Microgrid for Resilience Project – Villalba, Puerto Rico

FEMA Webinar Presentation

SANDIA DEMONSTRATIONS TEAM

4/26/23
What we do and why:
Support communities, state energy offices, utilities, academia, and the overall ES industry to **demonstrate and validate the equitable use of resilient, and secure energy storage systems on and off the grid through deployment projects**. Sandia’s work in innovative deployment projects advance DOE’s goals of facilitating decarbonization of the grid by improving acceptance and understanding of energy storage systems and serving communities by enabling equitable clean energy access.

Why Are Sandia’s Demonstration Team Projects Important?
Facilitate the early adoption of energy storage technologies in support of DOE’s goals of an equitable, clean, resilient and secure grid of the future

- Act as a bridge between R&D efforts and commercial adoption of safe, resilient, and secure energy storage systems
- Validate technical models and results through collection and analysis of operational energy storage data
- Inform Codes and Standards development and best practices for installation and operation
- Increase public confidence by demonstrating energy storage technologies and showcasing its range of benefits
Deployment Projects Are a Foundational Element of the DOE/SNL ES Program

**Mid-1970’s – 1980’s**
- Energy Storage Program early years, first use of cost-share development projects to advance technologies
- 4-yr, $2.8M, cost-share deployment program for VRLA battery improvement with GNB

**1990’s**
- Major ES developments occur through SNL’s cost-share deployment projects program
- Cooperative Agreement placed by DOE/SNL to support the design, fabrication, and testing of the first modular “AC Battery” - PQ2000 R&D 100 Award in 1997

**2000 - 2010**
- Growth period for ES on utility systems with new technologies being piloted
- Microgrid projects grow in scale and scope with several deployments in rural and remote communities including Alaska and Hawaii

**2010 - 2020**
- Major growth in the deployment of both FTM and BTM ES
- Sterling Municipal Light Dept. installs first utility scale and largest system in New England.
- 2017 Grid Edge Award winner by Greentech Media Finalist for the 5th Annual Energy Storage North America (ESNA) Innovation Awards

**2020 - Future**
- Demonstrate and validate the equitable use of resilient, and secure energy storage systems on and off the grid through deployment projects
- SNL/CEC PIER program flywheel ES demonstration project for ‘rapid response’ frequency regulation

**1992 – Sandia performs specialized evaluation of flooded lead acid batteries for PREPA’s 20MW BESS (C&D Charter Power Systems)**
- Long Duration Energy Storage
- Community based projects
- ES cybersecurity
- ES data & analytics
Why Villalba, PR?

• Located in the mountainous central region of PR
  • Outages in the central region typically last longer than other parts of the island

• One of 5 participating municipalities of Consorcio Energético de la Montaña (known as CEM)
  • Sandia performed an earlier analysis for Municipality sized microgrids

• Villalba Mayor Luis Javier Hernández Ortiz is the Director of CEM

• Through its Energy Storage for Social Equity (ES4SE) Program, DOE has asked Sandia to implement a pilot project in Villalba
‘Downtown’ branch of 5901-02 feeds all initial identified critical loads
1. Hospital
2. City Hall
3. Theater
4. Former school
5. Public transportation terminal
6. City planning office
7. City revenue office
8. City public square
Top Three Critical Loads – Potential Separate Building Microgrids

#1 – Hospital

#2 – City Hall

#3 – Theater
<table>
<thead>
<tr>
<th>Building</th>
<th>Microgrid</th>
<th>Existing Generator Size</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| Theater    | ![Icon] + ![Icon] + ![Icon] | 125kW                   | • Used as a Community shelter currently  
• Building is of newer construction – more electrical efficiency  
• Water storage tanks  
• Working generator  
• Large space available for services/shelter  
• Ability to prepare/serve meals?  
• Less additional electrical work inside the building would be required  
• Additional nearby buildings could be used to host solar  
• Theater pays more demand charges | • Smallest rooftop – least amount of solar |
| Hospital   | ![Icon] + ![Icon] + ![Icon] | 200kW                   | • Serves a critical need during emergencies  
• Working generator and diesel storage tank  
• Water storage tanks  
• Largest amount of solar rooftop availability | • For-profit entity  
• Might not serve as a Community shelter for the general public |
| City Hall  | ![Icon] + ![Icon] + ![Icon] | N/A (125kW)             | • Provides continuity of Gov’t services  
• Water storage? | • Building electrical system needs a lot of work  
• Only part of the building would be backed up  
• Generator non-functional  
• Least amount of space |
Project constraints to consider

Questions to consider that affect storage sizing:

- **Land & Rooftop Availability:**
  - What is the maximum amount of rooftop surface available?
  - Is there any additional adjacent land available for PV installation?

