Decarbonization
AGGREGATING WHAT EACH OF THE REGIONS IS CONTEMPLATING & WHAT IT MEANS

PREPARED FOR
Bank of America Future of Power Conference

PREPARED BY
Roger Lueken

September 23, 2020
Disclaimer

This presentation shall not be intended to serve as a substitute for your own analysis or for the exercise of your own business judgment in any decisions you might make, nor shall it constitute investment advice under any circumstances.

The Brattle Group does not accept liability under any theory for losses suffered, whether direct or consequential, arising from any party’s reliance on our analyses or from the failure of assets to have at any point or points in time any specific economic value, and cannot be held responsible for any conclusion drawn from this presentation should it prove to be inaccurate.

Any recipient of this presentation, whether in electronic, hard copy, visual, or oral form, proposing to engage in commercial activity or make commercial decisions in relation to energy markets and/or energy prices anywhere in the world should apply dedicated, specialist analysis to the specific legal and business challenges spanning the activities/decisions in question. This presentation in no way offers to substitute for such analysis.
Absent Federal leadership, a patchwork of state approaches has emerged that vary in stringency and approach.

100% Clean Energy Policies
As of April 2020

**New England:** States must accelerate clean energy builds to meet GHG targets

**New York:** Massive renewable buildout needed to achieve 100% carbon-free electricity by 2040

**California:** Achieving 2045 carbon neutrality requires decarbonizing non-electric sectors

**Texas:** Market-driven decarbonization underway

Source: Center for American Progress. [States are Laying a Road Map for Climate Leadership](https://www.americanprogress.org/issues/environment/reports/2020/04/30/480247/), April 30, 2020.
Cleaner and Cheaper: What will the energy transformation look like?

Deeply-decarbonized economies will likely depend on rapid electrification (1.5-3x historical demand), a dominant role for non-emitting supply, and reliance on non-traditional resource types (storage, DR, DER) to provide essential reliability services.

State sets GHG emissions targets to address climate change.

Demand is driven by electrification needs triggered by the GHG goals.

Increase in supply resources needed to match higher electric demand.

Source: Brattle illustrative analysis
## Market Value and Revenue Opportunities will shift as the grid decarbonizes

<table>
<thead>
<tr>
<th>Market</th>
<th>Value</th>
<th>Market Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>↓</td>
<td>• Lower energy prices on average</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Higher on-peak prices, driven by CO₂ pricing and scarcity pricing</td>
</tr>
<tr>
<td>Clean &amp; Carbon-Free</td>
<td>↑</td>
<td>• CO₂ pricing and/or clean energy payments needed to meet mandates and customer demand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Value must be large enough to attract new clean resources</td>
</tr>
<tr>
<td>Flexibility &amp; Scarcity Pricing</td>
<td>↑</td>
<td>• Need more and new types of flexibility products</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Higher price volatility and spikes reward flexibility</td>
</tr>
<tr>
<td>Capacity</td>
<td>↓↑</td>
<td>• Value may go up or down</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Down if additional clean energy contributes to excess supply</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Up if new fossil plants are needed for capacity, but E&amp;AS revenues fall</td>
</tr>
<tr>
<td>Adjacent Consumer Products &amp; Services</td>
<td>↑</td>
<td>• Technology and consumer-driver demand for adjacent products and services (smart home, electric vehicles)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Participation may overlap with other markets</td>
</tr>
</tbody>
</table>

*Source: Center for American Progress. [States are Laying a Road Map for Climate Leadership](https://www.statesclimatelliance.org/), April 30, 2020.*
New York: A comprehensive set of clean energy policies

