Electricity Markets: Sectors in Transition

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Electricity Markets: Sectors in Transition

1. Electricity Market Trends

2. Challenges and Opportunities in North American Electricity Markets

3. Potential Implications for Québec

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1. Electricity Market Trends
Renewable energy growing faster than other resources, costs becoming competitive with fossil-fuel generators (International Energy Agency (IEA))

• Renewable energy projects will account for half of growth in global supply over next 20 years

• Changing supply mix towards renewable energy will force changes to wholesale electricity markets
Increasing Renewable Energy Supply

- US supply trends: coal (1950s-1980s); nuclear (1970s-1980s); natural gas (1990s-2000s); renewables (2010s+)

Increasing Renewable Energy Supply

- Increasing wind and solar energy supply partially driving increasing energy storage development

In 2016, for the first time in U.S. history, solar was the largest source of new electricity generation capacity, with approximately 40% of all new generation capacity. Wind and solar combined for 70% of new generation.
• Some U.S. jurisdictions project wind and solar energy plus storage to be cost competitive with other supply, projecting to continue increasing development of these supply resources.
<table>
<thead>
<tr>
<th>Generation Technology</th>
<th># of Bids</th>
<th># of Projects</th>
<th>Project MW</th>
<th>Median Bid Price or Equivalent</th>
<th>Pricing Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustion Turbine/IC Engines</td>
<td>30</td>
<td>13</td>
<td>2,466</td>
<td>$4.80</td>
<td>$/kW-mo</td>
</tr>
<tr>
<td>Combustion Turbine with Battery Storage</td>
<td>7</td>
<td>3</td>
<td>476</td>
<td>$6.20</td>
<td>$/kW-mo</td>
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<tr>
<td>Gas-Fired Combined Cycles</td>
<td>2</td>
<td>2</td>
<td>451</td>
<td>$11.50</td>
<td>$/kW-mo</td>
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<tr>
<td>Stand-alone Battery Storage</td>
<td>28</td>
<td>21</td>
<td>1,614</td>
<td>$11.30</td>
<td>$/kW-mo</td>
</tr>
<tr>
<td>Compressed Air Energy Storage</td>
<td>1</td>
<td>1</td>
<td>317</td>
<td></td>
<td>$/kW-mo</td>
</tr>
<tr>
<td>Wind</td>
<td>96</td>
<td>42</td>
<td>17,380</td>
<td>$18.10</td>
<td>$/MWh</td>
</tr>
<tr>
<td>Wind and Solar</td>
<td>5</td>
<td>4</td>
<td>2,162</td>
<td>$19.90</td>
<td>$/MWh</td>
</tr>
<tr>
<td>Wind with Battery Storage</td>
<td>11</td>
<td>8</td>
<td>5,097</td>
<td>$21.00</td>
<td>$/MWh</td>
</tr>
<tr>
<td>Solar (PV)</td>
<td>152</td>
<td>75</td>
<td>13,435</td>
<td>$29.50</td>
<td>$/MWh</td>
</tr>
<tr>
<td>Wind and Solar and Battery Storage</td>
<td>7</td>
<td>7</td>
<td>4,048</td>
<td>$30.60</td>
<td>$/MWh</td>
</tr>
<tr>
<td>Solar (PV) with Battery Storage</td>
<td>87</td>
<td>59</td>
<td>10,813</td>
<td>$36.00</td>
<td>$/MWh</td>
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<tr>
<td>IC Engine with Solar</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td></td>
<td>$/MWh</td>
</tr>
<tr>
<td>Waste Heat</td>
<td>2</td>
<td>1</td>
<td>11</td>
<td></td>
<td>$/MWh</td>
</tr>
<tr>
<td>Biomass</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td></td>
<td>$/MWh</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>430</td>
<td>238</td>
<td>58,283</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Xcel Energy (Colorado) 2017 Request for Proposals (RFP) received responses for wind, wind+solar, wind+storage, and wind+solar+storage, etc.
Hawaiian Electric Co. RFP – Announced Results (October 2018)

