Sandia National Laboratories

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Microgrid for Resilience Project – Villalba, Puerto Rico

FEMA Webinar Presentation

SANDIA DEMONSTRATIONS TEAM

4/26/23

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Sandia Energy Storage Demonstrations Projects Team

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

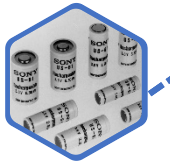
Mid-1970's – 1980's

Energy Storage Program early years, first use of cost-share development projects to advance technologies

Major ES developments occur through SNL's cost-share deployment projects program

1990's

4-yr, $2.8M, cost-share deployment program for VRLA battery improvement with GNB



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

1992 – Sandia performs specialized evaluation of flooded lead acid batteries for PREPA's 20MW BESS (C&D Charter Power Systems)

AEP/SNL cost-shared deployment of the first 'DESS'

SNL/CEC PIER program flywheel ES demonstration project for 'rapid response' frequency regulation

2000 - 2010

Growth period for ES on utility systems with new technologies being piloted

Major growth in the deployment of both FTM and BTM ES

2010 - 2020

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

Microgrid projects grow in scale and scope with several deployments in rural and remote communities including Alaska and Hawaii

Long Duration Energy Storage

Community based projects

ES cybersecurity

ES data & analytics

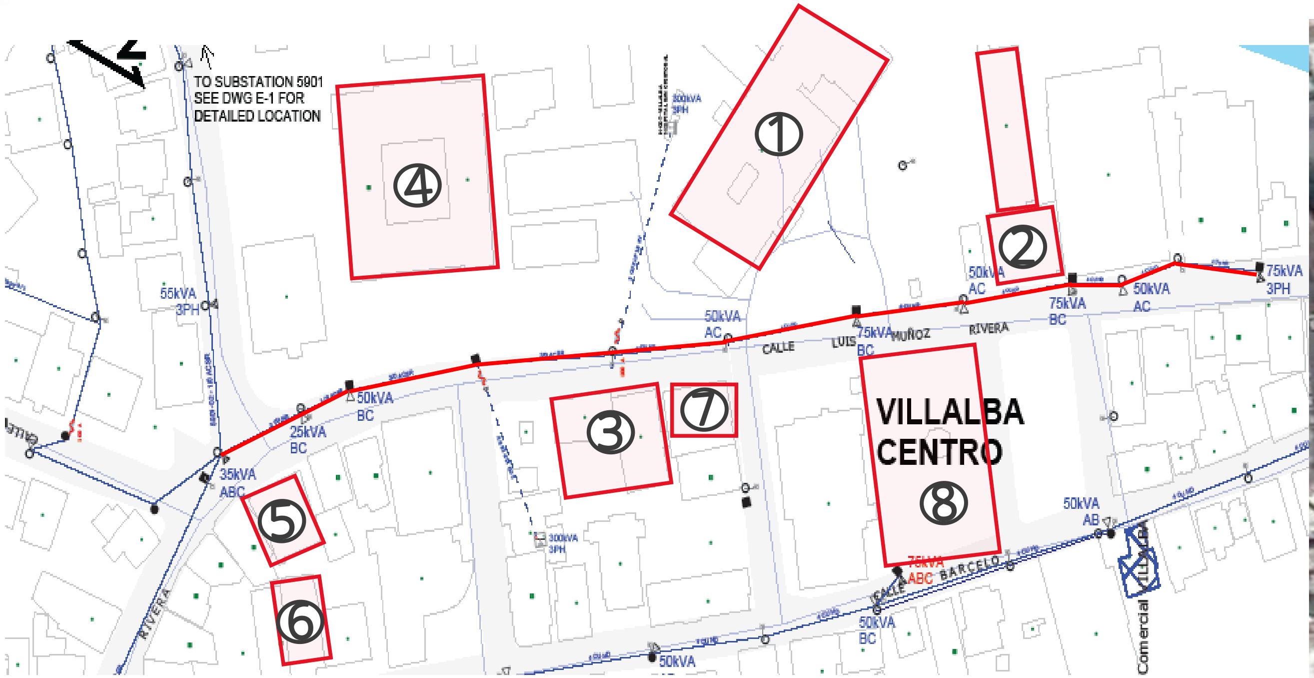
2020 - Future

Demonstrate and validate the equitable use of resilient, and secure energy storage systems on and off the grid through deployment projects

