Enphase AC Battery Parameters for NREL System Advisor Model (SAM)

Background

The National Renewable Energy Laboratory (NREL) System Advisor Model (SAM) is a performance and financial modeling tool that facilitates decision making for people involved in the renewable energy industry. SAM links solar energy resource models and a grid interactive battery model with detailed financial models. The battery model in SAM was validated against existing models as well as physical testing of off-the-shelf battery equipment.

At the time of writing, SAM does not contain a database of battery makes and models. This document provides information on the Enphase AC Battery (B280-1200-LL-I-US00-RF0) for sizing and financial modeling.

This document assumes general familiarity with PV modeling tools. For introductory how-to videos, visit: https://sam.nrel.gov/videos.

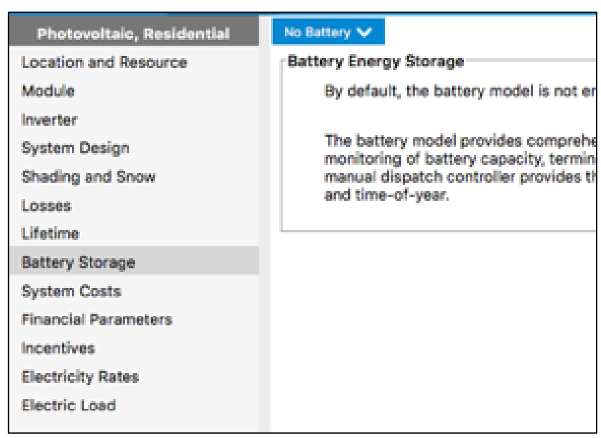
Download SAM and example file

Modeling the Enphase AC Battery requires SAM version 2017.1.17 or later. You can download SAM from: https://sam.nrel.gov/download.

You can download an example SAM file with defaults for the Enphase AC Battery from: http://enphase.com/sites/default/files/B280_1200_LL_example.sam.

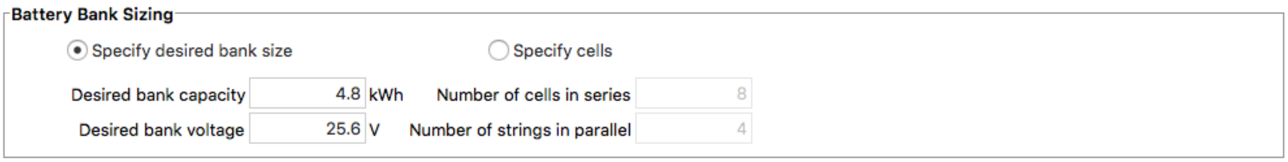
Defining AC Battery Characteristics

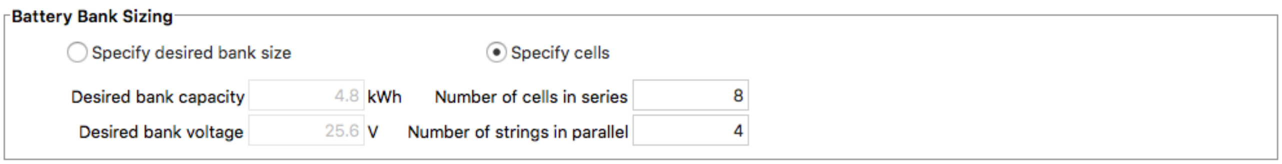
To enable the grid interactive battery model, select **Battery Storage** from the SAM left navigation menu and then select **enable battery** in the drop down menu. This displays the parameters and options to adjust.



Battery Bank Sizing

SAM uses the **Desired bank voltage** field in conjunction with **Desired bank capacity** to determine the number of battery cells in series and number of strings in parallel. The Enphase AC Battery scales from a single battery. Batteries must be specified in multiples of 1.2 kWh (for example, a system with four planned AC Batteries). First, multiply these four batteries by 1.2 kWh. Then, enter the amount, 4.8 kWh in the **Desired bank capacity field**. The AC Battery has eight internal cells in series with a nominal bank voltage of 25.6 V. This can be specified discretely by selecting **Specify cells**. When using this option, the number of strings in parallel will correspond with the number of AC batteries.





