Grid Tied Battery Energy Storage: A Regulated Utility’s Path Forward

Sherif Abdelrazek, Ph.D., PE

5 June 2018
- Duke Energy R&D and Early Adoption of Energy Storage
- Energy Storage Project Pipeline within Duke Energy
- Duke Energy’s Future Outlook for Energy Storage: Renewables Integration
  - Ancillary Services
  - Renewables Integration
Duke Energy R&D and Early Adoption of Energy Storage

Energy Storage Project Pipeline within Duke Energy

Duke Energy’s Future Outlook for Energy Storage: Renewables Integration
  - Ancillary Services
  - Renewables Integration
Duke Energy R&D and Early Adoption of Energy Storage

Duke Energy tested the most technically attractive lithium battery chemistries with nearly 40MW of R&D and Commercial Installations.
Duke Energy R&D and Early Adoption of Energy Storage

Explore Technology (R&D)  Scalable Demonstration (Prove Business Case)  Regulated Asset (Capture Benefits)

We have been here…  Now we are moving here…
- Duke Energy R&D and Early Adoption of Energy Storage

- **Energy Storage Project Pipeline within Duke Energy**

- Duke Energy’s Future Outlook for Energy Storage: Renewables Integration
  - Ancillary Services
  - Renewables Integration
Energy Storage Project Pipeline within Duke Energy

- **DEO**
  - 10 MW pilot program included in ESP

- **DEI**
  - 5 MW Camp Atterbury and 5 MW Nabb
  - Approved by IURC

- **DEF**
  - 50 MW included in utility rate settlement
  - Approved by FPSC

- **DEP/DEC**
  - 95 kWh Mt. Sterling Microgrid (Commissioned)
  - 75MW placeholder in the Carolinas IRP
    - 4 MW Hot Springs and 9 MW AVL Rock Hill (Announced)
Duke Energy R&D and Early Adoption of Energy Storage

Energy Storage Project Pipeline within Duke Energy

**Duke Energy’s Future Outlook for Energy Storage: Renewables Integration**
- Ancillary Services
- Renewables Integration
Duke Energy's Future Outlook for Energy Storage

Duke Energy’s ES Outlook

Ancillary Services

Stand Alone

AC Coupled Solar Plus Storage

Renewables Integration

DC Coupled Solar Plus Storage
How does the utility grid perceive energy storage?
How does the utility grid perceive energy storage?

Well, as seen by the grid,

Energy = Storage
How does the utility grid perceive energy storage?

Well, as seen by the grid,
How does the utility grid perceive energy storage?

Well, as seen by the grid,

Energy Storage = \[\text{graphical representation}\]
How does the utility grid perceive energy storage?

Well, as seen by the grid,

\[
\text{Energy Storage} = \text{\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{energy_storage_diagram}
\caption{Energy Storage Concept}
\end{figure}} + \text{\begin{figure}[h]
\centering
\includegraphics[width=0.3\textwidth]{grid_diagram}
\caption{Grid Concept}
\end{figure}} + \text{\begin{figure}[h]
\centering
\includegraphics[width=0.2\textwidth]{storage_diagram}
\caption{Storage Concept}
\end{figure}}
\]
How does the utility grid perceive energy storage?

Well, as seen by the grid,
How does the utility grid perceive energy storage?

Well, as seen by the grid,

Energy Storage = All Basic Physical Electrical Elements in One!
Energy Storage Opportunities Identification & Implementation in a Regulated Environment

- Find nodes on the grid with maximum ES need.
- Conduct detailed ES studies to identify ES applications and stackability.
- Prioritize ES opportunities according to net value.
- Implement ES Projects that are in the rate payers best interest.

**ES Can Become Cost Effective Through:**

1. Multi-Application Systems
2. Multi-Avoided Cost Stream Systems
Find nodes on the grid with maximum ES need.

Conduct detailed ES studies to identify ES applications and stackability

Prioritize ES opportunities according to net value

Implement ES Projects that are in the rate payers best interest

**Multi-Application Systems:**
1. The current cost of ESSs rarely allow single use case ESSs
2. ES applications can stack in simultaneous manners
3. Utility ES resiliency functions can be easily added to support customer power quality improvement at minimal additional cost
Energy Storage Opportunities Identification & Implementation in a Regulated Environment

- Find nodes on the grid with maximum ES need.
- Conduct detailed ES studies to identify ES applications and stackability.
- Prioritize ES opportunities according to net value.
- Implement ES Projects that are in the rate payers best interest.

- **Multi-Avoided Cost Stream Systems:**
  1. Multi-avoided cost value stream projects can counter act high ES cost in regulated environments.
  2. Stacking of multiple functions may not be necessary here.
Multi-Application Energy Storage Systems Operation Example: PVS+PLS


Duke Energy’s Future Outlook for Energy Storage: Ancillary Services
Multi-Avoided Cost Streams Energy Storage Systems Example: Mt. Sterling Microgrid

- **12.47kV Waterville Village Distribution Feeder**
  - Installed in 1960s
  - 5 Miles from nearest disconnection point
  - 48 poles
  - 1 customer (Mt. Sterling Fire Tower)

- **Planned Upgrades**
  - 22 poles to be replaced through 2026
  - High cost due to helicopter operation

- **O&M Challenges**
  - Inaccessible Terrain
  - High cost vegetation management and restoration
  - Averages 3+ major outage events per year
    - Roughly 1 week per outage
Overview: Utility-owned and -operated Microgrid that serves a remote customer off-grid through 100% renewable energy

Problem: Inaccessible line installed in 1960s to support 1 customer load requires high-cost upgrades and long-term outages

Timeline: 11/2016– Filed for regulatory approval; 04/2017– Received regulatory approval; 05/2017– Construction complete
Topologies:

**AC coupled**

- Mature
  - Camp Atterbury/Hot Springs Projects

**DC coupled**

- Recently Mature
  - Technical & Financial Analysis Phase
Topologies:

**AC coupled**

- **Mature**
  - Camp Atterbury/Hot Springs Projects
  - Advantage: Better for ancillary services functions for ESSs

**DC coupled**

- **Recently Mature**
  - Technical & Financial Analysis Phase
  - Advantage: More efficient for renewables Integration. Provides a semi-dispatchable trait to solar facilities, reduces power intermittency
Topologies:

**AC coupled**

Mature
Camp Atterbury/Hot Springs Projects

- Advantage: Better for ancillary services functions for ESSs

**DC coupled**

Recently Mature
Technical & Financial Analysis Phase

- Advantage: More efficient for renewables Integration. Provides a semi-dispatchable trait to solar facilities, reduces power intermittency

Decline in cost of modules drives towards higher DC/AC ratio designs

Decline in cost of ES drives better economics for DC coupled Solar Plus Storage Systems. Especially with higher DC AC ratio solar facilities
Goal: maximize solar DC capacity relative to inverter capacity such that the additional capacity can be charged during the day and discharged during times when solar production is less than inverter maximum capacity.

- **Advantages:**
  1. Intermittency reduction
  2. Improved grid impact of solar facilities (semi-dispatchable)
  3. Ability for solar facilities to reduce power without loss
  4. Reduction of “Duck Curve” effect
  5. Can provide resiliency benefits
1. Duke Energy views energy storage as a prime grid ancillary services tool.

2. Energy storage projects pursuing ancillary services benefits are more successful when grid locations are identified properly.

3. Renewables integration applications of energy storage are better suited for some topologies versus others.

4. DC coupled solar plus storage systems can reduce negative impacts of solar facilities on the grid.
Questions ?