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

Villalba Municipality Identified Critical Loads



‘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

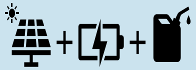
Top Three Critical Loads – Potential Separate Building Microgrids

#1 – Hospital

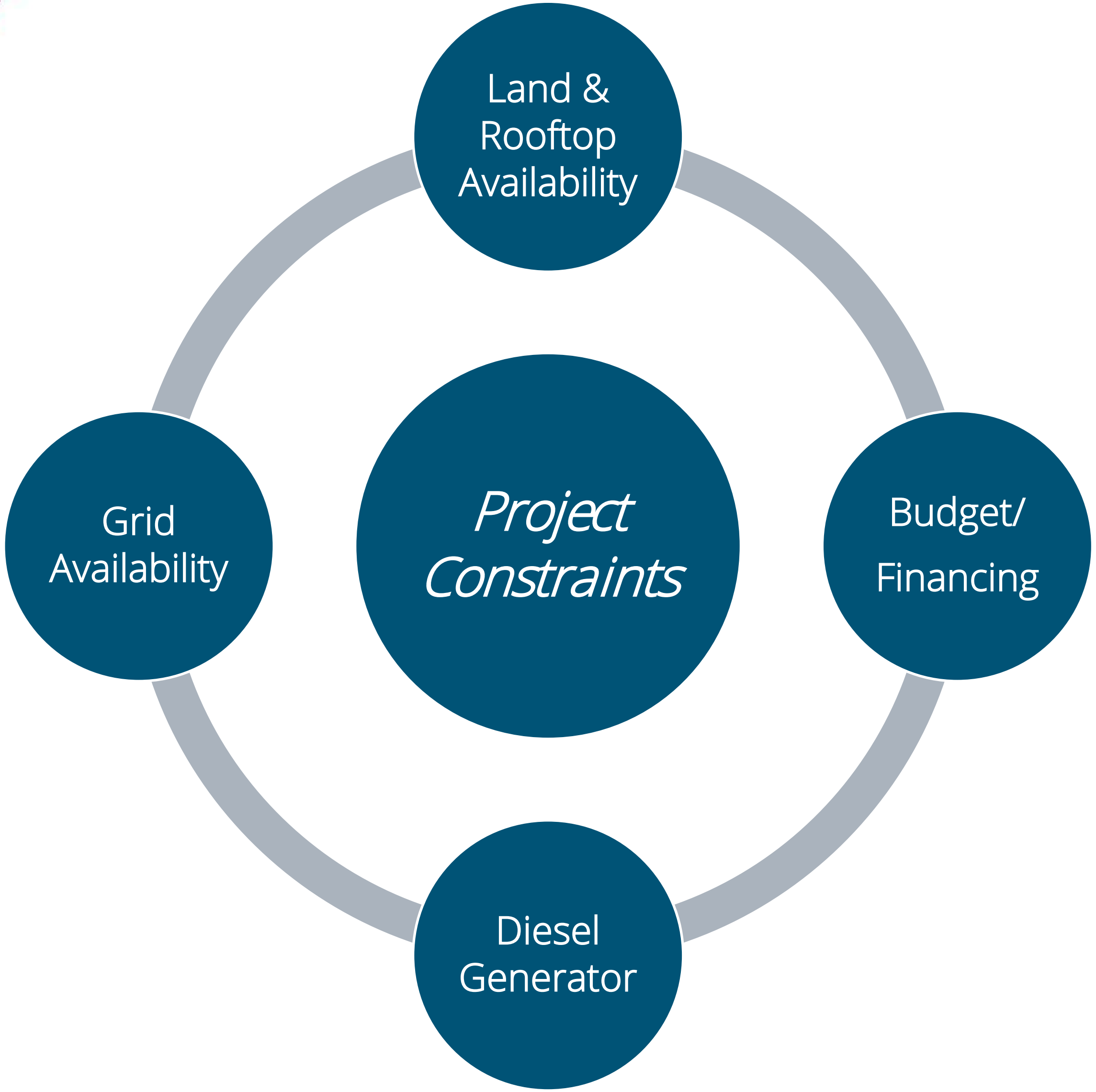
#2 – City Hall

#3 – Theater

Pros and Cons of Each Critical Load Building Microgrid

Building	Microgrid	Existing Generator Size	Pros	Cons
Theater		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		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		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?*

