Energy Storage in the Southeast

Phase I Review and Recommendations

Presented by:
Richard A. Simmons, PhD, PE

April 18, 2018

INTERSECT 2018
Atlanta, GA
Outline

- Objective
- Experts Consulted
- Trends in Energy Storage: the SE in context
- Use Cases and Value Stacking
  - National Approaches
  - Implications for the Southeast
- Opportunities & Recommendations
Energy Storage (ES) Study Objective

This study seeks to shed light on a few *simple* questions:

- What opportunities exist for **grid-scale** energy storage in the Southeast?
- What can the region learn from **macro-trends** and other deployments?
- What steps and decisions are needed **at a system level**?
- What role, if any, does **policy** have to inform such steps?

Questions are *simple*, but answers are much more *complex*…
Good fit with EPICenter Approach

EPICenter’s sub-national, multi-discipline collaborative approach can facilitate a timely discussion within the region:

- Access to national and regional expertise
- Understand why common technologies are not universally deployable:
  - In every business environment
  - In every regulatory construct
- Leverage the “energy advantage” and strengths of the Southeast
## Experts Consulted

<table>
<thead>
<tr>
<th>Utility</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zak Kuznar</td>
<td>Duke Energy</td>
</tr>
<tr>
<td>Colette LaMontagne</td>
<td>National Grid</td>
</tr>
<tr>
<td>Adam Siegelstein</td>
<td>NextEra Energy Resources</td>
</tr>
<tr>
<td>Christopher Parent</td>
<td>ISO New England</td>
</tr>
<tr>
<td>Steve Baxley</td>
<td>Southern Company Services</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Industry</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tim Ash</td>
<td>AES Energy Storage (Fluence)</td>
</tr>
<tr>
<td>David Bradwell</td>
<td>Ambri</td>
</tr>
<tr>
<td>Michael Berlinski</td>
<td>Customized Energy Solutions</td>
</tr>
<tr>
<td>Jason Burwen</td>
<td>Energy Storage Association</td>
</tr>
<tr>
<td>Kelly Speakes-Backman</td>
<td>Energy Storage Association</td>
</tr>
<tr>
<td>Craig Irwin</td>
<td>Roth Capital Partners</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Academic/Research</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varun Sivaram</td>
<td>Council on Foreign Relations</td>
</tr>
<tr>
<td>Mike Aller</td>
<td>Energy Florida</td>
</tr>
<tr>
<td>Cara Marcy</td>
<td>Energy Information Administration</td>
</tr>
<tr>
<td>Haresh Kamath</td>
<td>EPRI</td>
</tr>
<tr>
<td>David Hart</td>
<td>George Mason</td>
</tr>
<tr>
<td>Deepak Divan</td>
<td>Georgia Tech, ECE</td>
</tr>
<tr>
<td>Santiago Grijalva</td>
<td>Georgia Tech, ECE</td>
</tr>
<tr>
<td>Sadegh Vejdan</td>
<td>Georgia Tech, ECE</td>
</tr>
<tr>
<td>Bill Bonvillian</td>
<td>MIT</td>
</tr>
<tr>
<td>Francis O’Sullivan</td>
<td>MIT</td>
</tr>
<tr>
<td>Paul Denholm</td>
<td>National Renewable Energy Lab</td>
</tr>
<tr>
<td>Bill Grieco</td>
<td>Southern Research Institute</td>
</tr>
<tr>
<td>Bert Taube</td>
<td>Southern Research Institute</td>
</tr>
<tr>
<td>Vincent Sprenkle</td>
<td>Pacific Northwest National Lab</td>
</tr>
<tr>
<td>Rick Ferrera</td>
<td>UCSD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Federal &amp; State Policy Perspectives</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colette Honorable</td>
<td>FERC Commissioner (Former)</td>
</tr>
<tr>
<td>Carla Peterman</td>
<td>California Public Service Commissioner</td>
</tr>
<tr>
<td>Jamie Barber</td>
<td>Georgia PSC EERE Manager</td>
</tr>
<tr>
<td>Sara Baldwin Auck</td>
<td>Interstate Renewable Energy Council</td>
</tr>
</tbody>
</table>
Current & Future ES Technologies

Legend:
- Mechanical storage
- Electro-chemical storage
- Thermal storage
- Electrical storage
- Chemical storage

Capital requirement x Technology risk

Time

Research Development Demonstration Deployment Mature Technology

Flow batteries
Lithium-ion batteries
Molten salt
Flywheel (low speed)
Sodium-sulfur (NaS) batteries
Compressed air energy storage (CAES)
Pumped hydro storage (PHS)
ES Use cases at a glance
ES Use Case Trends

Key Trends

- Frequency Regulation dominated until 2016, beginning to saturate
- Capacity trend (with longer durations) driven by California
- A wide range of states are pairing renewables with storage
- Behind the meter (“Bill management”) is a relatively stable market

ES Growth Projections

Annual ES Revenue Projections by Use Case, 2017-2025

Value should accrue to: business and society

(Source: Navigant Research)
Conditions that Favor Energy Storage:

The following market and regulatory factors generally help “pull” grid-scale ES:

