Regional Energy Challenges

Connecticut Power & Energy Society

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What is the Question?

New England needs **infrastructure**

• *Resource vulnerabilities, state policy*

Infrastructure costs **money**

• *Consumers will pay*

But which consumers should pay…

• …*for what, and how?*
Regional Energy Challenges

The challenge

- Starting from today, how might/should New England’s power system evolve to maintain reliability, given the following key factors:
  - Negative winter demand growth, modest summer growth
  - Tightening winter fuel supply conditions
  - Potential retirements (coal, oil, nuclear)
  - Rapid growth in distributed resources (energy efficiency, solar)
  - Multiple resource options, grid-level and distributed, gas and non-gas

What is the context?

- Starting point – wholesale market outcomes: *enable competition, minimize long-run costs and risks to electricity consumers*
  - Including recent major changes to ensure reliability, *in the face of fuel delivery challenges*

- Market corrections – state policy goals:
  - achieve carbon reduction and energy/economic policy goals (to extent not already reflected)

- Key driver – fully integrated assessment of ratepayer costs and risks, considering policy goals and market impacts
A Rude Awakening?

New England Emissions vs. RGGI and Clean Power Plan Emission Goals

2013 Emissions without Pilgrim

2013 Emissions

Clean Power Plan, assuming constant annual progress towards 2030

BAU?

Potential RGGI Cap, projected at current annual reduction rate

<table>
<thead>
<tr>
<th>Unit Name</th>
<th>Operating (OP)/Renewed License Dates</th>
<th>License Expiration Date</th>
<th>Reactor Type</th>
<th>Electrical Output (MWe)</th>
<th>Reactor Vendor/Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millstone 2</td>
<td>September 26, 1975/November 28, 2005</td>
<td>July 31, 2035</td>
<td>Pressurized water</td>
<td>884</td>
<td>Combustion Engineering (vendor)</td>
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<tr>
<td>Millstone 3</td>
<td>January 31, 1986/November 28, 2005</td>
<td>November 25, 2045</td>
<td>Pressurized water</td>
<td>1,227</td>
<td>Westinghouse/four-loop</td>
</tr>
<tr>
<td>Pilgrim</td>
<td>June 8, 1972/May 29, 2012</td>
<td>June 8, 2032</td>
<td>Boiling water</td>
<td>685</td>
<td>General Electric/type 3</td>
</tr>
<tr>
<td>Seabrook</td>
<td>OP: March 15, 1990</td>
<td>March 15, 2030</td>
<td>Pressurized water</td>
<td>1,295</td>
<td>Westinghouse/four-loop</td>
</tr>
</tbody>
</table>

Pilgrim replacement assumes 2014 Pilgrim output (5.8 TWh) at New England marginal emission rate (941 lb/MWh). Table from ISONE.
### Changing Resource Mix

<table>
<thead>
<tr>
<th>State</th>
<th>Annual Energy Savings (GWh)</th>
<th>Summer Peak Demand Reductions (MW)</th>
<th>Winter Peak Demand Reductions (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015</td>
<td>2024</td>
<td>CAGR(3)</td>
</tr>
<tr>
<td>CT</td>
<td>2,554</td>
<td>4,655</td>
<td>6.9</td>
</tr>
<tr>
<td>ME</td>
<td>1,025</td>
<td>2,012</td>
<td>7.8</td>
</tr>
<tr>
<td>MA</td>
<td>4,382</td>
<td>12,018</td>
<td>11.9</td>
</tr>
<tr>
<td>NH</td>
<td>508</td>
<td>936</td>
<td>7.0</td>
</tr>
<tr>
<td>RI</td>
<td>720</td>
<td>1,860</td>
<td>11.1</td>
</tr>
<tr>
<td>VT</td>
<td>791</td>
<td>1,486</td>
<td>7.3</td>
</tr>
<tr>
<td>ISO</td>
<td>9,980</td>
<td>22,967</td>
<td>9.7</td>
</tr>
</tbody>
</table>