Critical Loads Analysis

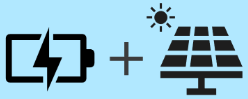
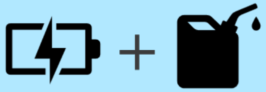
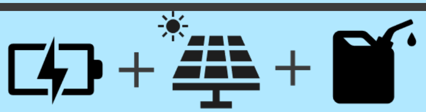
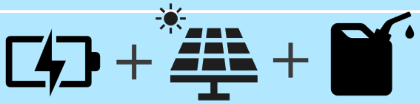
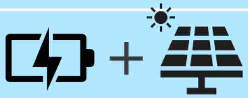
Grid Tied With Back-Up

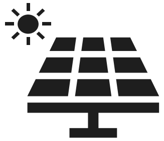
- Solar limited to a maximum of roof-top capacity and a no solar included option
- Reduce diesel generator utilization during an outage (chose a reduction of 66%)
- Outage Durations (Hours): [24, 48, 72, 168]
- BESS + solar could provide non-outage services (daily demand reduction, net metering, etc.)

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

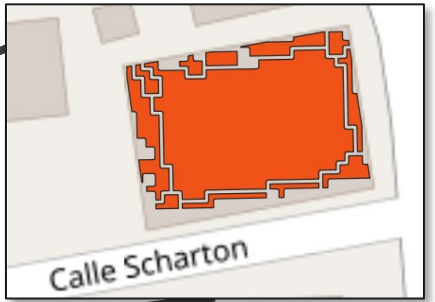
Scenarios Considered

Scenario		Sensitivities		
Configuration	**Technology**	**Outage Duration (hours)**	**PV Amount**	**Diesel Runtime**
Grid Tied With Backup		24 – 168	Rooftop constrained	≤ 33% of outage duration
		24 – 168	Rooftop constrained	-
		24 – 168	-	≤ 33% of outage duration
Future Work (Permanently Islanded)		8760	Optimized Sizing	≤25% of the annual energy consumption
		8760	Optimized Sizing	500 hours annual runtime
		8760	Optimized Sizing	-

 4-hr BESS  Rooftop Solar  Diesel Generator

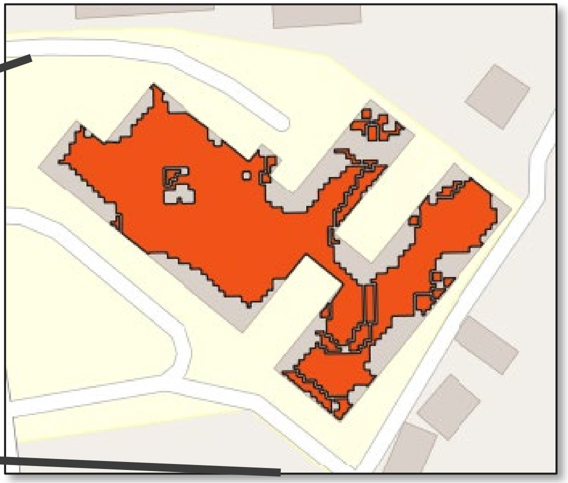
Rooftop Availability

- Satellite imagery of available rooftop area for PV
- Assuming an dc-to-ac ratio of 1.2
- Power density of 182 W/m^2
- Accounts for shading



Theater:

- Rooftop availability: 366 m^2
- PV potential: 56 kWdc



Hospital:

