



Modeling a Photovoltaic Battery System in SAM 2016.3.14

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Presentation Outline

- SAM's battery modeling capabilities
- Designing the battery system
- Downloading electricity rate data for a time-of-use rate with demand charges from the NREL URDB
- Programming the dispatch strategy
- An optimal sizing approach
- Viewing and interpreting results

System Advisor Model (SAM)

Free software that combines detailed performance and financial models to estimate the cost of energy for systems

Developed by NREL with funding from DOE

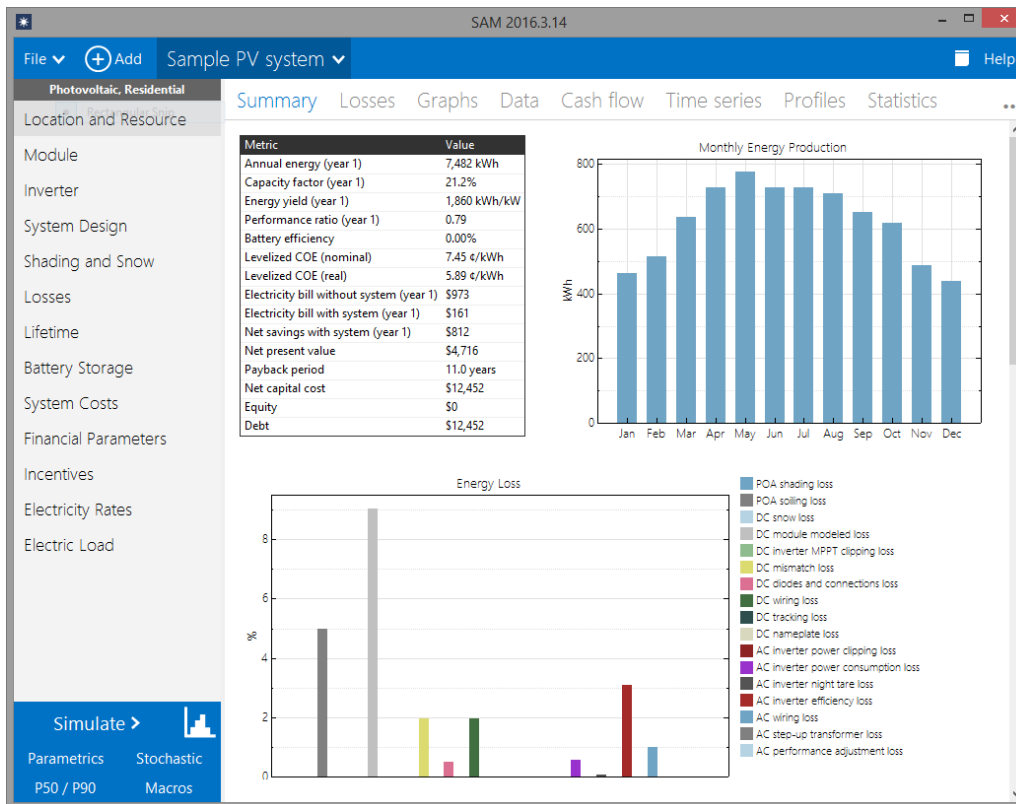
Windows, OSX, and Linux

One or two new versions per year, with more frequent patches.

Software Development Kit (SDK)

Support

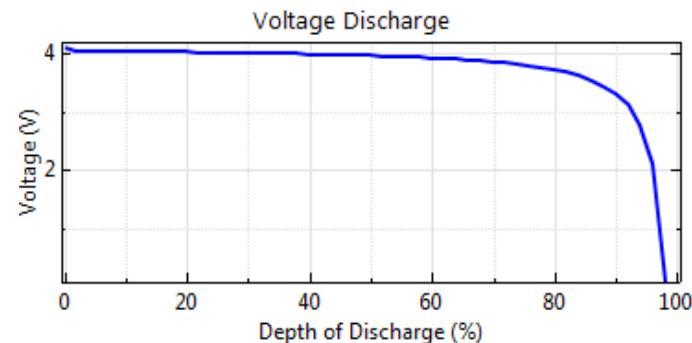
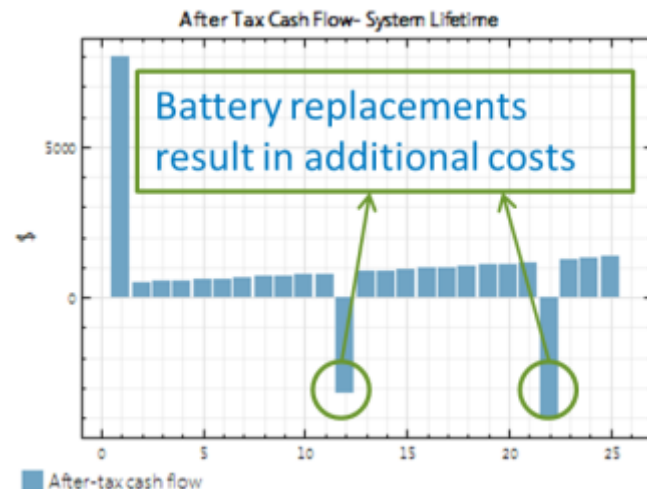
- Help system
- Website documents
- Online forum
- Contact form on website



