Recent Improvements in PV+Battery Modeling in NREL’s System Advisor Model

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Background
NREL’s System Advisor Model is free, open-source techno-economic analysis software that facilitates decision-making for people in the renewable energy industry.

Desktop software: https://sam.nrel.gov/
Open-source code: https://github.com/NREL/SAM/

The PV+Battery model in SAM combines SAM’s detailed PV performance model with a nonlinear generic electrochemical battery model. The PV can be AC or DC coupled to the battery model. The following configurations are also available:

- PVWatts-Battery
- Generic System-Battery
- Stand-alone Battery

The technology models can be used with utility scale, front of meter systems and PPA or merchant plant revenue, or behind the meter systems which offset utility bills.

The generic electrochemical battery model includes the following subcomponents:

- Cell Capacity
- Lifetime Fade
- Voltage Curves
- Thermal Effects

The battery can be dispatched with various heuristic options, or a custom (potentially optimized) timeseries can be provided.

References:

Dispatch Algorithms
New PV Smoothing algorithm (right) provides front of meter PV+Battery systems with the ability to smooth their output to avoid ramp-rate violations in relevant markets.

New Price Signals dispatch algorithm (bottom) considers utility rates in addition to PV and load forecasts to minimize utility bills while considering battery degradation.

Grid Outage Analysis
New support for outage analysis in behind the meter models, which affects battery performance. Users can now specify:

- Critical load
  - Percent of load or time series
  - Time steps of the outage (could be entire analysis period for off-grid)

Outage analysis can run two ways, which can be combined:

- Calculate hours of autonomy for a hypothetical outage
- Meet the critical load during the outage, which affects the state of charge and economics

Outputs include the critical load (met and unmet) as well as the performance of the system. The electricity bill is zero during an outage, so caution should be used interpreting financial results from off-grid simulations. Future work will include value of lost load.

Battery Validation
Preliminary results from a comparison of SAM’s battery model to 10 second measured data over a year of cycles for NMC/Graphite cells from Smith et al. 2017.

The maximum output power of the cell is 270 W, so mean power error is within 8%, and in the room-temperature cases (cells 1 and 2), within 2.5%.

Levelized Cost of Storage

- Metric for comparing storage technologies
- Presented in addition to full-system LCOE
- SAM accounts for dispatch strategy, charging costs, replacement costs, etc.
- Charging cost for PV charging is based on PV LCOE
- Charging cost for grid charging is either market price or retail rate

<table>
<thead>
<tr>
<th>Price Signals Dispatch Example</th>
<th>Peak Shaving Dispatch Example</th>
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</thead>
<tbody>
<tr>
<td>San Diego Hospital PV Only Charging</td>
<td>50.21 7.10 331 69.15 7.07 387</td>
</tr>
<tr>
<td>San Diego Hospital Grid Charging</td>
<td>39.67 20.04 504 76.32 14.32 499</td>
</tr>
</tbody>
</table>

Varying dispatch and charging options for the NMC/Graphite Chemistry.