PROJECT NAME: Grid Resiliency with a 100% Renewable Microgrid

Last 5 digits of project number: **09027**

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BACKGROUND and OVERVIEW

- Project overcomes frequency stability and system control issues when operating distribution microgrids in a low inertia, **high PV penetration** environment without fossil fuel generators.
- Implemented a grid-forming inverter and advanced control features at SDG&E's Borrego Springs Microgrid to **demonstrate islanding and blackstart using renewable resources**.
- Autonomous ultracapacitor (UCAP) system implemented to support frequency stabilization.
- Simulation and emulation in advance of deployment **de-risks field operations**.

METHODS

- Electromagnetic transient (EMT) and hardware-in-the-loop (HIL) simulation of microgrid using relevant field cases – **PV intermittency, customer PV generation, large customer loads.** HIL includes microgrid controller and island master grid-forming (GFM) battery inverter.
- Integration of island master GFM battery inverters with **active and reactive power (P,Q) control.**
- Development and implementation of microgrid control scheme for **interoperability** of GFM and grid following (GFL) inverters.
- Field validation through synchrophasor (PMU) measurement of frequency during islanding, blackstart, load steps, and 4-quadrant control testing.

KEY MILESTONES

- ✓ EMT and HIL simulation of Borrego Springs Microgrid test cases
- ✓ Integration of GFM and GFL battery inverters validated operation through microgrid controller.
- ✓ Field evaluation of microgrid blackstart
- Demonstrate frequency response of ultracapacitor (UCAP) integrated into microgrid controller
- Conduct community-wide demonstration

CONCLUSION

- Inverter-based DERs' performance can meet and exceed the performance of diesel generators to support microgrid operations.
- Impact: Improves ability of grid operators to **integrate increasing amounts of solar generation onto the grid in a cost-effective, secure, resilient, and reliable manner.**

SYSTEMS INTEGRATION TRACK

NREL/PO-5D00-89143

Interoperable, **inverter-based distributed energy resources (DERs)** enable **100% renewable and resilient utility microgrids**

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SOLAR ENERGY TECHNOLOGIES OFFICE

Project Partner: National Renewable Energy Laboratory
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BORREGO SPRINGS MICROGRID

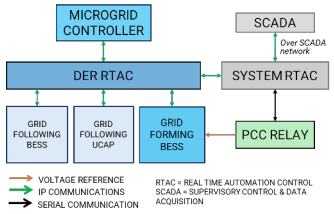
Borrego Springs is a remote desert community served by a single radial overhead transmission line, with higher risk of outage due to extreme weather conditions. The distribution grid has ~8.6MW of rooftop PV, a 6.3MW PV plant, critical loads, and large agricultural loads. Diesel generators have been historically required to blackstart, island, and stabilize microgrid frequency.

RENEWABLE DERs IMPLEMENTED

Integrated DERs:

- 1MW / 3MWh Li-ion battery (BESS), *grid-forming island master*
- 0.5MW / 1.5MWh Li-ion battery (BESS) Li-ion battery, *grid-following*
- 0.3MW ultracapacitor (UCAP), *fast frequency support*

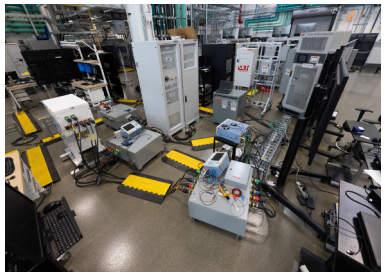
SECURE, INTEROPERABLE CONFIGURATION DEVELOPED

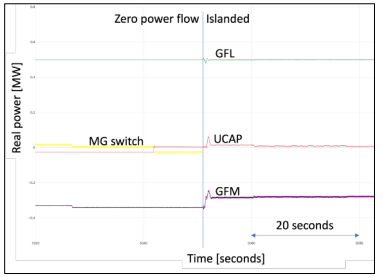


Configuration enables microgrid operators to have autonomy and flexibility to deploy a variety of assets in different configurations.

- **Microgrid controller** provides visual real time status of all DERs, commands based on use cases and asset availability.
- **DER RTAC** aggregates individual DER assets and executes action, utilizing commands from the microgrid controller.
- **SYSTEM RTAC** receives key information from the DERs for system protection and provides top-level supervisory control via SCADA.

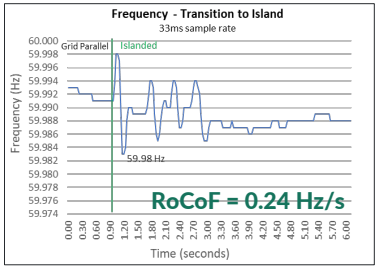
HARDWARE-IN-THE-LOOP (HIL) DEMONSTRATION

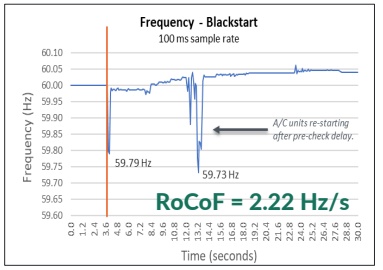




Successful planned islanding with GFM inverter HIL controlled through microgrid controller CHIL. GFL inverter is dispatched at rated power, leaving maximum capacity for GFM inverter to respond to net load steps. UCAP is activated because frequency dropped below 59.7 Hz.

FIELD EVALUATION: BLACKSTART AND ISLANDING





Successful island and blackstart with grid-forming inverter controlled through microgrid controller, arresting rate of change of frequency (RoCoF) and maintaining frequency within 59.7 – 60.3Hz.

Four quadrant testing confirms adequate and stable power flow in all directions with real and reactive power.