- **High rates**

- **Clean Energy/Climate Support Policies**
  - RPS, Net metering, ES Mandates, Other incentives

- **New Additions of Capacity or Infrastructure**
  - Rapid Deployment of Renewables
  - Upgrades to T&D Infrastructure

- **Need for Improved Resilience**
  - (e.g., against extreme events)
U.S. Rates:

US Avg: 10.27 ¢/kWh

NE Avg: 16.13 ¢/kWh

SE State: ¢/kWh
- NC: 9.20
- SC: 9.79
- TN: 9.23
- GA: 9.59
- AL: 9.56
- MS: 8.67
- FL: 9.91

CA: 15.23 ¢/kWh

AK: 21.53 ¢/kWh

HI: 23.87 ¢/kWh

Note: The map shows the highest demand charge in each utility territory. Number of different rate structures across the US complicates analysis and decision-making for ES deployment.

Note: Data shown are based on commercial utility tariffs from the Utility Rate Database, as of Aug 2016.
Renewable Portfolio Standard (RPS) Policies

www.dsireusa.org / February 2017

- ME: 40% x 2017
- NH: 24.8% x 2025
- VT: 75% x 2032
- MA: 15% x 2020 (new resources)
- 6.03% x 2016 (existing resources)
- RI: 38.5% x 2035
- CT: 27% x 2020
- NJ: 20.38% RE x 2020 + 4.1% solar by 2027
- PA: 18% x 2021†
- DE: 25% x 2026‡
- MD: 25% x 2020
- DC: 50% x 2032

29 States + Washington
DC + 3 territories have a Renewable Portfolio Standard
(8 states and 1 territories have renewable portfolio goals)

Source: DOE/EERE & dsire:
http://www.dsireusa.org/resources/detailed-summary-maps/
U.S. Wind Energy:

Figure 4.8 Wind Energy Share of Electric Generation by State, 2016

[Map showing wind energy share by state]
Net Metering Policies:

38 States + DC, AS, USVI, & PR have mandatory Net Metering rules

Source: NC Clean Energy Tech Center, dsire database
http://www.dsireusa.org/resources/detailed-summary-maps/
State Policy Actions on Energy Storage

Note: Map is not reflective of all state activities on energy storage. Certain early stage policy/regulatory efforts, grant programs and/or pilot projects may not be reflected herein.

Note: As of April 2017

Trends We See

EPICenter Analysis from data derived from:

- DOE Global Energy Storage Database
- Bloomberg New Energy Finance
Electrochemical Storage, Cumulative Installed Capacity, 2010

Battery cost: $1000 per kWh

Sources:
Deployments: DOE Global Energy Storage Database
Battery Price Estimates: Bloomberg New Energy Finance
Electrochemical Storage, Cumulative Installed Capacity, 2011

Battery cost: $800

Sources:
Deployments: DOE Global Energy Storage Database
Battery Price Estimates: Bloomberg New Energy Finance
Electrochemical Storage, Cumulative Installed Capacity, 2012

Battery cost: $642

Sources:
Deployments: DOE Global Energy Storage Database
Battery Price Estimates: Bloomberg New Energy Finance
Electrochemical Storage, Cumulative Installed Capacity, 2013

2013 Battery cost: $599

Sources:
Deployments: DOE Global Energy Storage Database
Battery Price Estimates: Bloomberg New Energy Finance
Electrochemical Storage, Cumulative Installed Capacity, 2014

Battery cost: $540

Sources:
Deployments: DOE Global Energy Storage Database
Battery Price Estimates: Bloomberg New Energy Finance
Electrochemical Storage, Cumulative Installed Capacity, 2015

Battery cost: $350

Sources:
Deployments: DOE Global Energy Storage Database
Battery Price Estimates: Bloomberg New Energy Finance
Electrochemical Storage, Cumulative Installed Capacity, 2016

Battery cost: $273

Sources:
Deployments: DOE Global Energy Storage Database
Battery Price Estimates: Bloomberg New Energy Finance
Electrochemical Storage, Cumulative Installed Capacity, 2017

*Battery cost: <$260

Sources:
Deployments: DOE Global Energy Storage Database
Battery Price Estimates: *Author’s Estimate
Electrochemical Storage, Cumulative Installed Capacity, 2018

*Battery cost < $260

Sources:
Deployments: DOE Global Energy Storage Database
Battery Price Estimates: *Author’s Estimate
Battery Cost Trends, through 2020

Battery Prices may be declining faster than earlier models predicted

Note: As of July 2017
Li-Ion Energy Storage Project Locations

http://www.energystorageexchange.org/
Sizes range from 1kW-100MW and are behind and in-front of the meter.
Data shows operational, contracted and announced lithium-ion battery projects commissioned beginning January, 2009.
Key Takeaways:
• Use case combinations do not stack additively
• Some unintended effects result if profit maximization is sole objective
• Co-benefits “across the meter” are complex, but may be critical
Vertically-integrated, regulated utilities:

- Vertical integration (G,T&D) may ease valuation and implementation
  - Single owner-operator
  - Large asset base
  - Long term planning

SE Generating Mix Evolution:

- Growth in Nuclear AND Solar PV (Interesting interplay)
- CO₂ Emissions have been subordinate to other factors, but steadily declining
- What (generating source) will be dispatched during the charging phase?