Solar

<table>
<thead>
<tr>
<th>Project name</th>
<th>Island</th>
<th>Developer</th>
<th>Size</th>
<th>Storage</th>
<th>Cost per KWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waikoloa Solar</td>
<td>Hawai‘i</td>
<td>AES</td>
<td>30 MW</td>
<td>120 MWh</td>
<td>$0.08</td>
</tr>
<tr>
<td>Hale Kuawehi</td>
<td>Hawai‘i</td>
<td>Innergex</td>
<td>30 MW</td>
<td>120 MWh</td>
<td>$0.09</td>
</tr>
<tr>
<td>Kuihelani Solar</td>
<td>Maui</td>
<td>AES</td>
<td>60 MW</td>
<td>240 MWh</td>
<td>$0.08</td>
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<tr>
<td>Paehu Solar</td>
<td>Maui</td>
<td>Innergex</td>
<td>15 MW</td>
<td>60 MWh</td>
<td>$0.12</td>
</tr>
<tr>
<td>Hoohana</td>
<td>O‘ahu</td>
<td>174 Power Global</td>
<td>52 MW</td>
<td>208 MWh</td>
<td>$0.10</td>
</tr>
<tr>
<td>Mililani Solar</td>
<td>O‘ahu</td>
<td>Clearway</td>
<td>39 MW</td>
<td>156 MWh</td>
<td>$0.09</td>
</tr>
<tr>
<td>Waiawa Solar</td>
<td>O‘ahu</td>
<td>Clearway</td>
<td>36 MW</td>
<td>144 MWh</td>
<td>$0.10</td>
</tr>
</tbody>
</table>

- Hawaiian Electric Co. set records for lowest solar+storage
  - Range of $8/MWh to $12/MWh ($US) for solar+storage projects
Energy Storage Cost Declines – Trending Similar to Solar Cost Declines

- Costs of energy storage technologies (e.g., lithium-ion) declining dramatically, and projected to continue declining in future
Declining Costs – Solar, Storage, etc.

- Projections of declining costs (especially solar and battery storage) used by Ontario IESO to model different future market scenarios

NREL 2018 Annual Technology Baseline [http://www.nrel.gov/analysis/data_tech_baseline.html](http://www.nrel.gov/analysis/data_tech_baseline.html)
2. Challenges and Opportunities in North American Electricity Markets
Emerging issues without present consensus

1. Are markets adequately accommodating public policy goals? What regulatory and market design changes would further enable deployment of resources that achieve goals of reliability, affordability, innovation, resource mix?

2. What are the market impacts of environmental regulations that further constrain deployment of needed resources?

3. What are the market impacts of integrating higher levels of non-emitting and distributed resources?

4. Are today’s markets and regulatory frameworks adequately designed to acquire needed resources to better integrate multiple resources (e.g., distributed resources)?
Challenges and Opportunities


**Alberta**
- Coal-fired generation closure by 2030
- REP Round 1 to 3 – ‘cheap’ contracted wind generation
- Capacity Market planned implementation for 2020

**Ontario**
- Market Renewal Program (Locational Marginal Pricing, Day-Ahead Market, Capacity Market)
- OEB Modernization Review Panel

**New England**
- Aggressive state targets for renewables
- Relatively high customer rates
- Controversial FERC approved changes to Capacity Market
- Likely FERC approval for controversial ‘out of market’ contract for reliability-based generation

**New York**
- Reforming the Energy Vision (REV)
- 50% renewable supply by 2030 – multiple state RFPs
- NYISO proposal to price carbon in wholesale energy market
- ‘Out of market’ payments for nuclear generation

**California and Southwest U.S.**
- Aggressive state policies (e.g., renewables, innovation, etc.)
- Dialogue to expand Energy Imbalance Market (EIM) across multiple states
- Significant penetration of Distributed Energy Resources (DERs), causing review of regulatory frameworks (e.g., rate design, etc.) and wholesale market design

**Texas**
- Shortage pricing through Operating Reserve Demand Curve and very high Maximum Market Clearing Price ($9,000/MWh)

**PJM**
- FERC decision forthcoming regarding ‘out of market’ payments to nuclear and coal-fired generation and impacts to wholesale markets
- PJM following New England’s lead with proposed Capacity Market changes

**Ontario Independent Electricity System Operator**

**Ontario Electric System Operator**

**Alberta Electric System Operator**

**New York ISO**

**New England ISO**

**Midcontinent ISO**

**California ISO**

**Southwest Power Pool**

**Electric Reliability Council of Texas**

**PJM Interconnection**

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3. Potential Implications for Québec
Québec and Electricity Markets in Transition

- Relatively low electricity rates for Québec customers
  - Majority from Hydro-Québec (HQ) patrimonial supply

- Despite technology improvements and declining costs for solar, storage, etc., slower uptake in Québec

- Exports from Québec to US markets to continue ... but will face competition as costs of wind, solar, storage continue declining
  - e.g., competition from off-shore wind energy projects

- Québec has winter supply needs, opportunities for Independent Power Producers (IPPs)
  - Especially if New England Clean Energy Connect transmission project built

- IPPs with expiring Power Purchase Agreements (PPAs) with HQ need to be aware of supply options