### Description of Key Policies

<table>
<thead>
<tr>
<th>Climate Leadership and Community Protection Act (CLCPA)</th>
<th>Policy Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Renewable generation:</strong> 70% of NY annual electricity supplied from renewables (solar, wind, hydro) by 2030</td>
<td>2009 <strong>RGGI:</strong> First control period</td>
</tr>
<tr>
<td><strong>100% zero emissions</strong> by 2040</td>
<td></td>
</tr>
<tr>
<td><strong>Solar:</strong> 6,000 MW distributed solar by 2025</td>
<td>2016 <strong>ZEC:</strong> Program in effect</td>
</tr>
<tr>
<td><strong>Offshore wind:</strong> 9,000 MW by 2035</td>
<td></td>
</tr>
<tr>
<td><strong>Storage:</strong> 3,000 MW by 2030</td>
<td></td>
</tr>
<tr>
<td><strong>Economy-wide emissions:</strong> 85% reduction by 2050 and 40% reduction by 2030 from 1990 levels</td>
<td>2025 <strong>Solar:</strong> 6,000 MW mandate</td>
</tr>
<tr>
<td><strong>Efficiency:</strong> Reduction of 185 trillion BTU from 2025 forecast</td>
<td><strong>NOX Rule:</strong> In full effect</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RGGI</th>
<th>2029 <strong>ZEC:</strong> Program expires</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Northeast regional cap-and-trade program</strong></td>
<td>2030 <strong>CLCPA:</strong> 70% renewable electricity</td>
</tr>
<tr>
<td><strong>Avg. 2019 price:</strong> $5.4/ton; expected to reach $12.6 by 2030</td>
<td><strong>Storage:</strong> 3,000 MW mandate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zero-Emissions Credit (ZEC) Program</th>
<th>2035 <strong>OSW:</strong> 9,000 MW mandate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Zero emission credit payments to New York nuclear plants</strong></td>
<td>2040 <strong>CLCPA:</strong> 100% zero emissions electricity</td>
</tr>
<tr>
<td><strong>Program expires March 2029</strong></td>
<td>2050 <strong>CLCPA:</strong> 85% NY economy-wide decarbonization</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DEC NOX rule</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DEC rule to reduce NOX emissions from peakers</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Peakers built pre-1986 will most likely retire instead of retrofit to meet emissions requirements</strong></td>
<td></td>
</tr>
</tbody>
</table>

New York: Electrification could increase loads 40% by 2040

New York: Massive need for renewables and storage

**Resources that grow in capacity**
- **Renewables** to meet zero-emissions mandate
- **Storage and flexible load** for short-term balancing
- **Dispatchable zero-emission resources**: gas-fired generators switch to zero-carbon fuel (RNG) in 2040, for long-term balancing

**Resources that maintain their capacity**
- **Pumped storage** for short-term balancing
- **Hydro** continues to provide clean power

**Resources that shrink in capacity**
- Portion of **nuclear fleet** retires by 2030 due to high refurbishment costs
- **Oil-fired generation** fully retires by 2040
New York: Future 100% carbon-free grid will badly need flexible supply and flexible customers

New England: New England states must accelerate the addition of clean energy resources to achieve GHG targets

Annual clean energy resource additions need to increase by 4–8x overall

Large-scale solar resource additions will need to increase by 10–25x to meet these goals

Source:
California: Achieving carbon neutrality means decarbonizing non-electric sectors

California’s Emission Targets

California’s Emissions by Sector

Carbon neutral by 2045 (E.O. B-55-18)

Electricity only <20% of total emissions

Source:
**Texas:** Market-driven decarbonization, with 26 GW of wind & solar added through 2019; much more on its way
Texas: The long-term outlook includes gas, absent future Federal decarbonization policies

- **Wind, solar, and storage** capacity will continue to grow with falling costs and growing load

- **Gas will continue to play an important role**
  - Remains a low cost source of flexibility and firm capacity
  - Gas’s role may change if Texas adopted decarbonization policies

- **Flexible generators** may earn a premium from the balancing challenges created by renewables
  - As wind and solar grow, net load becomes more volatile
  - Flexible resources can profit from scarcity pricing by responding to imbalances in real time

---

**Total ERCOT Installed Generation Capacity**

*Source: Brattle analysis*
As systems decarbonize, **more flexibility** will be needed across all timescales.

### Batteries and load flexibility can provide short-term balancing.

### Seasonal balancing is the more difficult challenge, requiring new technologies such as seasonal storage or zero-emission dispatchable generation.