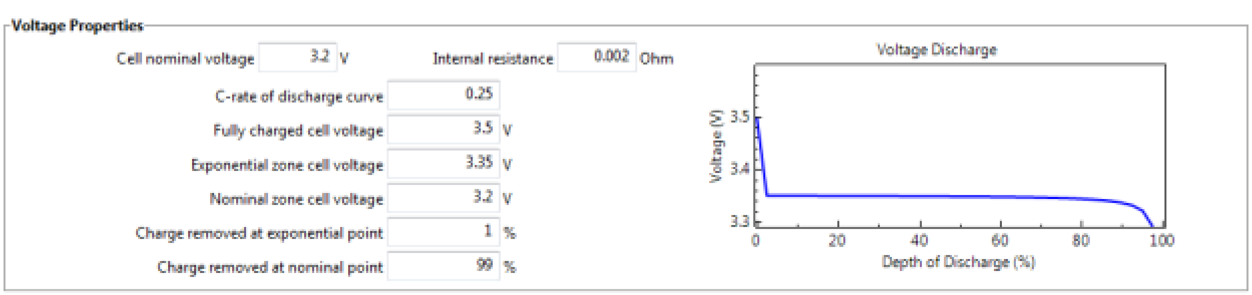
Chemistry

For the Battery type, select “Lithium Ion: Lithium Iron Phosphate (LFP)”.

Voltage Properties

Adjust the voltage properties of the cell to match the values in the following table:

Cell Nominal Voltage:	3.2 V
Internal Resistance:	0.002 Ohms
C-rate of discharge curve	0.25
Fully charged cell voltage	3.5 V
Exponential zone cell voltage	3.35 V
Nominal zone cell voltage	3.2 V
Charge removed at exponential point	1%
Charge removed at nominal point	99%



Current and Capacity

Adjust the properties to match the following values: .

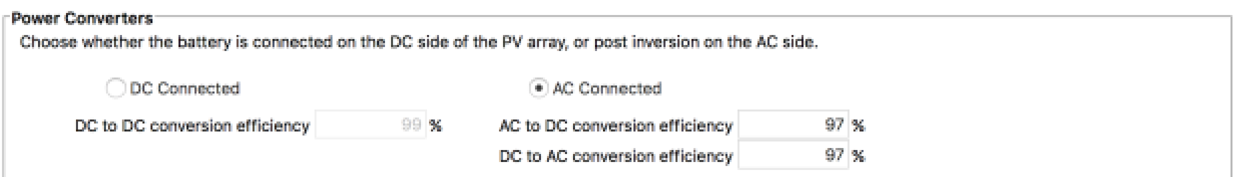
Cell capacity	48.5 Ah
Max C-rate charge/discharge	0.24 per/hour

SAM computes certain properties that cannot be edited directly. Note that these values may vary slightly from values found on the product data sheet. This does not significantly affect modeling performance.

Power Converters

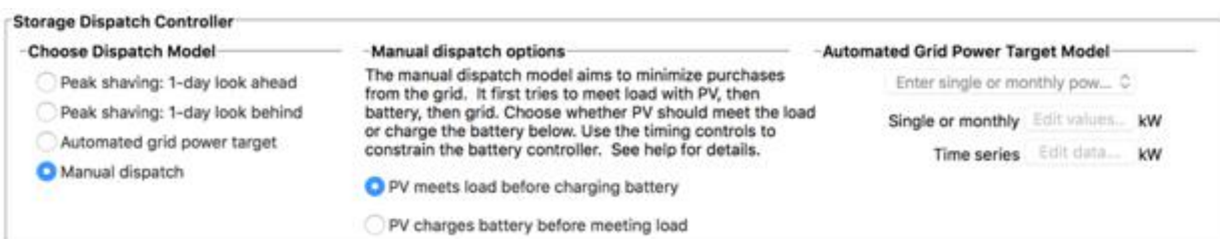
The Enphase AC Battery solution is coupled on the AC side of the PV inverter system. In SAM, this is referred to as **AC Connected**. Adjust the conversion efficiencies to the following values:

AC to DC conversion efficiency	97%
DC to AC conversion efficiency	97%



Storage Dispatch Controller

The Envoy S-Metered controls the AC Battery and dispatches based on the primary use case of the system, which is best modeled in SAM using the **Manual Dispatch** Model. Make sure to also select **PV meets load before charging battery**.



Charge Limits and Priority

Once the full capacity of the AC battery is reached, adjust these parameters as follows.

