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Optimizing Solar + Storage for Cost Savings and Resiliency

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Abstract

- Behind-the-meter solar-plus-storage systems can provide utility savings through demand charge reduction, energy arbitrage, time-shifting excess PV production, and / or selling ancillary services
- Solar-plus-storage systems can also offer some energy resiliency during grid outages, but amount of resiliency is difficult to quantify
- We developed a method to estimate the resiliency that a solar-plus-storage system can provide and optimally size the system to minimize energy costs, including grid outage costs
- Results indicate that including the value of resiliency during the feasibility stage can result in larger systems and increased resiliency in a cost-optimal system

Defining Resiliency for Solar-Plus-Storage

- Resiliency provided by a solar-plus-storage system is fundamentally different than that provided by a diesel generator
  - Generators provide sufficient electricity to meet the load until its fuel reserves are depleted
  - Electricity provided by solar-plus-storage systems is less predictable; it depends on the:
    - Battery state of charge at the time of the power outage
    - Solar resource
- Resiliency provided by a solar-plus-storage system may be of lower quality than that of a diesel generator, and therefore may have a lower economic value
- However, including even a small incremental value of resiliency could be enough to make a project economically viable

Methodology

Estimating the Resiliency of Solar + Storage

- The amount of time a solar-plus-storage system can sustain an electrical load during a grid outage depends on the solar resource, electrical load, and battery state of charge at the time the outage occurs
- Calculate the number of hours that a PV-battery system can sustain the load for an outage beginning every hour of the year. (Fig. 1)
- Define resiliency metric *R* as the average number of hours (5.2 hours) that the system can sustain the load

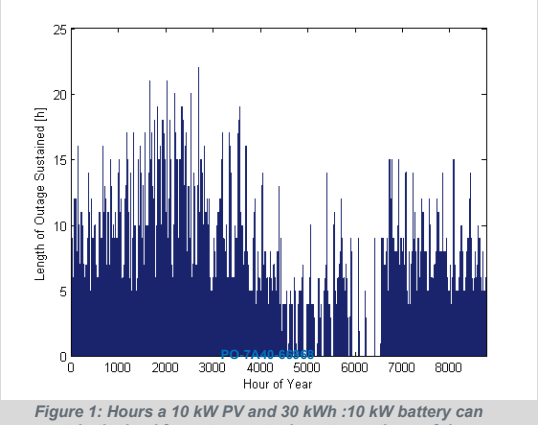

Figure 1: Hours a 10 kW PV and 30 kWh :10 kW battery can sustain the load for outages starting at every hour of the year.

Valuing the Resiliency Benefit

- Estimate annual cost of grid interruptions (ACI) based on average duration and hourly cost of outages ($283/hour)
- Fully reliable, available backup power will eliminate ACI; solar-plus-storage will only partially reduce due to uncertain availability
  - Reduce by 50% to $143/hour

Optimizing with Resiliency

- Optimize size of solar-plus-storage system for cost savings and increased resiliency
- Resiliency metric R is defined as:

$$x_1 \times s_1 + x_2 \times s_2$$

where s_1 and s_2 are the sizes of the PV and battery capacity, and x_1 and x_2 are regression coefficients obtained from a range of *R* values calculated for various system sizes

Results

- Model used to optimally size a solar-plus-storage system for a building in New York
- Regression coefficients for the resiliency metric found by performing parametric sweeps of system sizes and recording R for each combination (Fig. 2)
- First optimized system to minimize lifecycle cost of energy without valuing the resiliency benefit, then re-optimized with the value of the resiliency included
  - Solar-plus-storage system size increased by 15-31% when resiliency is valued
  - Resiliency increased by 105% (Table 1)
- Both increase as the price a customer is willing to pay for resiliency increase (Fig. 3)

Table 1	Resiliency Benefit Valued at $0 / hour	Resiliency Benefit Value at $143 / hour
PV Size	11.3 kW	13.4 kW
Battery Size	14.2 kWh : 8.1 kW	18.6 kWh : 9.3 kW
Life Cycle Cost	$266,638	$269,071
Net Present Value	$16,695	$14,262
Resiliency (hours)	0.38	0.78

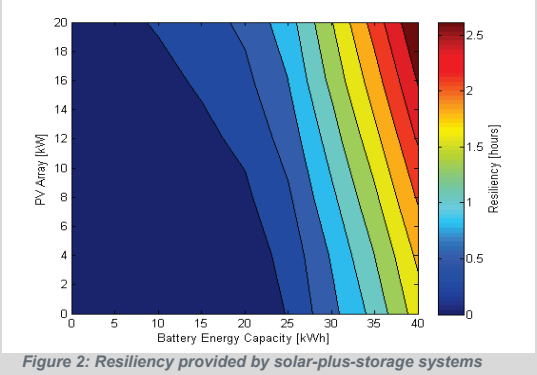

Figure 2: Resiliency provided by solar-plus-storage systems

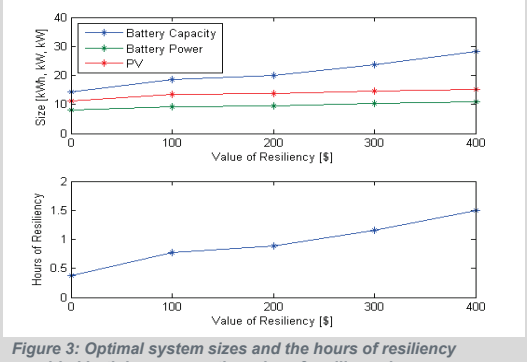

Figure 3: Optimal system sizes and the hours of resiliency provided both increase as the value of resiliency increases

Conclusion

- While the value of resiliency on its own may not justify the installation of a solar-plus-storage system, including the value of resiliency alongside other value streams may justify larger solar-plus-storage systems
- Future work may include:
  - Adding other storage value streams
  - Sustaining longer outages during catastrophic events
  - Considering other possible definitions of *R* (hours that a critical load can be met, or fraction of hours that a partial load could be met)

About REopt

REopt is NREL's software modeling platform for energy systems integration and optimization. It is a techno-economic model offering concurrent, multiple technology integration and optimization capabilities to help clients meet their cost savings and energy performance goals.

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

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