Modeling Photovoltaic Module-Level Power Electronics in the System Advisor Model

Module-level power electronics-- such as DC power optimizers, microinverters, and those found in AC modules-- are increasing in popularity in smaller-scale photovoltaic (PV) systems as their prices continue to decline. Therefore, it is important to provide PV modelers with guidelines about how to model these distributed power electronics appropriately in PV modeling software. This paper extends the work completed at NREL that provided recommendations to model the performance of distributed power electronics in NREL's popular PVWatts calculator [1], to provide similar guidelines for modeling these technologies in NREL's more complex System Advisor Model (SAM) versions 2015.6.30 and later.

New Loss Input

In order to allow additional granularity in the loss assumptions for power electronics-- specifically DC power optimizers-- versus string inverters, we added a new loss input, "DC power optimizer loss" (see Figure 1). This loss contributes to the Total DC power loss, but is constrained to be the same for all four subarrays since SAM currently requires that all four subarrays in a single case use the same inverter technology. Note that multiple inverter technologies for a single project can be modeled by setting up two separate cases and using the "Combine Cases" macro added in the 2015.1.30 release of SAM.

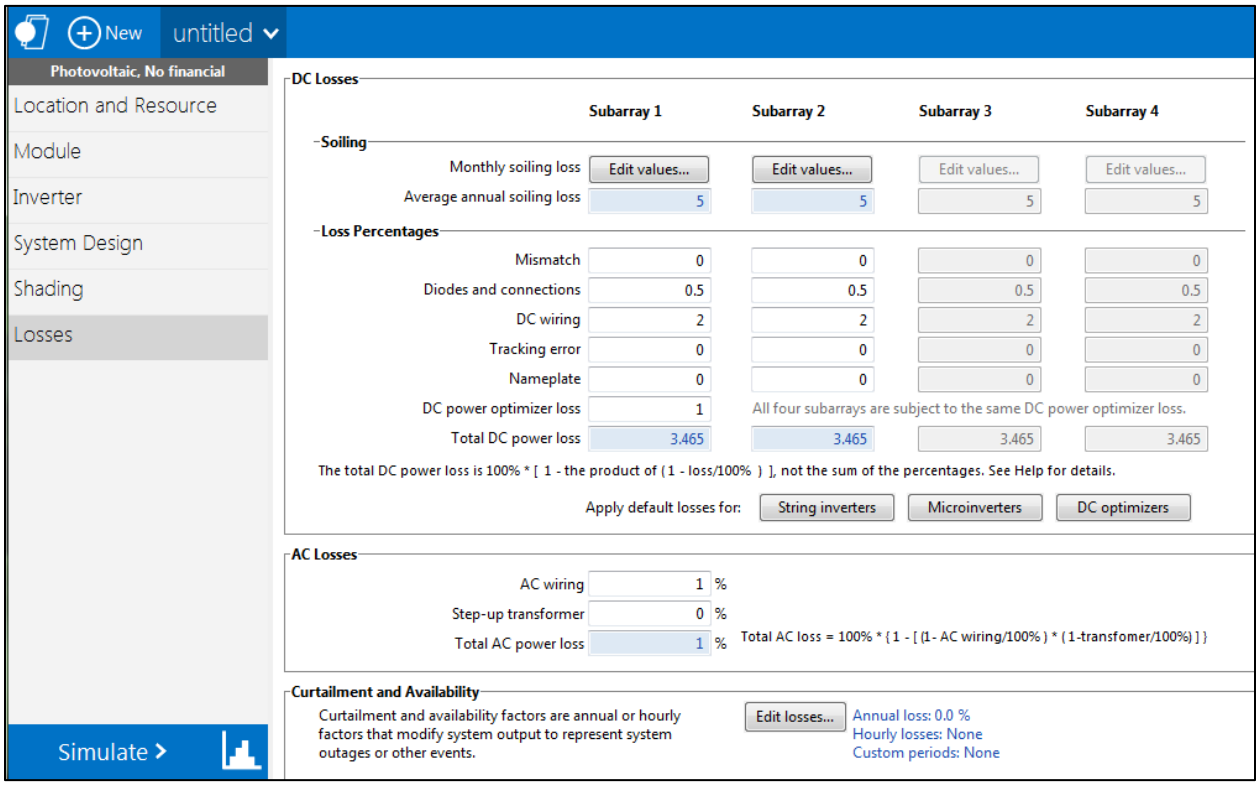

Figure 1. New DC power optimizer loss input in SAM

The new loss input in the user interface corresponds to a new input to the SAM Simulation Core (SSC) compute module pvsamv1 called "dcoptimizer_loss". This input is required for software development kit (SDK) users running the pvsamv1 compute module.

Recommended Loss Assumptions

A prior NREL whitepaper [1] develops a comprehensive list of recommended loss assumptions for modeling distributed power electronics in PVWatts. Examination of these recommendations and the underlying photovoltaic models in SAM [2] demonstrates that similar assumptions can be applied to the System Advisor Model to more accurately represent the behavior of module-level power electronics, without the addition of new loss factors. Table 1 summarizes the way that these recommendations can be applied in SAM. Shaded cells highlight values that differ from SAM default losses, which assumes string inverters.