**Sources and Notes**: Illustrative examples. Load data is from NYISO’s 2020 “High Electrification” CLCPA Load Case forecast. Generation capacities in both examples set such that total renewable generation over the period matches load. Left: Forecast for 8/19/2020; capacity of 63 GW assumed of each renewable type. Right: Capacity of 22 GW assumed for each type.
Near-Term Technology Wild Card: How will EVs affect load, and can vehicle-to-grid (V2G) provide balancing?

Electric Vehicles Deployed
Projection, Brattle Forecast

- Almost 15 million EVs anticipated on the road in U.S. by 2030

Total EV Battery Capacity
Assuming 75 kWh average battery size

- EV battery deployments to outpace grid-scale batteries 5-to-1
Long-Term Technology Wild Card: Can clean fuels or long-duration storage manage seasonal imbalances?

- Clean dispatchable supply is needed only when systems approach 100% decarbonized.
- Clean fuels or long-duration storage provide balancing by acting both as a **load** (soaking up renewables) and as **supply** (meeting peak load).
- The jury is out on what technologies will serve this role (hydrogen, renewable gas, long-duration storage?)

**New York Clean Fuel Production and Consumption in 2040**

- Clean fuel **produced** off-peak from otherwise curtailed renewable supply.
- Clean fuel **consumed** in peak periods to meet load.

**Takeaways:** Decarbonization provides new opportunities and challenges for investors

— **Short-term,** where are the biggest opportunities to invest in solar, wind, and storage?

— **Mid-term,** what frameworks will attract needed clean (RECs? carbon pricing?), and how will they interact with markets?

— **Long-term,** what technologies can provide multi-day/seasonal balancing?
Author Bio & Contact information

**Dr. Roger Lueken** is a Senior Associate at *The Brattle Group* with expertise in decarbonization, the economics of energy storage, and wholesale market design. Dr. Lueken has worked with clients throughout the U.S. and internationally, including market operators, investors, regulated utilities, and other market participants.

Dr. Lueken earned his Ph.D. in Engineering and Public Policy from the Carnegie Mellon Electricity Industry Center at Carnegie Mellon University, and a Masters of Engineering and Public Policy from the University of Maryland. He received a B.S. in Mechanical Engineering from Purdue University.

**Roger Lueken**
Senior Associate, Washington, D.C.

+1.202.763.9433
Roger.Lueken@brattle.com
The Brattle Group provides consulting and expert testimony in economics, finance, and regulation to corporations, law firms, and governments around the world. We aim for the highest level of client service and quality in our industry.
Our Offices

BOSTON  BRUSSELS  CHICAGO  LONDON

MADRID  NEW YORK  ROME  SAN FRANCISCO

SYDNEY  TORONTO  WASHINGTON
Our Practices and Industries

**ENERGY & UTILITIES**

- Competition & Market Manipulation
- Distributed Energy Resources
- Electric Transmission
- Electricity Market Modeling & Resource Planning
- Electrification & Growth Opportunities
- Energy Litigation
- Energy Storage
- Environmental Policy, Planning and Compliance
- Finance and Ratemaking
- Gas/Electric Coordination
- Market Design
- Natural Gas & Petroleum
- Nuclear
- Renewable & Alternative Energy

**LITIGATION**

- Accounting
- Analysis of Market Manipulation
- Antitrust/Competition
- Bankruptcy & Restructuring
- Big Data & Document Analytics
- Commercial Damages
- Environmental Litigation & Regulation
- Intellectual Property
- International Arbitration
- International Trade
- Labor & Employment
- Mergers & Acquisitions Litigation
- Product Liability
- Securities & Finance
- Tax Controversy & Transfer Pricing
- Valuation
- White Collar Investigations & Litigation

**INDUSTRIES**

- Electric Power
- Financial Institutions
- Infrastructure
- Natural Gas & Petroleum
- Pharmaceuticals & Medical Devices
- Telecommunications, Internet, and Media
- Transportation
- Water