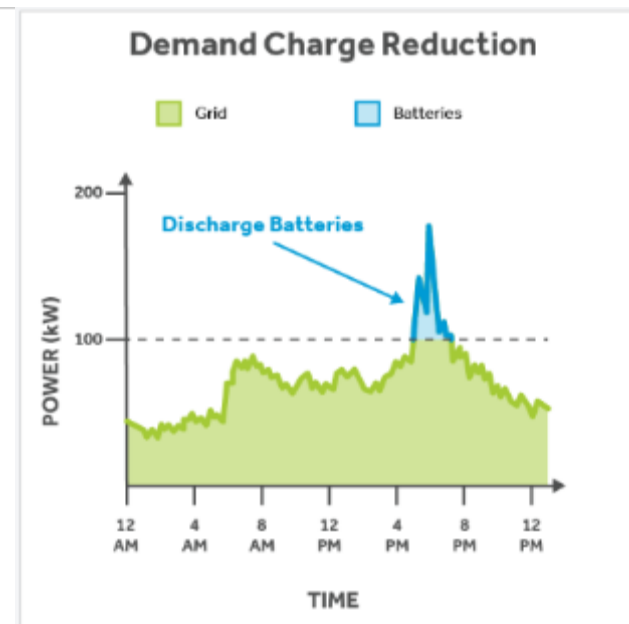
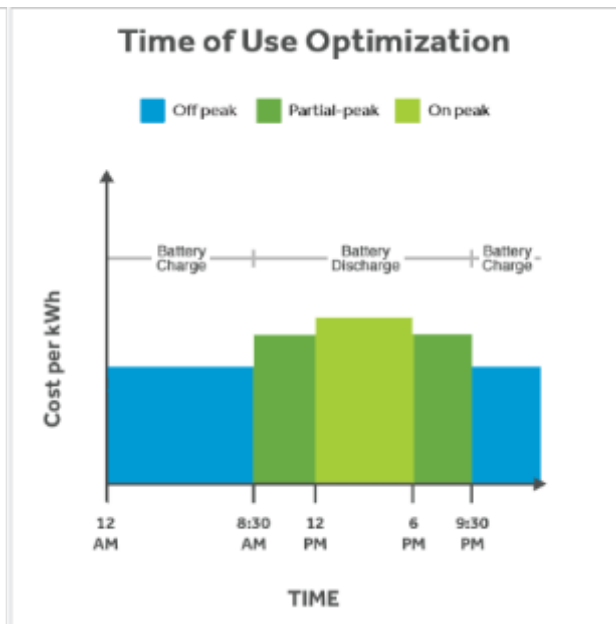
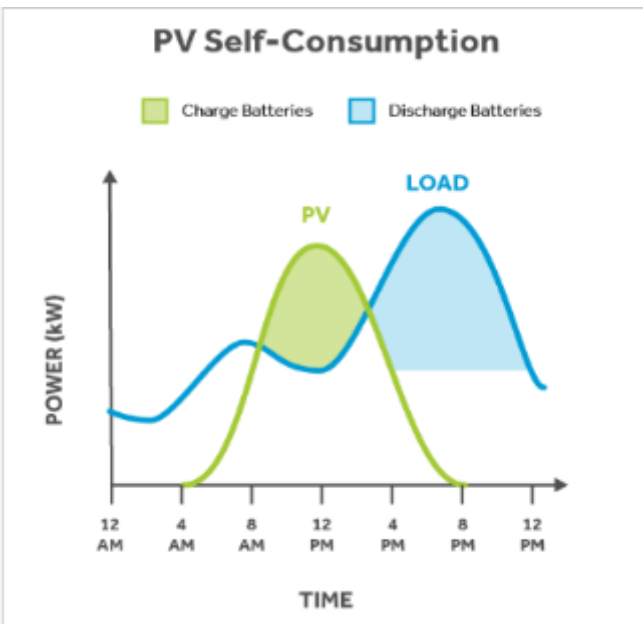
<http://sam.nrel.gov/download>