Table 1. Default SAM Losses for String Inverters Compared to Recommended Losses for Module-Level Power Electronics (Differences Highlighted)

Loss	SAM Default (String Inverters)	Microinverter/AC Module Recommendation	DC Optimizer Recommendation
Mismatch	2%	0%	0%
Diodes & connections	0.5%	0.5%	0.5%
DC wiring	2%	2%	2%
Tracking error	0%	0%	0%
Nameplate	0%	0%	0%
DC power optimizer	0%	0%	1%*
AC wiring	1%	1%	1%
Step-up transformer	0%	0%	0%
Availability	0%	0%	0%
Shading	Modeled explicitly in SAM (see below)**		

* A loss of 1% assumes newer DC power optimizer technology. If the DC power optimizer being modeled was manufactured prior to 2012, this loss should be increased to 2.5% [1]. This new DC power optimizer loss accounts for the additional efficiency loss due to the introduction of DC power electronics into a system. See [1] for further detail.

**Note that shading losses are not specified in this table. SAM, unlike PVWatts, models shading explicitly or accepts pre-calculated loss factors, negating the need for a modified loss assumption. However, any shading losses that are input into SAM should be decreased according to the guidelines in [1] if module-level power electronics are used.

Implementation in SAM

To facilitate ease of applying the correct loss assumptions for string inverters, microinverters, and DC optimizers in SAM, we added three buttons to the "Losses" page that will apply the default losses shown in Table 1 for string inverters, microinverters/AC modules, and DC power optimizers. These buttons are shown in Figure 2.

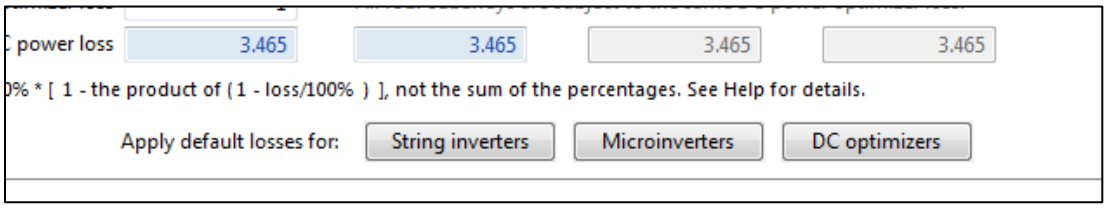

Figure 2. Close-up of the three new buttons to apply default losses for various inverter technologies

References

[1] MacAlpine, S. and Deline, C. Modeling Microinverters and DC Power Optimizers in PVWatts. NREL Technical Report NREL/TP-5J00-63463, January 2015.
[2] Gilman, P. SAM Photovoltaic Model Technical Reference. NREL Technical Report (Forthcoming). April 2015.

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