
August 14, 2009
Planning Advisory Committee
Potential Transmission

• ISO developed sixteen conceptual transmission configurations:
  – Thirteen 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 will be required if the region pursues specific projects
  – New voltage classes will be needed for higher wind penetration scenarios (345 kV is the backbone of the existing system)
Preliminary Maps and Cost Estimates for Potential Transmission

- **List of Maps** (number of maps):
  - Base system map (1)
  - Wind scenarios and potential transmission (13)
    - 2,000 MW wind scenario and potential transmission (2)
    - 2,000 MW offshore-only wind scenario and potential transmission (2)
    - 4,000 MW wind scenario and potential transmission (2)
    - 4,000 MW offshore-only wind scenario and potential transmission (2)
    - 5,500 MW wind scenario (4,000 MW offshore and 1,500 MW onshore) (1)
    - 8,000 MW wind scenario and potential transmission (2)
    - 12,000 MW wind scenario and potential transmission (2)
  - Interconnection scenarios (3)
    - 1,500 MW New Brunswick interconnection (1)
    - 1,500 MW Québec interconnection (1)
    - 10,000 MW New York interconnection (1)

- **Preliminary Transmission Cost Estimates**
The Challenge: Connecting Wind Energy to Load Centers

- Region’s population and electricity demand are substantially concentrated in southern New England.

- Potential wind resources do not substantially overlap high population and high energy demand areas.

- Therefore, new “backbone” transmission will be required to connect potential wind resources to load centers in New England.
Base System Map

• 2019 Base Transmission System Prior to Potential Transmission System Expansions
2,000 MW Wind Scenario and Potential Transmission

<table>
<thead>
<tr>
<th>State</th>
<th>MW</th>
<th>BD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecticut</td>
<td>1080</td>
<td>0</td>
</tr>
<tr>
<td>Maine</td>
<td>80</td>
<td>0</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>105</td>
<td>0</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>90</td>
<td>0</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Vermont</td>
<td>90</td>
<td>0</td>
</tr>
</tbody>
</table>

- **HVDC Submarine Cable**
- **New 345kV By 2030**
- **115kV Upgrades By 2030**
2,000 MW Offshore Wind Scenario and Potential Transmission

<table>
<thead>
<tr>
<th>State</th>
<th>Distribution</th>
<th>Actual New</th>
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<tbody>
<tr>
<td>Conventional</td>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td>New</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Rhode Island</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vermont</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- HVDC Submarine Cable
- New 345kV By 2030
- 115kV Upgrades By 2030
4,000 MW Wind Scenario and Potential Transmission

<table>
<thead>
<tr>
<th>State</th>
<th>Wind Energy</th>
<th>New 345kV or 500kV</th>
<th>115kV Upgrades</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecticut</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Maine</td>
<td>1,250</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>650</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>95</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>35</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vermont</td>
<td>150</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>
4,000 MW **Offshore** Wind Scenario and Potential Transmission
Transmission for 5,500 MW of Wind

- Potential transmission to connect:
  - 4,000 MW of offshore wind, and
  - 1,500 MW of onshore wind
8,000 MW Wind Scenario and Potential Transmission
12,000 MW Wind Case and Potential Transmission

<table>
<thead>
<tr>
<th>State</th>
<th>Type</th>
<th>Year</th>
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<tbody>
<tr>
<td>Massachusetts</td>
<td>New 345kV</td>
<td>2030</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>New 500kV or 765kV</td>
<td>2030</td>
</tr>
<tr>
<td>Vermont</td>
<td>New 500kV or 765kV</td>
<td>2030</td>
</tr>
</tbody>
</table>

- ■■■■ New 500kV or 765kV By 2030
- ■■■■ New 345kV By 2030
- ■■■■ 115kV Upgrades By 2030
Other Transmission Interconnections

3,000 MW from Québec and New Brunswick

10,000 MW from Midwest via New York

1,500 MW Bipolar HVDC By 2030

New 500kV or 765kV By 2030
Cost Estimate Range Development Methodology

**Step 1**
PROPOSE POTENTIAL T-SYSTEM EXPANSION ONE-LINE DIAGRAMS (Note 1)
CEII Sensitive!

**Step 2**
IDENTIFY & QUANTIFY “CRITICAL TRANSMISSION ELEMENTS” (Note 2)
IDENTIFY & QUANTIFY “CRITICAL SUBSTATION ELEMENTS” (Note 3)