Battery Model Overview

- Techno-economic model for residential, commercial, and third-party ownership systems
 - Lead acid & lithium ion battery chemistries
 - System lifetime analysis including battery replacement costs
 - Models for terminal voltage, capacity, temperature
 - Multiple dispatch controllers available



Motivation for behind-the-meter storage



Images from: <http://www.aquionenergy.com/>



- Batteries charged primarily from PV eligible for Federal ITC subject to 75% cliff
- End of NEM in some states



- Residential and commercial utility rate structures with high TOU charges.
- Charge when rate is low, discharge when rate is high



- Commercial utility structures can have very high TOU demand charges.

Example Case Study

- Evaluate economics of installing PV-coupled battery system for demand-charge reduction:
 - Los Angeles, CA
 - Commercial building with 170 kW peak load
 - Southern California Edison TOU-GS-2 Option B

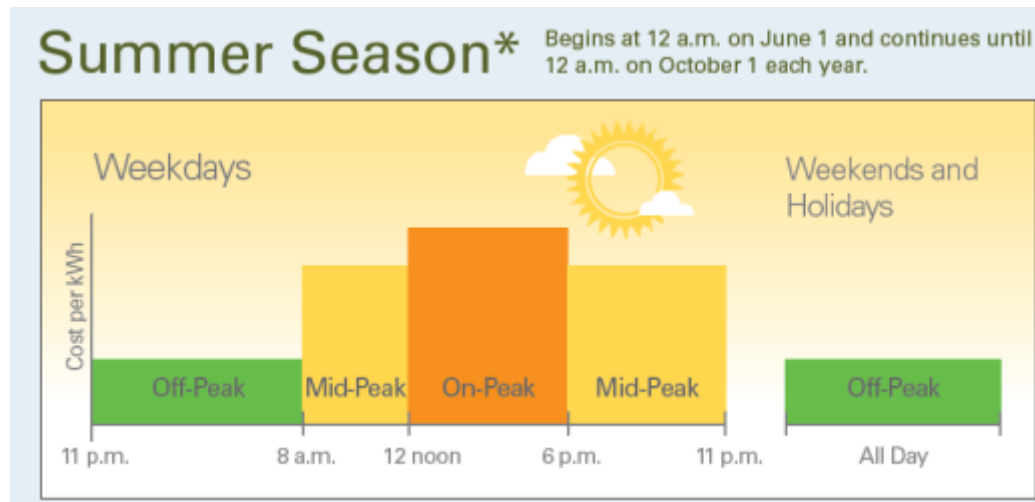


Image from SCE TOU-GS-2 Option B datasheet

Lithium Ion Battery System

- Model battery similar to Tesla Powerwall
 - Lithium-ion nickel manganese cobalt
 - Assumed can cycle full 6.4 kWh down to 20% of state-of-charge over 10 year warranty.
 - Assume battery degrades ~20% over 10 years.
 - Full installed capacity is then:
 $6.4 \text{ kWh} / 0.8 / 0.8 = 10 \text{ kWh}$

