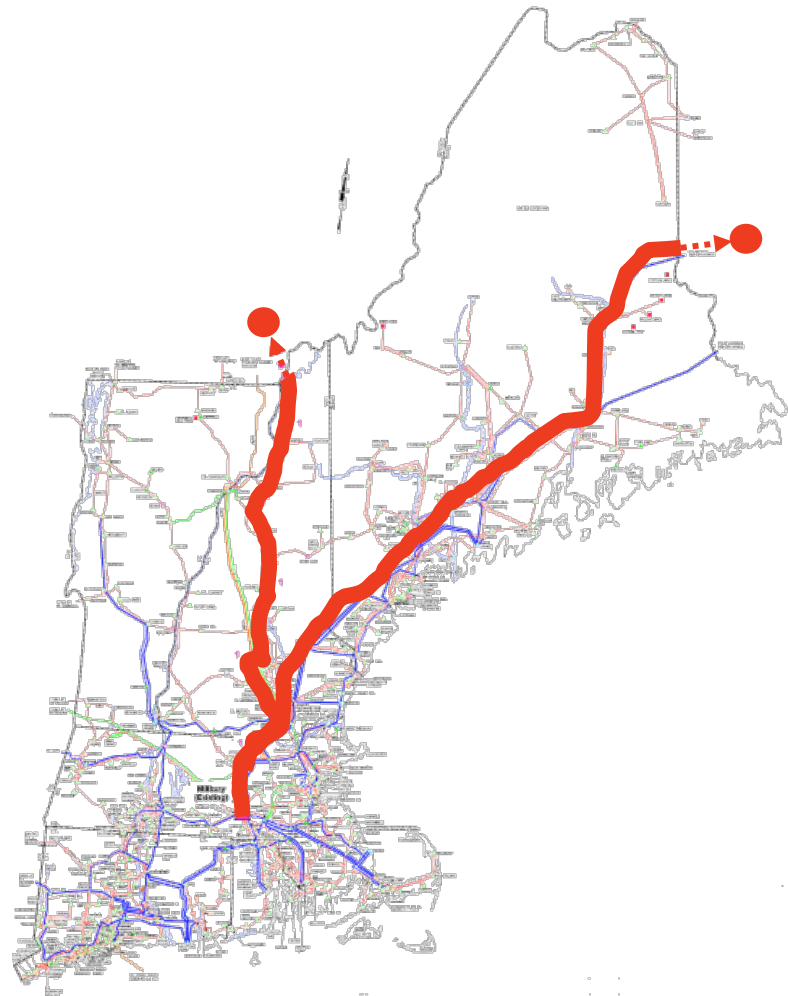
# Transmission for 5,500 MW of Wind

- Potential transmission to connect 4,000 MW of offshore and 1,500 MW of near-shore 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 Eastern Canada
  - Import 1,500 MW from Québec via new +/-450 kV HVDC line
    - Preliminary cost estimate: \$1.6 billion
  - Import 1,500 MW from New Brunswick via new +/-450 kV HVDC line
    - Preliminary cost estimate: \$2 billion
  - Cost estimates represent only the cost of potential transmission facilities in New England



# Transmission for 12,000 MW of Wind

- 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: \$20-\$47 billion
  - Transmission reinforcements required to deliver power within New England, *plus*
  - ISO's estimate of New England's share of cost of building transmission from Midwest to NY-NE border



# 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