Sandia National Laboratories

DEPLOYMENT OF BATTERY STORAGE SYSTEMS FOR OFF-GRID APPLICATIONS ON MOLOKA'I

Henry Guan, Timothy Wilcox, Waylon Clark (*Sandia National Laboratories*), **Ali Andrews** (*Shake Energy Collaborative*)
Liliana Napoleon, Leilani Chow, Leimana Ritte-Camara (*Ho'ahu Energy Cooperative Molokai*)

PROJECT PROFILE

Topic: Demonstration Projects | **Vertical:** Grid Integration and Field Validation

Strategic Pathway: Optimize

Project start and finish: FY22-FY26

PROBLEM

Remote, off-grid, and infrastructure-limited communities face persistent challenges in obtaining **reliable, affordable, and usable electricity service**. These challenges are often driven by:

- High operating and maintenance costs
- Limited system flexibility
- Difficulty supporting modern residential loads
- Complex site, permitting, and logistics constraints

Off-grid households on Molokaʻi often rely on small generators to supply all of their electrical needs while refrigeration needs are often met through propane and/or ice-based systems. These arrangements can lead to inconsistent service, high operating costs, frequent maintenance needs, and limited ability to support modern household loads.

APPROACH

This project is a **real world case study** that focused on **improving off-grid power system performance by deploying resilient, reliable and flexible residential systems** that demonstrate how integrated variable generation and battery energy storage can **improve affordability, reliability, usability, and long-term operation** in remote settings.

Sandia National Laboratories, in partnership with Shake Energy Collaborative, Ho'ahu Energy Cooperative, and Pacific Northwest National Laboratory, planned and developed **a replicable system design with 11 kWh of battery energy storage and 4 kW of variable generation** to install at **14 locations** across Moloka'i.

Sandia National Laboratories provided technical support on:

- System design
- Site screening and permitting strategy
- Safety codes and standards (NFPA 855) review
- Collaboration with contractor for safety codes compliance and implementation of safety best practices from past demonstration deployments
- Flexible system configurations for nonstandard sites
- Data collection

Fig. 1. System Deployment Locations on Moloka'i, HI

RESULTS

The project demonstrated that **energy storage can be deployed successfully** across constrained field conditions, with deployment methods that can adapt to meet unique location requirements.

Four sites required modified designs due to permitting and structure constraints. The project showed that a templated system can be modified to **preserve deployment success** under variable site conditions.

Key Results included:

- 14 residential off-grid systems installed
- Increased power availability and system reliability resulting in overall quality of life improvement by eliminating the need to refuel or swap out gas generators (especially during nighttime) for critical loads (24/7 medical devices).
- Approximately **5x reduction in the cost** of providing for electricity and refrigeration

Fig. 2. Containerized Battery Energy Storage Installation

CONCLUSIONS & IMPACT

- Energy storage can help address reliability and operability challenges in areas where there is no access to electrical infrastructure.
- This project demonstrates that battery energy storage systems with variable generation can greatly increase energy affordability for off-grid residents when compared to other methods currently in use on Moloka'i.
- This project demonstrates that storage-based systems can remain deployable even when standard installation pathways are not available.
- Its impact extends beyond the 14 installed systems by offering a repeatable model that meets safety codes and standards for improving reliability, adaptability, and implementation success in remote distributed power applications.

FUTURE DIRECTIONS

Next steps focus on refining both system design and deployment processes using operational experience and moving from a one-time deployment to repeatable deployments while incorporating improvements over time. Future deployments can use these lessons learned to improve site screening, cost estimation, and technology selection.

Next activities on Molokaʻi include:

- Completing an impact assessment
- Reviewing operating data
- Developing written safety and use guidance

This material is based upon work supported by the U.S. Department of Energy, Office of Electricity (OE), Energy Storage Division.

Sandia National Laboratories | U.S. DEPARTMENT of ENERGY | NNSA

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

SAND2026-23915C

HOĀHU ENERGY COOPERATIVE MOLOKAI