- **Grid Availability:**
  - What are the expected outages that is being considered for ES sizing?
  - When do these outages occur?

- **Diesel Generator:**
  - Utilization - What are the operational limitations of the installed diesel generators?
  - Fuel – Will it be available during an emergency?

- **Budget/Financing:**
  - What is the overall budget?
  - Is there potential for PPA or other revenue streams?
Grid Tied With Back-Up

- Solar limited to a maximum of roof-top capacity and a no solar included option
- Reduce diesel generator utilization during an outage (chose a reduction of 66%)
- Outage Durations (Hours): [24, 48, 72, 168]
- BESS + solar could provide non-outage services (daily demand reduction, net metering, etc.)

Future work (Permanently islanded – no grid connection):

- BESS + solar with existing diesel fuel generator contribution up to the limits prescribed by Regulation 9028 – Final Microgrid Regulation (see addendum A)
- BESS + solar only
### Scenarios Considered

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Technology</th>
<th>Outage Duration (hours)</th>
<th>PV Amount</th>
<th>Diesel Runtime</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grid Tied With Backup</strong></td>
<td><img src="image" alt="Lightning bolt + Solar panel + Battery" /></td>
<td>24 – 168</td>
<td>Rooftop constrained</td>
<td>≤ 33% of outage duration</td>
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<tr>
<td></td>
<td><img src="image" alt="Lightning bolt + Solar panel" /></td>
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</tr>
<tr>
<td><strong>Future Work (Permanently Islanded)</strong></td>
<td><img src="image" alt="Lightning bolt + Solar panel + Battery" /></td>
<td>8760</td>
<td>Optimized Sizing</td>
<td>≤25% of the annual energy consumption</td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="Lightning bolt + Solar panel + Battery" /></td>
<td>8760</td>
<td>Optimized Sizing</td>
<td>500 hours annual runtime</td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="Lightning bolt + Solar panel" /></td>
<td>8760</td>
<td>Optimized Sizing</td>
<td>-</td>
</tr>
</tbody>
</table>
Rooftop Availability

Theater:
- Rooftop availability: 366 m²
- PV potential: 56 kWdc

Hospital:
- Rooftop availability: 1357 m²
- PV potential: 363 kWdc

City Hall:
- Rooftop availability: 351 m²
- PV potential: 103 kWdc

- Satellite imagery of available rooftop area for PV
- Assuming an dc-to-ac ratio of 1.2
- Power density of 182 W/m²
- Accounts for shading
*Electrical energy meter installed since November 2022 (Validation of load assumptions on analysis)
Example of Grid Tied Analysis

PV + ES + Diesel (33%)
Where Does The Project Stand Now?

- Theater building was selected by the Municipality of Villalba for the building microgrid project
- Villalba and Sandia are working together to complete cost-share contracting
- Next Steps
  - Request for Proposal (RFP) development
  - Bid Solicitation/Review/Award
  - Project construction/commissioning/operations
Thank You

This work was Directed by Dr. Imre Gyuk through the Department of Energy Office of Electricity Delivery and Energy Reliability (DOE-OE) Stationary Energy Storage Program.