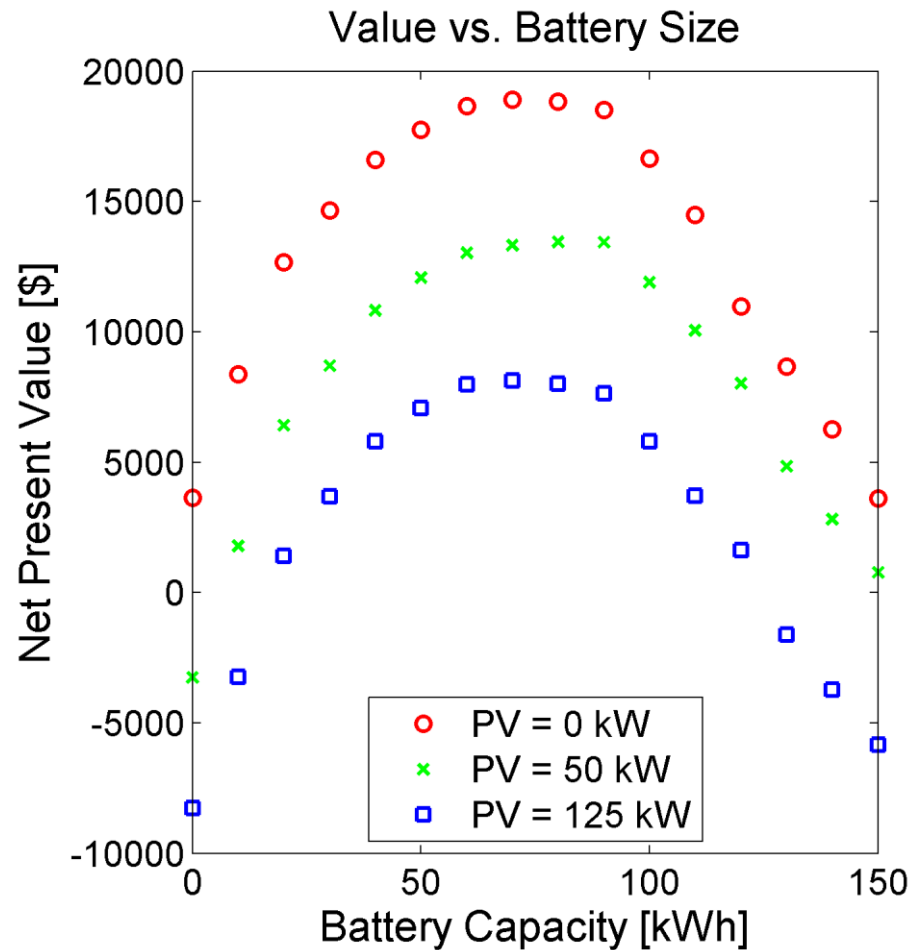
Property	Value
Capacity	6.4 kWh (100% DoD)
Power	3.3 kW
Efficiency	92%
Voltage	350 – 450 V
Current	9.8 A
Weight	97 kg
Dimensions	1300 mm x 860 mm x 180 mm
Warranty	10 years



Image from teslamotors.com/powerwall

SAM Demo

Example parametric sizing results

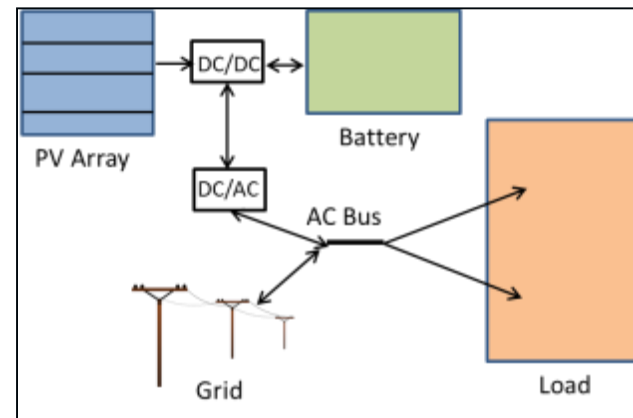


- NPV maximized for no PV system, battery bank capacity of 70 kWh
- Illustrates simulation-based method to approximate 'optimal' sizing.

Upcoming features

- Additional system configurations
- Additional battery chemistries
- Battery systems for PPA financial models
- Continued improvement of dispatch controllers
- Improved lifetime modeling for some battery chemistries

DC-connected battery



Flow batteries

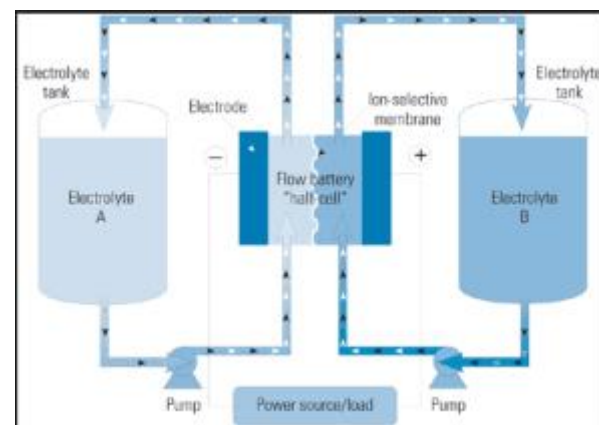


Image from tantaline.com

Questions?

- Website:
 - **sam.nrel.gov**
- Reports available
 - Economic Analysis Case Studies of Battery Energy Storage with SAM
 - **<http://www.nrel.gov/docs/fy16osti/64987.pdf>**
 - Technoeconomic Modeling of Battery Energy Storage in SAM
 - **<http://www.nrel.gov/docs/fy15osti/64641.pdf>**

Thank you!

www.nrel.gov