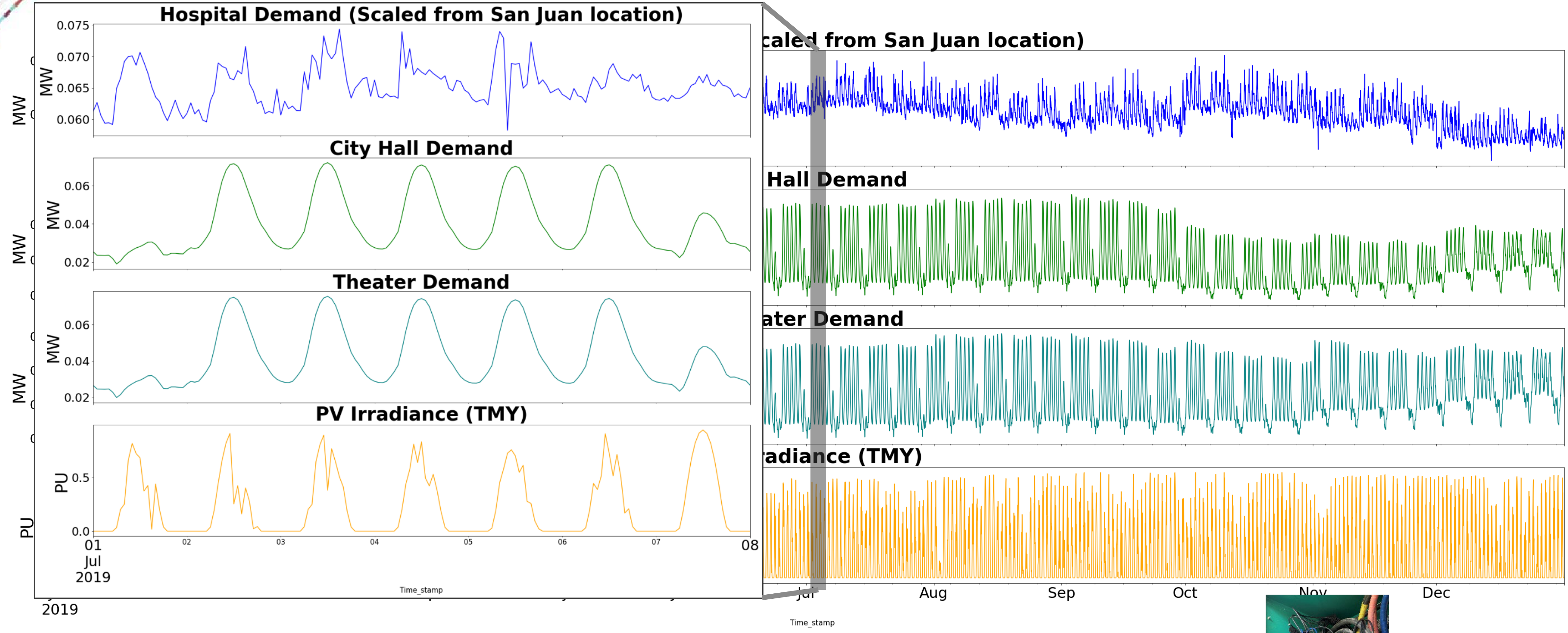
- Rooftop availability: 1357 m^2
- PV potential: 363 kWdc

City Hall:

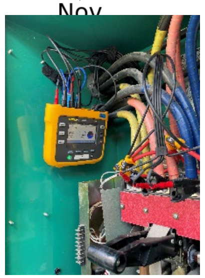
- Rooftop availability: 351 m^2
- PV potential: 103 kWdc

National Renewable Energy Laboratory (NREL). (2020). PV Rooftop Database for Puerto Rico (PVRDB-PR) [data set]. Retrieved from https://dx.doi.org/10.25984/1804725.