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Backup Slides
Microgrid generation resources:

- "Renewable" microgrid qualifications
  - Primary energy source has to be one or more of the defined "Renewable Resource"
    - Seventy-five percent (75%) of the energy output of the system during the 12-month period beginning with the date the Microgrid first produces electric energy and each 12-month period thereafter must be from a Renewable Resource
    - The fuel used by non-renewable generation must be no more than 2,500 Btu per total energy provided by the microgrid
    - The non-renewable generation must operate at a heat rate of no more than 13,000 Btu/kWh at full output; and
    - The sum of installed renewable energy generating capacity and electrical energy storage capacity (in MW) of the Microgrid shall exceed the expected peak demand of the Microgrid.
  - Except as otherwise provide herein, use of fossil fuel by a Microgrid may not, in the aggregate, exceed twenty-five percent (25%) of the total energy output of the system during the 12-month period beginning with the date the Microgrid first produces electric energy and each 12-month period thereafter.
### Addendum B – Generator Set Ratings

<table>
<thead>
<tr>
<th>ISO 8528 Rating</th>
<th>Caterpillar Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emergency Standby Power (ESP)</strong></td>
<td>The maximum power available during a variable electrical power sequence, under the stated operating conditions, for which a generating set is capable of delivering for up to 200 hours of operation per year with maintenance intervals and procedures being carried out as prescribed by the manufacturer. The permissible average power output over 24 hours of operation shall not exceed 70% of the ESP rating.</td>
</tr>
<tr>
<td><strong>Hospital Generator Nameplate</strong></td>
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</tr>
<tr>
<td><strong>Load Management Guidelines (Prime Power Rating)</strong></td>
<td>Load management is the deliberate control of loads on a generator set and/or utility to have the lowest possible electrical costs. Maximum of 500 hours per year with varying loads. Maximum load factor is 102%. Typical application is peak shaving.</td>
</tr>
<tr>
<td><strong>Prime Running Power (PRP)</strong></td>
<td>The maximum power which a generating set is capable of delivering continuously whilst supplying a variable electrical load when operated for an unlimited number of hours per year under the agreed operating conditions with the maintenance intervals and procedures being carried out as prescribed by the manufacturer. The permissible average power output over 24 hours of operation shall not exceed 70% of the PRP rating.</td>
</tr>
<tr>
<td><strong>Continuous Operating Power (COP)</strong></td>
<td>The maximum power which a generating set is capable of delivering continuously whilst supplying a constant electrical load when operated for an unlimited number of hours per year under the agreed operating conditions with the maintenance intervals and procedures being carried out as prescribed by the manufacturer.</td>
</tr>
</tbody>
</table>

**Table 1: ISO 8528 and Caterpillar Ratings**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td><strong>Emergency Standby Power (ESP)</strong></td>
<td>Typical usage of 60 hours per year with a maximum of 200 hours per year with varying loads. Average variable load factor is 70% of the ESP rating. No overload is available. Not for maintained utility paralleling applications.</td>
</tr>
<tr>
<td><strong>Standby Power</strong></td>
<td>Typical usage of 200 hours per year with a maximum of 500 hours per year with varying loads. Average variable load factor is 85% of the standby rating. No overload is available. Not for maintained utility paralleling applications.</td>
</tr>
<tr>
<td><strong>Mission Critical Standby</strong></td>
<td>Typical usage of 200 hours per year, with a maximum of 500 hours per year with varying loads. Average variable load factor is 85% of the standby rating. Typical peak demand of up to 100% of the rating for 5% of the operating time. No overload is available. Not for maintained utility paralleling applications. Typical application is data centers and healthcare.</td>
</tr>
</tbody>
</table>

**Hospital Generator Nameplate**

- **Caterpillar**
  - 100 N.E. Adams Street
  - Peoria, IL 61619
  - USA

- **Generating Set – ISO 8528**
  - **Model:** DDO-2
  - **Serial Number:** CAT/OE/ENG/D6405
  - **Northeast: 10066560/10066561
  - **Make of Manufacturer:** Caterpillar
  - **Rated Power:** 730 kW
  - **Rated Voltage:** 208 Cat.
  - **Rated Frequency:** 60 Hz
  - **RPM:** 1800
  - **Operating Set:** STANDBY

**Prime Power**

- **Rating:** Unlimited hours of usage. Average variable load factor is 72% of the Prime Power rating. 10% overload is available but limited to 12 hours and not to exceed 25% per year. The 10% overload is available in accordance with ISO 3046-1. Life to overhaul of the engine is dependent on operation as outlined in ISO 8528, and time spent during operation above 10% load may affect the life to overhaul.