Strategic demonstrations in the SE:

- Frequency Regulation Plus Renewables Integration
- Renewable Firming Plus Reserve (e.g., Military bases, Florida, NC)
- Transmission & Distribution Investment Deferral
- Other “Behind the Meter” deployments

Graphic Source: Northbridge Energy Partners, P. Kelly-Detwiler
Reasons for optimism in the SE:

- Cost curve!
- Technology maturity
- Lessons learned from other regions that are further along
- Value stacking is complicated…
  - So 2-3 valid use cases simplify things
  - Also need to minimize “uncertainty stacking”
- Support policies (such as subsidies and mandates) are complicated…
  - So perhaps approaches that minimize or limit these offer:
    - (A) A model that is more market-centric, self-sustaining
    - (B) A limiting case for other states as they envision wind down of financial incentives
- Behind the Meter is less regionally sensitive
- Well-diversified energy portfolios provide potential opportunities
## Potential Next Steps

### Near Term:
- Mine regional demos for policy insights
- Validation of (actual) aggregated value

### Intermediate Term (3-6 years):
- Develop initial guidance for IRP planning, 2019, 2022
- Model economics, emissions, valuation trends
- Storage as a complement to existing plans and existing asset base
- EPRI: “Don’t lose sight of the utility manifesto”
  - Energy storage viewed as a tool among others

### Long Term (10 years+):
- “Plan to Plan:” Take a more architectural, strategic approach to resource planning
- Model distribution level to accommodate trends toward decentralization, DER space-time effects
- Much larger than Energy Storage, but critical to inform IRP process and long term planning
- Learn lessons from other states: get ahead of this now
Sampling of SE Energy Storage Projects

- **Ancillary services**
- **T&D upgrade deferral**
- **Renewables integration/time shift**
- **Resiliency**
- **Reliability**
- **Back-up generation**
- **Peaker retirement**

**Needs vary widely, even within the SE**

<table>
<thead>
<tr>
<th>State</th>
<th>[kW]</th>
<th>[h]</th>
<th>Primary Use</th>
<th>Secondary Use</th>
<th>Tertiary Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>300</td>
<td>1.0</td>
<td>Renewables Firming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FL</td>
<td>1000</td>
<td>1.0</td>
<td>Resiliency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FL</td>
<td>200</td>
<td>2.0</td>
<td>Renewables Time Shift</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GA</td>
<td>1000</td>
<td>2.0</td>
<td>Time Shift</td>
<td>Load Following</td>
<td>Renewables Firming</td>
</tr>
<tr>
<td>KY</td>
<td>990</td>
<td>1.9</td>
<td>Bill Management</td>
<td>Reliability</td>
<td>Resiliency</td>
</tr>
<tr>
<td>NC</td>
<td>250</td>
<td>3.0</td>
<td>Time Shift</td>
<td>Renewables Firming</td>
<td>Voltage Support</td>
</tr>
<tr>
<td>NC</td>
<td>200</td>
<td>2.5</td>
<td>Demand Response</td>
<td>Time Shift</td>
<td>Frequency Regulation</td>
</tr>
<tr>
<td>NC</td>
<td>100</td>
<td>1.0</td>
<td>Bill Management</td>
<td>Frequency Regulation</td>
<td>Renewables Firming</td>
</tr>
<tr>
<td>NC</td>
<td>250</td>
<td>0.3</td>
<td>Load Following</td>
<td>Renewables Firming</td>
<td>Time Shift</td>
</tr>
<tr>
<td>TN</td>
<td>25</td>
<td>1.9</td>
<td>Distribution upgrade</td>
<td>Time Shift</td>
<td>Load Following</td>
</tr>
<tr>
<td>VA</td>
<td>48</td>
<td>2.0</td>
<td>Onsite Generation</td>
<td>Renewables Firming</td>
<td>Resiliency</td>
</tr>
</tbody>
</table>

Source: Deployments: DOE Global Energy Storage Database
ES-SE Policy Analysis Opportunity?

Battery Cost ($/kWh)

Emissions Intensity (CO₂/kWh)

Value Stack (NPV)

Uncertainty & Risk (Normalized)

Sources: BNEF, DOE/EIA, EPA, RMI (adapted)
Closing Thoughts

From INTERSECT 2017:

- “Technological innovation has outpaced policy and regulation”
  - Implication: Time is now to evaluate ES policies

- “Both near term and long term strategic solutions are needed”
  - Implication: ES demos & lessons learned should inform longer term planning

- “Economics of new technologies must improve”
  - Implication: Need to take a closer look at new cost projections and stacked value

- “Regional partnerships can accelerate progress”
  - Implication: Leverage the SE network while engaging more broadly
Thank you

For more info, please contact:

Richard A. Simmons, PhD, PE
Director, Energy Policy and Innovation Center
Georgia Tech Strategic Energy Institute
richard.simmons@me.gatech.edu
404-385-6326