**Step 3**
CALCULATE MID-RANGE (“TARGET”) COST ESTIMATE (Note 5)

**Step 4**
CALCULATE LOW-RANGE COST ESTIMATE (Note 6)
CALCULATE HIGH-RANGE COST ESTIMATE (Note 7)

**Notes:**

1. All One-Line Proposals Reviewed By ISO-NE Staff
2. By Voltage / By Circuit Configuration Type
3. By Voltage / By Substation Element Type
4. By NE Cost Zone / From Recent NE Experience
5. Calculation Produces Order-Of-Magnitude 2009 Dollars
6. Mid-Range Cost Estimate Decreased By 25%
7. Mid-Range Cost Estimate Increased By 25%.
Cost Estimate Range Development – Example

**Step 1**

Install +/-450kV, 1500MW HVDC From US / CN Border To Central Massachusetts

**Step 2**

A. Transmission:

1. 400 Mi Lattice Tower Line Traversing All 3 N.E. Cost Zones Using ROW Parallel To Other Existing T-Line ROWs

   2A. Z1: 110 Mi @ $3.5M / Mi

   2B. Z2: 235 Mi @ $4.5M / Mi

   2C. Z3: 55 Mi @ $5.5M / Mi

B. Substation:

1. One +/-450kV, 1500MW HVDC Converter Terminal, Complete With Connection To Existing 345kV Substation (Not Requiring Reinforcements)

2. Terminal Cost @ $270M (Or ~$180 / KW Installed And Interconnected)

**Step 3**

A. Transmission:

   110 X $3.5 = $385.0M

   235 X $4.5 = $1057.5M

   55 X $5.5 = $302.5M

   T-Subtotal = $1745M

B. Substation:

   1 X $270 = $270.0M

   S-Subtotal = $270M

C. Mid-Range ("Target") Estimate:

   T-Subtotal = $1745M

   S-Subtotal = $270M

   T&S Total = $2015M

**Step 4**

A. Mid-Range Estimate:

   Round $2015M = ~$2.0B

B. Low-Range Estimate:

   0.75 X $2.0B = ~$1.5B

C. High-Range Estimate:

   1.25 X $2.0M = ~$2.5B

Order-Of-Magnitude Cost Estimate Range Is $1.5B - $2.5B, Stated In 2009 $
## Preliminary Transmission Cost Estimates

<table>
<thead>
<tr>
<th>Description</th>
<th>Approx. circuit miles of new transmission</th>
<th>Preliminary order-of-magnitude cost estimate range by voltage class (2009 dollars)</th>
<th>Mid-range cost estimate</th>
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</thead>
<tbody>
<tr>
<td>1 2,000 MW On and Offshore Wind</td>
<td>1,785</td>
<td>345 kV/HVDC: $4.7B to $7.9B</td>
<td>$6.4B</td>
</tr>
<tr>
<td>2 2,000 MW Offshore Wind</td>
<td>1,015</td>
<td>345 kV/HVDC: $3.6B to $6.0B</td>
<td>$4.8B</td>
</tr>
</tbody>
</table>
| 3 4,000 MW On and Offshore Wind                  | 3,615                                    | 345 kV: $8.0B to $13.2B  
500 kV: $10.8B to $17.9B                        | $10.7B  
$14.3B                                         |
| 4 4,000 MW Offshore Wind                         | 1,430                                    | 345 kV/HVDC: $4.7B to $7.6B                                                       | $6.1B                   |
| 5 8,000 MW On and Offshore Wind                  | 4,320                                    | 500 kV: $13.4B to $22.4B  
765 kV: $17.3B to $28.9B                        | $17.9B  
$23.0B                                          |
| 6 12,000 MW On and Offshore Wind                 | 4,320                                    | 500 kV: $14.5B to $24.2B  
765 kV: $18.9B to 31.5B                         | $19.3B  
$25.2B                                          |
| 7 1,500 MW New Brunswick Interconnection*        | 400                                      | +/-450 kV HVDC: $1.5B to $2.5B                                                    | $2.0B                   |
| 8 1,500 MW Québec Interconnection*               | 280                                      | +/-450 kV HVDC: $1.1B to $1.9B                                                    | $1.6B                   |
| 9 10,000 MW New York Interconnection**           | 1,020                                    | 500 kV: $4.7B to $7.7B  
765 kV: $6.8B to $11.2B                         | $6.3B  
$8.9B                                          |

Source: ISO New England and Energy Initiatives Group

* 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.