### Annual Energy Savings (GWh)

#### Summer Peak Loads (MW)

- **CT**: 2,554 - 4,655, CAGR 6.9
- **ME**: 1,025 - 2,012, CAGR 7.8
- **MA**: 4,382 - 12,018, CAGR 11.9
- **NH**: 508 - 936, CAGR 7.0
- **RI**: 720 - 1,860, CAGR 11.1
- **VT**: 791 - 1,486, CAGR 7.3
- **ISO**: 9,980 - 22,967, CAGR 9.7

#### Winter Peak Loads (MW)

- **CT**: 420 - 732, CAGR 6.4
- **ME**: 157 - 264, CAGR 5.9
- **MA**: 760 - 1,904, CAGR 10.7
- **NH**: 84 - 155, CAGR 7.0
- **RI**: 139 - 315, CAGR 9.5
- **VT**: 124 - 210, CAGR 6
- **ISO**: 1,685 - 3,579, CAGR 8.7

### Source: ISONE
**Dependence on Natural Gas**

- Winter fuel delivery problem is important, and could get worse
  - Not a problem for heating & commercial/industrial process needs (Gas LDCs obligated to meet needs, backed where needed by federal siting authority)
  - Changing system will continue region’s electric system need for gas and oil
  - Fundamental disconnects exist between electricity and gas markets, industries, and law/regulation

- Additional gas-fired capacity will be added to replace legacy units; “nimble” capacity needed to facilitate renewable integration

- ISONE has taken steps within its purview – focused on market solutions to deliver low-cost, efficient outcomes
  - Incentives for investments for fuel assurance and performance when needed
    - FCM PI, 7-year lock-in, sloping demand curve
  - Reserve levels and pricing; energy market timing and flexibility
  - Performance auditing, increased vision into gas system conditions

- Left to market, solutions would emerge
  - …but most likely not involve major natural gas pipeline capacity additions (for electricity generation) – too expensive
Integrated Assessment

![Integrated Assessment Chart]

Lower total costs, Higher total emissions

Higher total costs, Higher total emissions

Note: Pipeline solutions include an estimate for incremental in-region GHG emissions from fugitive methane leaks.
#### Other Considerations

**Many tradeoffs**

- Markets versus state approach
- Up-front investment versus adjustable annual costs
- Shades on levels of reliability
- Siting/permitting
- Installation/ramping challenges
- Out-of-region GHG implications

