The Future of Clean Energy in the U.S.

DRIVERS, INNOVATIONS, AND CHALLENGES

PRESENTED BY
Sam Newell

PRESENTED FOR
Morgan Stanley Equity Research

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Agenda

I. Drivers of Clean Energy Investment
II. Innovations to Watch
III. Long-term Challenges
State Clean Energy Mandates

Renewable & Clean Energy Standards

www.dsireusa.org / September 2020

30 States + DC have a Renewable Portfolio Standard, 5 states have a Clean Energy Standard (8 states have renewable portfolio goals, 5 states have clean energy goals)

New York Needs +35 GW Renewables by 2030, 80 GW by 2040

Resources that grow in capacity
- Renewables to meet zero-emissions mandate
- Storage and flexible load for short-term balancing (+5 GW storage by 2030; 14 GW storage + 3 GW flex load by 2030)
- Dispatchable generation: 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

But State Mandates are Not the Only Driver

**Annual Renewable Capacity Additions**

Many Utility Targets Exceed RPS, for Environmental & Economic Reasons

Corporate Renewable Purchases Are Growing

Renewable Energy Penetration So Far, By Region

INNOVATIONS TO WATCH

Larger Turbines

INNOVATIONS TO WATCH

Cost Declines Exhibited in Offshore Wind PPAs

INNOVATIONS TO WATCH

Ongoing Development & Implementation of Storage

Projected Installed Cost for 4-hr Li-ion Storage Systems


Source: https://emp.lbl.gov/generation-storage-and-hybrid-capacity
Electrification

Total U.S. Greenhouse Gas Emissions by Economic Sector in 2018

Source: https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

INNOVATIONS TO WATCH

V2G?

EV and Grid-scale Battery Capacity

Source: Brattle analysis
Load Flexibility

US Cost-Effective Load Flexibility Potential

Existing Capability

- Behavioral + Smart Tstat
- DLC
- Interruptible Tariff

59 GW (6.7% of peak)

16 GW

1. Expanded conventional programs
2. New load flexibility programs and value streams

40 GW

2019-2030 market transition:
AMI deployment, EV adoption, customer growth, T&D expansion, renewables adoption

83 GW

2030 Potential

198 GW (20% of peak)

- Demand Bidding + EV Charging
- Dynamic Pricing
- Auto-DR
- Smart Water Heating
- Smart Thermostats
- Interruptible Tariff

## Brattle-NYISO Grid Evolution Study: Modeled vs. Feasible Resources

<table>
<thead>
<tr>
<th></th>
<th>Base Case Capacities</th>
<th>“Maximum Feasible” Capacity by 2030</th>
<th>Technical Potential</th>
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<tr>
<td></td>
<td>2030</td>
<td>2040</td>
<td>DPS</td>
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<tr>
<td><strong>Onshore Wind</strong></td>
<td>9.7 GW</td>
<td>23.3 GW</td>
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<tr>
<td><strong>Offshore Wind</strong></td>
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<td>25.1 GW</td>
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<tr>
<td><strong>Solar</strong></td>
<td>21.1 GW</td>
<td>38.1 GW</td>
<td>7 GW</td>
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</table>

LONG-TERM CHALLENGES

Declining Marginal Value

**Summer Marginal Capacity Value**

- Offshore Wind
- Solar
- Onshore Wind

**Winter Marginal Capacity Value**

- Offshore Wind
- Onshore Wind
- Solar

**Installed Capacity (MW)**

Supply Adequacy During Extended Low-Wind/Solar Periods

**Hourly Balancing Challenge**

- **Over generation** in high solar hours
- **Under generation** can be met with storage or flexible load

**Seasonal Balancing Challenge**

- **Over generation** in low-load shoulder months
- **Under generation** in summer months requires new technologies

**Monthly Load Onshore**

- **Wind**
- **Solar**
- **Offshore Wind**

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


See Disclaimer on Slide 2
New Technologies Needed for Long-Term Storage...by 2040

Minimal curtailments due to short- and long-term balancing (including RNG production)

Wind and solar become primary source of energy

Gas-fired generation falls, eventually switches to zero-emission fuel sources (RNG)

Dr. Samuel Newell leads The Brattle Group’s Electricity Practice.

He has 22 years of experience helping clients with wholesale market design, generation asset valuation, resource planning, and transmission planning. Much of his work addresses the industry’s transition to clean energy. He frequently provides expert reports and testimony to ISOs, the FERC, state regulatory commissions, and the American Arbitration Association.

Dr. Newell earned a Ph.D. in Technology Management & Policy from the Massachusetts Institute of Technology, an M.S. in Materials Science & Engineering from Stanford University, and a B.A. in Chemistry & Physics from Harvard College.

Learn more about Sam
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