Sizing of Distributed PV and Energy Storage – Bldg. Load Profiles

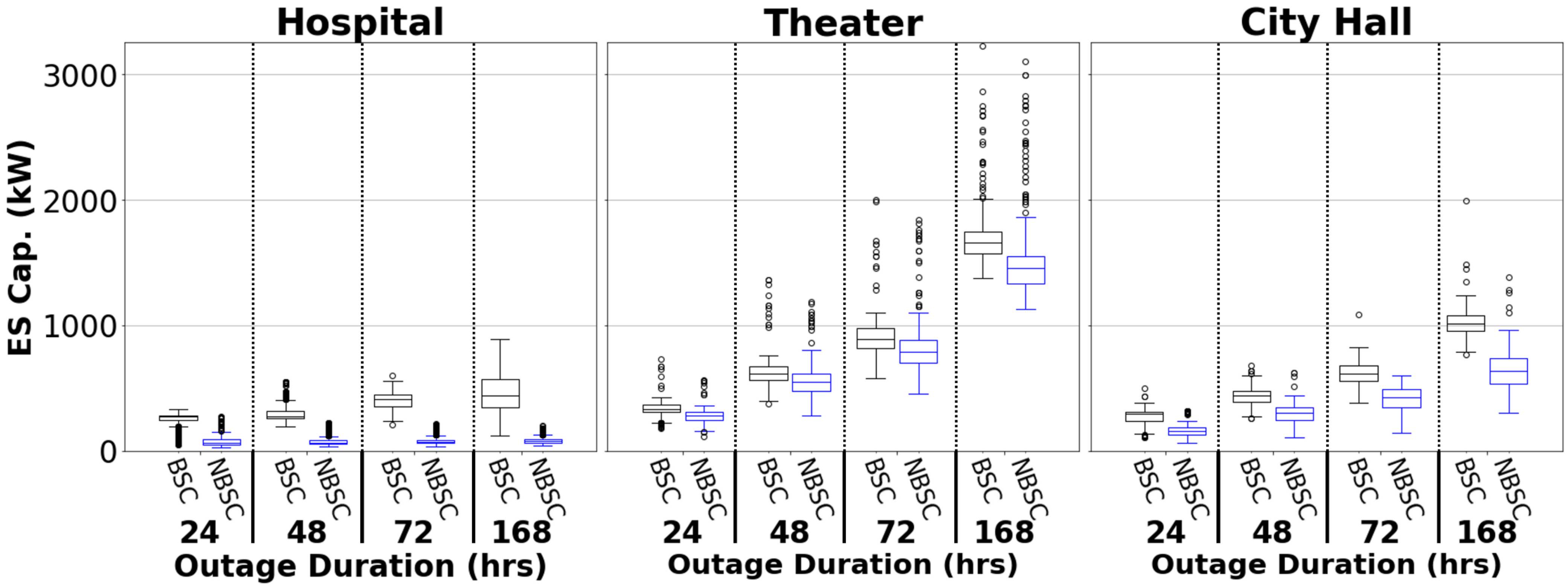


*Electrical energy meter installed since November 2022 (Validation of load assumptions on analysis)



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

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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.

Backup Slides

Addendum A – Regulation 9028 Technical Requirements

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 1: ISO 8528 and Caterpillar Ratings			
ISO 8528 Rating		Caterpillar Rating	
Rating	Definition	Rating	Definition
Emergency Standby Power (ESP)	The maximum power available during a variable electrical power sequence, under the stated operating conditions, for which a generating set is capable of delivering in the event of a utility power outage or under test conditions for up to 200 hours of operation per year with maintenance intervals and procedures being carried out as prescribed by the manufactures. The permissible average power output over 24 hours of operation shall not exceed 70% of the ESP rating.	Emergency Standby Power (ESP)	Typical usage of 50 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.
No ISO equivalent		Standby Power	Typical usage of 200 hours per year, with a maximum of 500 hours per year with varying loads. Average variable load factor is 70% of Standby rating. No overload is available. Not for maintained utility paralleling applications.
		Mission Critical Standby	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 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.
Limited Time Running Power (LTP)	The maximum power available under the agreed operating conditions, for which the generating set is capable of delivering for up to 500 hours of operation per year with the maintenance intervals and procedures being carried out as prescribed by the manufacturers.	Load Management Guidelines (Prime Power Rating)	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 100%. Typical application is peak shaving.
Prime Running Power (PRP)	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.	Prime Power	Unlimited hours of usage. Average variable load factor is 70% of the Prime Power rating. 10% overload available, but limited to 1 in 12 hours and not to exceed 25 hours per year. The 10% overload is available in accordance with ISO 3046-1. Life to overhaul of the engine is dependant on operating as outlined in ISO 8528, and time spent during operation above 70% load may affect the life to overhaul.
Continuous Operating Power (COP)	The maximum power which the generation 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.	Continuous Power	Unlimited hours of usage. Non-varying load factor is 70%-100% of the published Continuous Power rating. Typical pear demand is 100% of the continuous rating for 100% of the operating hours.

Hospital Generator Nameplate