<table>
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<tr>
<th>Solution Set</th>
<th>Other Considerations</th>
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<tbody>
<tr>
<td><strong>Market Driven Outcomes</strong></td>
<td></td>
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</table>
| SS 1a: Dual-fuel Capacity ("Status Quo") | - No up-front investment and requires no action on the part of legislatures or regulators  
- Dual-fuel upgrade costs may not be passed on to consumers (unless upgrade cost affects marginal capacity cost)  
- Costs borne by producers represent a reduction in profits  
- Relying on oil during winter peak periods has only limited impact on winter gas prices; when oil prices are low, economic oil-fired generation can reduce on-site inventories leading into stressed winter conditions  
- Air quality permits often restrict total hours of oil-fired operation, though restrictions generally allow more hours of operation than needed to address winter peak reliability needs  
- Operation time at units will be limited by the quantity and size of oil storage tanks, ability to switch from gas to oil, and ability to replenish supplies, which can be challenging during extreme cold periods |
| SS 1b: Firm LNG Capacity | - No up-front costs to customers; implementation costs reflected in energy market prices on as-needed basis  
- LNG use targeted to deficiency may have only limited impact on winter delivered gas prices  
- Creates flexibility with respect to intra-annual operations and allows for 5 year lead time for renegotiation or pursuit of alternative solution sets if needed  
- Contract prices and terms are untested at this point; firm commitments remain dependent on contract language and financial penalties; imports constrained by global price risk, global supply production risk  
- Prices ultimately would be set by few suppliers with limited competition |
| **Incremental Pipeline Capacity** | |
| SS 2: Incremental Pipeline: | - Major up-front investment creates long-term ratemaking cost obligation; obligation remains even if use or value of assets diminish or is limited for any reason (e.g., evolution of GHG reduction goals/obligations)  
- Increased certainty of solution set once approved; known in-service date allows for accountability and tracking of progress made by a single entity  
- Mechanism to guarantee firm transportation for electricity generation at winter peak is unknown  
- Increased capacity reduces or eliminates the value of existing capacity release benefits, which may lead to a net loss for gas ratepayers, LDC shareholders, and portfolio managers  
- Increased in-region flows may be used to serve other markets or LNG exports, potentially increasing pipeline utilization and reducing or eliminating price suppression benefits  
- Faces significant siting and regulatory challenges, potential local property value impacts and non-GHG environmental impacts  
- May increase GHG outside New England, and an associated increase in natural gas production and consumption would also increase non-GHG environmental impacts |
| **Energy Efficiency, Demand Response, and Renewable Energy** | |
| SS 3a: Energy Efficiency and Demand Response | - Up-front investment is annual, and can be adapted on an annual basis in consideration of actual need and changes in technology, policy and cost factors; actual technologies/programs relied on could adjust in response to technology and cost breakthroughs  
- Requires a sustained commitment by states for investment, likely over many years; absent a commitment the EE/DR solution cannot be counted on to meet deficiency in later years  
- Realization could be limited by ability to ramp up resources and providers; full suite of benefits are not immediately available  
- Requires robust monitoring and verification to ensure expected winter peak impacts are being realized  
- Annual costs are not certain – could either grow or decline in later years |
| SS 3b/c: Energy Efficiency and Firm Imports (existing and new transmission) | - (See above in SS 3a regarding EE)  
- Major up-front investment creates long-term ratemaking cost obligations; ratemaking obligation remains even if use or value of assets diminish or is limited for any reason  
- Must guarantee and price firm winter/year-round capacity; otherwise, cannot be counted on to address deficiency; availability and cost of a firm winter deliverable product is unknown |
Incredibly complicated economic, policy, and environmental challenge for the region

Markets will preserve reliability, but will not necessarily produce outcomes consistent with policy maker objectives

- Yet interference with market outcomes has its own risks

State-driven efficiency, pipeline, and transmission approaches all produce market price benefits

Efficiency, renewable paths are the only ones consistent with long-term climate objectives
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ABOUT US

- Focused on being the #1 global leader in fuel cells
- Headquarters and operations in South Windsor, CT
- Leading-edge R&D staff with broad patent portfolio
- Made in the U.S.A. with automated production line
- Expert global service team with 24/7 support

50 years of fuel cell experience
300+ innovative employees
110 megawatts installed
12 million fleet hours
10 year cell stack life
THE CALIFORNIA DUCK CURVE

Intermittent renewables are challenging grid resources
purecell® model 400

440 kw fuel cell
combined heat and power
system fueled by natural gas

reliable
- continuous power operation
- 95+% capacity factor
- grid-independent emergency power
- 10 year fuel cell life

dispatchable
- 0 – 100% power set-point
- 10 kw/sec ramp rate
- multi-mw scalable
- small footprint

class 1 renewable
- 90% system efficiency
- ultra-low air emissions
- no water consumption
DISPATCHABLE POWER

Reliable and controllable power for production facility

- Load-following
- Fast ramping
- Steady output

Graph showing Fuel Cell Output and Facility Demand.
FAST RAMPING

Zero to full power in 45 seconds

Performance is scalable with # of units

30 MW site can respond in same time period
PURECELL SYSTEM

- 6x more energy output
- 4x more CO₂ savings
- 300x less land use

Compared to U.S. average fossil-fueled generation
Fuel cells and solar can work together to provide level supply/load.
GS Power 4.8 MW (operating since 2010)

Korea Southeast Power 5.7 MW on multi-level structure (in commissioning)

Busan City District Heat Plant 30 MW on multi-level structure (under construction)