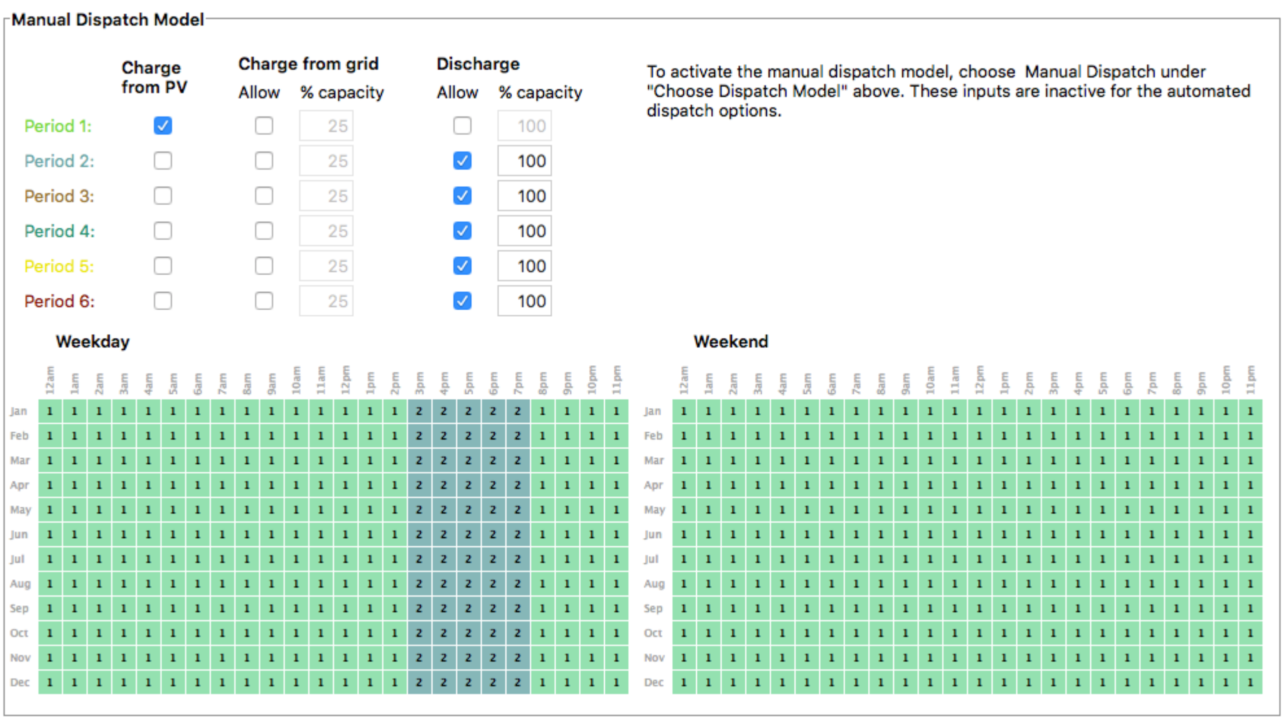
Minimum state of charge	0.001%
Maximum state of charge	100%
Minimum time at charge state	0.001 min

Manual Dispatch Model

The following section depicts the operating characteristics of a Manual Dispatch Model.

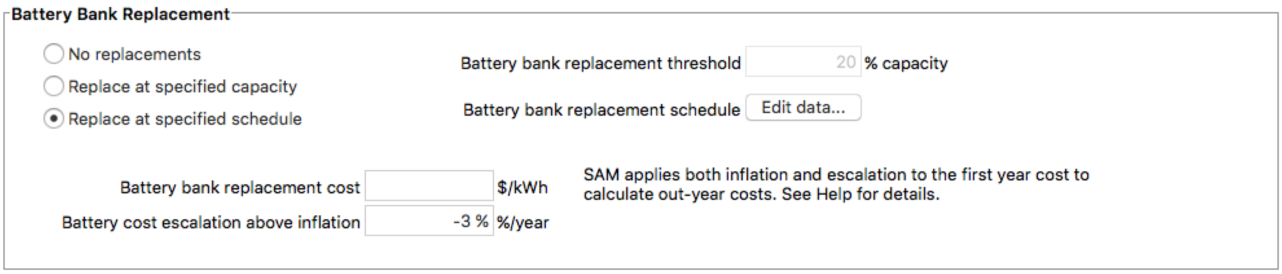
Batteries are a dispatchable resource, they can be charged and discharged on command. For modeling purposes, an algorithm must control the power dispatch behavior of the battery. The manual dispatch controller does not know about electricity rates and periods of charge, so discharge must be manually defined to match the desired behavior for the appropriate tariff. The dispatch scheme shown responds to a Time of Use (TOU) tariff that has a more expensive electric rate from 3-8 PM on weekdays. During the less expensive Period 1, the battery is allowed to charge from PV, but not allowed to discharge. During the more expensive Period 2, the battery is allowed to discharge 100 percent of capacity.

To quickly customize the dispatch settings, select a range of hours and months then enter the number corresponding to the appropriate period.



