Hawaiʻi Natural Energy Institute Research Highlights

Grid Integration & Renewable Power Generation

Ka Honua Momona: Maximizing Efficiency of Off-Grid Nano-Grid

OBJECTIVE AND SIGNIFICANCE: The project's objective was to convert an existing off-grid solar PV system comprising 5.1 kW PV panels, battery storage and a backup fossil fueled generator, into a more efficient "smart" nano-grid utilizing site-scale automated load and demand management strategies to minimize wasted generation, while eliminating the need for fossil fuel backup.

Figure 1. Ka Honua Momona, Kanakakai, Molokaʻi, Hawaiʻi, the site of the off-grid, nanogrid storage project.

BACKGROUND: From 2013-2018, Ka Honua Momona (KHM), a not-for-profit community organization in Kaunakakai, Molokaʻi operated from an off-grid system consisting of 18 PV panels, dual 7200-watt Outback inverters, 40 kWh of lead acid storage, and a fossil-fuel back-up generator. KHM found that their renewable energy was not used efficiently, largely due to varied daily site utilization patterns that range from a very low baseline load (e.g., internet router and refrigerator) to a high load (e.g., large events utilizing air conditioning, lighting, and kitchen loads) that exceeds generation and storage capacity. This off-grid multiple-battery bank power and thermal storage system was designed to capture and utilize the excess energy generated when the building is not in use and the batteries are full, in float mode.

To help stabilize the nano-grid by mitigating inefficiencies in generation and storage, HNEI identified three goals:

- Test, compare, and utilize three 9 kWh Sunverge integrated energy storage systems in an off-grid environment;
- Pilot a "smart" generation schema to automatically redirect excess solar energy generation (load dump) to other loads that would be useful to KHM, such as water heating and water distillation; and
- Identify practical design issues when using multiple battery banks and multiple inverters.

PROJECT STATUS/RESULTS: HNEI implemented a "smart" strategy installing water heaters as a variable load for excess generation. Two water heaters use small, dedicated Heliatos™ solar thermal water heaters to provide nominally sufficient hot water for the two bathrooms. The solar thermal hot water is then augmented by a secondary of batteries where the power is redirected after the batteries are fully charged and in a "float" condition. This load diversion is precisely controlled by solid state auto transfer switches that transfer power to the water heaters when the battery voltages are one volt below "float" voltage and will cutout load diversion when the batteries are two volts above low battery cutout (LBCO).

On the power supply side, PV panels initially charge the primary battery banks. Once the primary batteries reach full capacity, a solid state transfer switch that detects voltage shifts the solar generation to a secondary set of batteries at predetermined battery voltage condition. As these secondary batteries reach full capacity, the energy is redirected to a third bank of stand-by batteries. The third bank also serves a 50-gallon water heater and a small water distillation system, thereby utilizing renewable energy that would have been wasted otherwise once the batteries are in float.

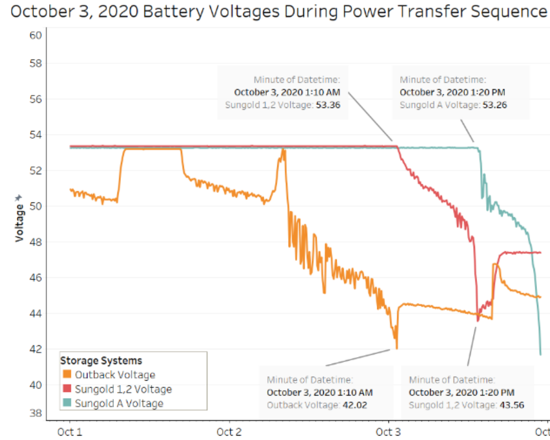

Figure 2. Sequence of 3 battery bank transfers from primary to secondary and tertiary based on voltages.

By creating a network of battery storage systems, a primary battery bank was able to serve a majority of the load when the building was not at peak capacity. For periods of higher load usage such as workshop events, weekend retreats, or extended meetings, a secondary bank of batteries backed up the primary. A third bank of batteries that was infrequently accessed by the users, fed excess energy to a water heater and a small countertop water distiller. While solar energy charged the batteries every day, the buildings were frequently not occupied, and as such, the batteries were commonly charged to full capacity with no load. This charge and discharge configuration directed the excess renewable energy to additional discretionary loads, thereby reducing waste in the system.

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