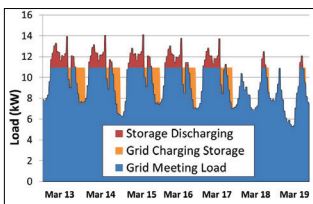


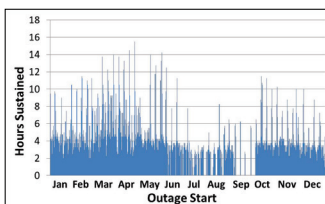
Travis Simpkins, PhD, Kate Anderson, Dylan Cutler, Dan Olis, Emma Elgqvist, Nick DiOrio, Andy Walker, PhD

Optimizing Behind the Meter Storage for Cost and Resiliency

- Photovoltaic (PV)-battery systems can provide some resiliency
 - Resiliency is difficult to quantify and value
- Evaluated PV, storage, and diesel generators for cost savings and resiliency of critical infrastructure in New York City
- Valuing added resiliency from PV-batteries during design phase can increase component sizes and improve economic viability



Battery is strategically discharged to reduce peak demand



Hours PV/battery can sustain the load for outages starting at every hour of the year

Optimizing Lab Testing

- Consolidated Utility Base Energy (CUBE) is a PV-diesel-battery hybrid system designed to power forward operating bases
- Determined maximum fuel savings CUBE could achieve in the lab and anywhere in the world

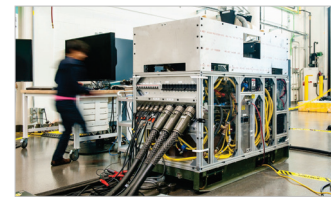
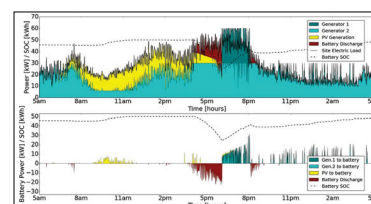


Photo by Dennis Schroeder, NREL 28830

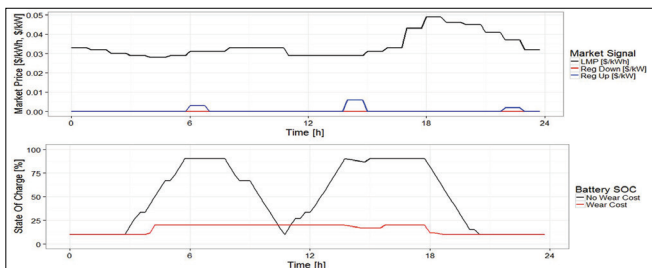


Optimal CUBE dispatch

- Informs the design of laboratory experiments, hardware configuration and control strategies
- Allows researchers to quickly run many scenarios before selecting the most relevant to verify in the lab

Optimizing Dispatch of Utility Scale Storage

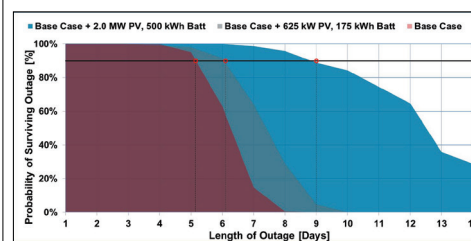
- Analyzed feeder with high-PV penetration for possible battery
- Optimized dispatch across multiple battery applications:
 - T&D deferral, PV smoothing, LMP arbitrage, frequency regulation
- Optimized dispatch strategy included effect of battery degradation
 - Informed simplified market participation strategy



Battery Dispatch Responding to Market Signals

Quantifying RE Impact on Outage Survivability

- Simulated thousands of random grid outages of varying duration
- Compared number of hours site could survive with diesel gensets and fixed fuel supply vs. gensets augmented with PV-battery
- Adding PV-battery gave site 90% chance of surviving an additional 1-4 days at no added lifecycle cost



RE extends outage survivability at no added cost

	LCC (\$MM)	Outage Survivability (Days)
Base Case*	20.0	5
Scenario 1	19.5	6
Scenario 2	20.1	9

*Base case = 2.5 MW diesel gensets, 4,500 gallons of fuel

Economics of Deep Energy Reduction in Remote Communities



Photo by Dennis Schroeder, NREL 16307

- Determined optimal system sizes and dispatching to meet goal of 75% fuel reduction in Alaska village using hybrid systems
 - Wind
 - Diesel generator
 - Battery
 - Dispatchable heaters with storage
- 75% fuel savings is challenging
 - Not quite economically viable today
 - Difficulty is offsetting heating fuel
- >50% fuel savings can be achieved while also saving money

Optimizing Existing Energy System Operation

- Alcatraz Island (NPS) implemented PV-diesel-battery off-grid system in 2012
- System did not save as much fuel as expected
- Used REopt to refine dispatch strategy – generators were charging battery too often, reducing storage capacity for PV
- Optimized operating strategy will increase use of existing PV and reduce fuel consumption.
 - Additional 15,000 gallons per year of diesel savings (\$71K per year)
 - Longer battery life due to 33% reduced battery throughput



Photo courtesy of the National Park Service

About REopt

REopt is NREL's modeling platform for energy systems integration and optimization. Formulated as a mixed-integer linear program, it is used for techno-economic analysis of renewable and conventional generation, energy storage, dispatchable loads, and energy efficiency that help clients meet cost savings and energy performance goals.

REopt has been used to assess energy and storage opportunities in on-grid and off-grid applications at over 7000 sites including cities, campuses, military bases, federal buildings, universities, utilities, private industry, and remote communities.

Learn more at: http://www.nrel.gov/tech_deployment/tools_reopt.html

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July 15, 2016
NREL/PO-7A40-67125