Optimizing Energy Storage Economics

NREL NATIONAL RENEWABLE ENERGY LABORATORY

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Basics of Battery Economics

- Battery storage economics are driven by the dispatch strategy
- Batteries can derive value from multiple revenue streams
- The value derived from discharging the battery must be greater than the cost incurred to charge the battery, regardless of the application

Energy Storage Value Streams

- Demand management
  - Reduce demand charges on utility bill
- Energy arbitrage
  - Buy energy during low price periods, consume stored energy during high price periods
- Ancillary services
  - Get paid to provide grid support to the ISO
- Demand response
  - Get paid by utility to reduce demand
- Resiliency
  - Serve critical loads during grid outages
- TD deferral
  - Get paid to help utility delay upgrades
- Capacity markets
  - Get paid by ISO to provide capacity
- Others may be possible as well

Application Stacking Challenge

- Batteries can only do one thing at a time
  - But each use may only need a few hours per year
- To maximize ROI, must determine:
  - What application battery should serve
  - When it should serve it
- Requires an optimization model

About REopt

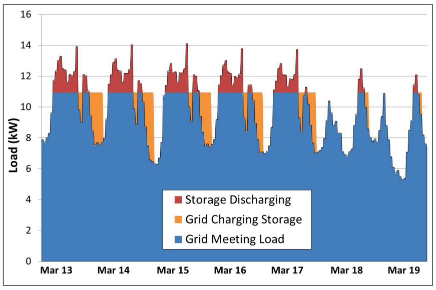
REopt is NREL's software modeling platform for energy systems integration and optimization. Formulated as a mixed-integer linear program, it is used for techno-economic analysis of renewable and conventional generation, energy storage, dispatchable loads, and energy efficiency to help clients meet cost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

REopt has been used to assess electrical, thermal, and water storage opportunities in on-grid and off-grid applications for :

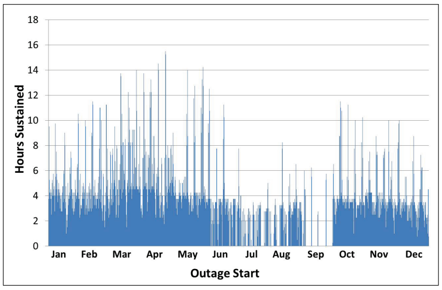
- DOE Solar
- New York City
- Time Warner Cable
- Miami University
- Wells Fargo
- Fort Hunter Liggett
- Los Alamitos Army Airfield
- San Diego Gas and Electric
- Dept. of Interior
- NREL campus
- Clean Energy Collective
- City University of New York
- National Energy Laboratory of Hawaii
- Army Rapid Equipping Force
- US Air Force Academy
- US Bureau of Reclamation
- National Park Service
- Solar Electric Power Association
- Army Office of Energy Initiatives
- General Services Administration
- Universities

Behind the Meter Demand Reduction and Energy Arbitrage

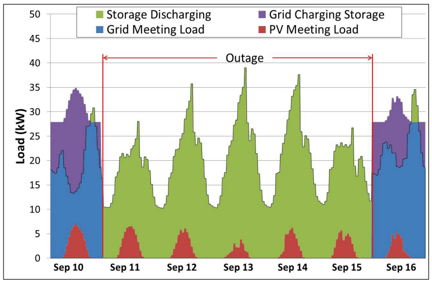
REopt was used to evaluate technical and economic viability of PV, storage, and diesel generators for cost-savings and increased resiliency of critical infrastructure in New York City.



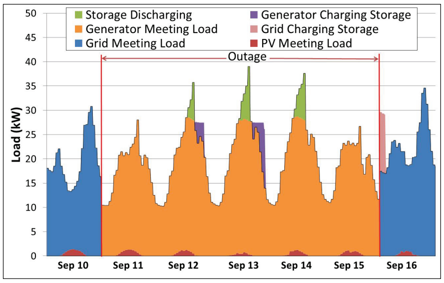
The optimally sized battery is charged during off-peak periods and discharged during peak periods to reduce peak demand. (Scenario 1)



Without an explicit resiliency requirement, the optimally sized PV-battery system sustains the critical load for an average of 2.4 hours during an outage. (Scenario 1)



The PV-battery system can sustain the critical load for 5 days if the sizes of the components are increased significantly. (Scenario 2)

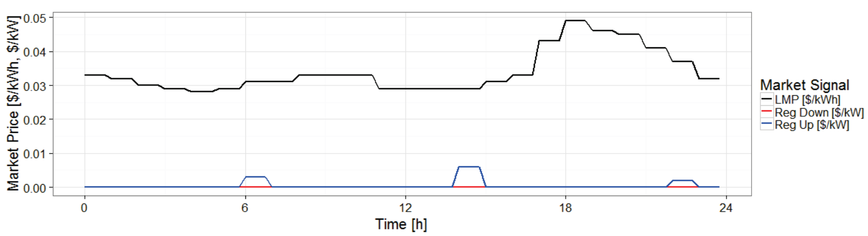


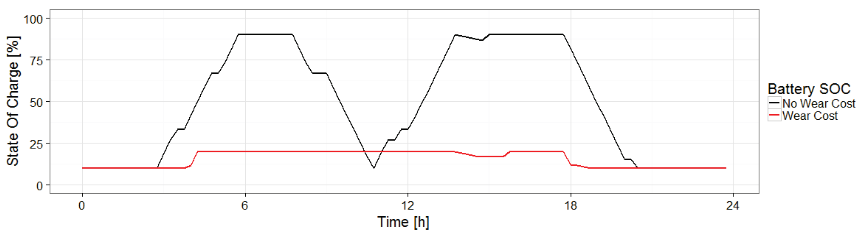
A PV-battery-diesel hybrid can sustain the critical load for 5 days at a lower lifecycle cost than the PV-battery system alone. (Scenario 3)

Scenario Number	1	2	3	4
Scenario Description	PV & Battery: no resiliency required	PV & Battery: 5-day outage	PV, Battery, Diesel: 5-day outage	Diesel Only: 5-day outage
PV Size	0	10 kW	2 kW	0
Battery Size	26 kWh/ 9 kW	2781 kWh/ 37 kW	36 kWh/ 11 kW	0
Diesel Generator Size	0	0 kW	27 kW	39 kW
Total Capital Cost	$22,520	$1,515,120	$76,620	$58,500
Base Case Life Cycle Cost	$371,141	$371,141	$371,141	$371,141
PV/Battery/Diesel Case Life Cycle Cost	$348,594	$1,928,617	$387,608	$434,379
Net Present Value	$22,547	-$1,557,476	-$16,467	-$63,239

Utility Scale Deployment

- Battery to be installed on feeder in California with high PV penetration
- Value streams considered: T&D deferral, PV smoothing, LMP arbitrage, frequency regulation
- REopt determined optimal dispatch to maximize ROI across all value streams





Battery Dispatch Responding to Market Signals

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

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