Battery Bank Replacement

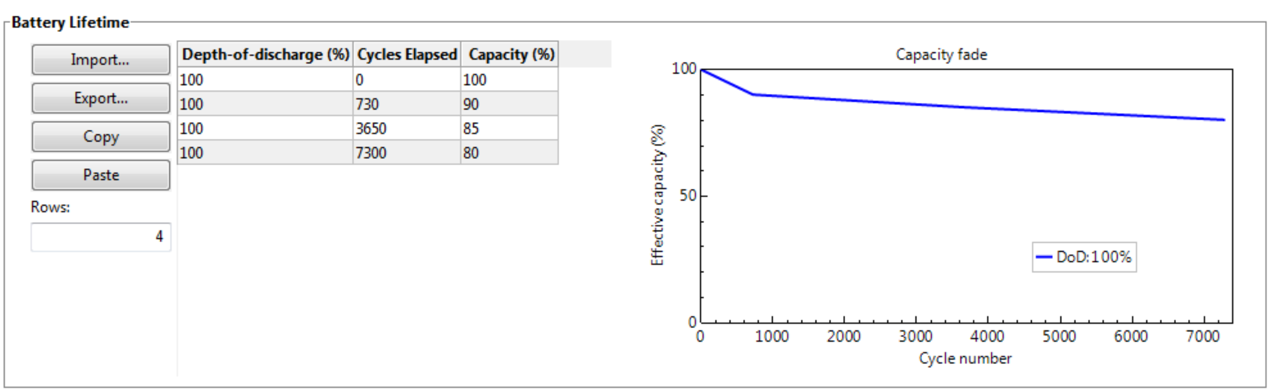
SAM allows the model to include a replacement for the battery bank at a capacity or time schedule. The replacement costs can be specified as well.



Battery Lifetime

SAM considers battery cycling to be the primary cause of battery degradation. Four rows of data that correspond with the warranty parameters of the Enphase AC Battery are sufficient for economic modeling purposes.

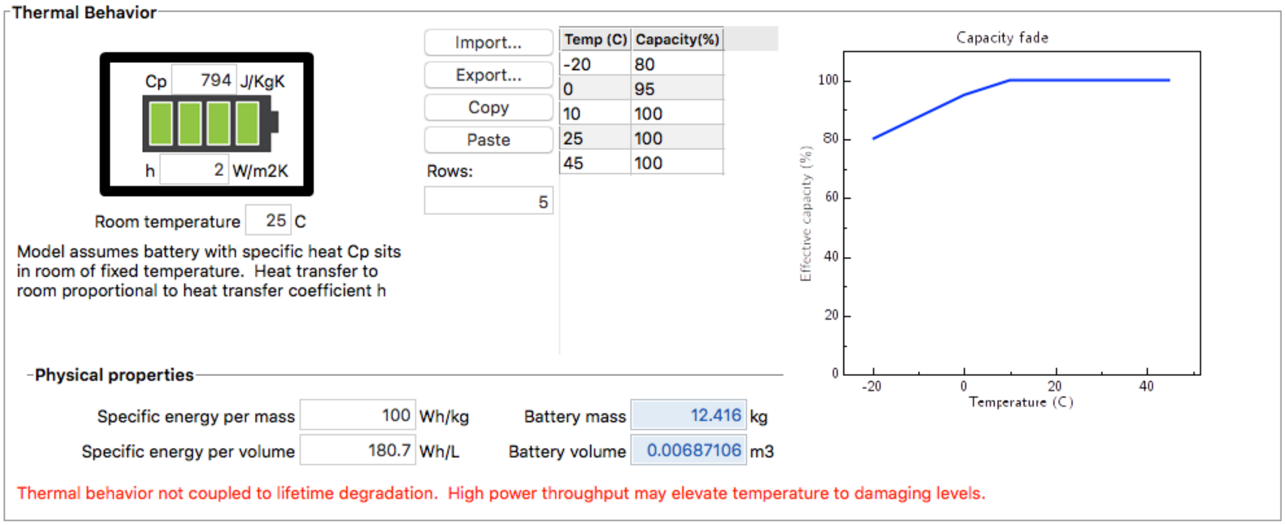
Depth-of-discharge (%)	Cycles Elapsed	Capacity (%)
100	0	100
100	730	90
100	3650	85
100	7300	80



Thermal Behavior

Capacity is affected by the thermal environment of the AC Battery location. The following table lists the available capacity of the AC Battery at various ambient temperatures.

Temp (C)	Capacity (%)
-20	80
0	95
10	100
25	100
45	100



Further Resources

All images of NREL SAM used with permission.

NREL SAM includes detailed help files. Additional information can be found in:

Diorio, N., Dobos, A., Janzou, S., Nelson, A., & Lundstrom, B. (2015). Technoeconomic Modeling of Battery Energy Storage in SAM Technoeconomic Modeling of Battery Energy Storage in SAM, (September). Retrieved from http://www.nrel.gov/docs/fy15osti/64641.pdf.

