Mismatch Calculations in HelioScope

HelioScope is the only program on the market that rigorously calculates the system performance of solar arrays – which includes calculating mismatch losses. This application note details the mismatch calculations, with a particular focus on the baseline mismatch assumptions.

What are Mismatch Losses

Mismatch losses in HelioScope are not user-defined de-rates. Instead, the mismatch losses are calculated based on comparing the sum of each module's max potential power versus the actual system power based on series & parallel circuit constraints.

There are three sources of mismatch in HelioScope:

1) Shading losses, from obstructions or row-to-row shading
2) Orientation differences between modules in the same circuit (this is rare)
3) Baseline mismatch, variables that create mismatch between modules by imposing statistical differences between the modules' operating conditions. These are the focus of this application note, and include:
   a) Irradiance variation (i.e. differences in sunlight)
   b) Temperature differences
   c) Module nameplate power differences (i.e. module binning)

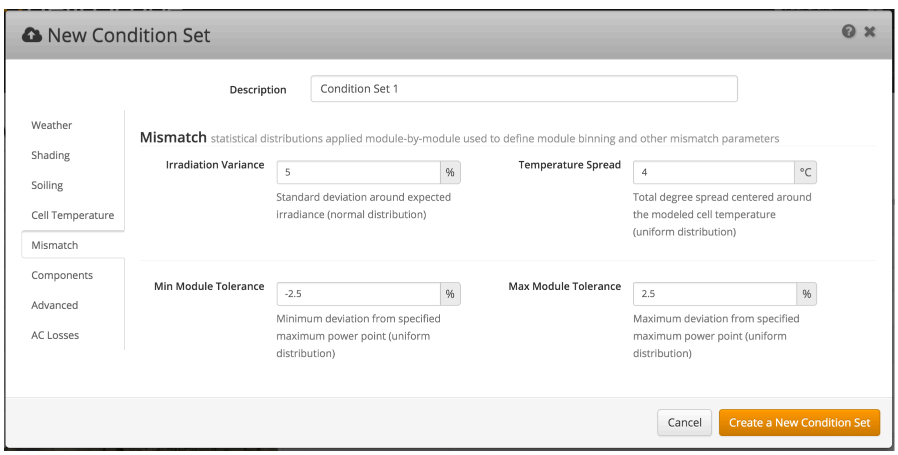

Figure 1: Mismatch inputs for HelioScope

The three mismatch variables can be summarized in the table below:

Parameter	Description	Conceptual Causes	Distribution
Irradiation Variance	Differences in sunlight between modules	• Variable soiling • Vegetation between modules • Partial cloud cover	Normal distribution
Temperature Spread	Differences in operating temperature between modules	• Air flow across array	Uniform distribution
Module Tolerance	Differences in module nameplate power. Specifically, this is applied as differences in current	• Manufacturing binning range	Uniform distribution

All of these attributes are applied statistically across the array: each module is randomly sampled from each of the defined ranges – and that module will then have those deltas (in irradiance, temperature, and nameplate power) applied for all calculations each hour.

Effects of Mismatch Variables

The baseline mismatch values were chosen in order to generate mismatch values of approximately 2%, as many other solar modeling tools have similar mismatch default losses. However, the actual losses will depend slightly based on the module chosen (in general, lower fill-factor modules have lower mismatch losses), and the string length (shorter strings have slightly lower mismatch losses). This also has the added benefit of automatically showing performance benefits for module-level power electronics (i.e. microinverters or optimizers).

This can be seen in the sensitivity analysis below. By varying the module or string length[1] (keeping the mismatch variables constant), we can see slight differences in the mismatch losses:

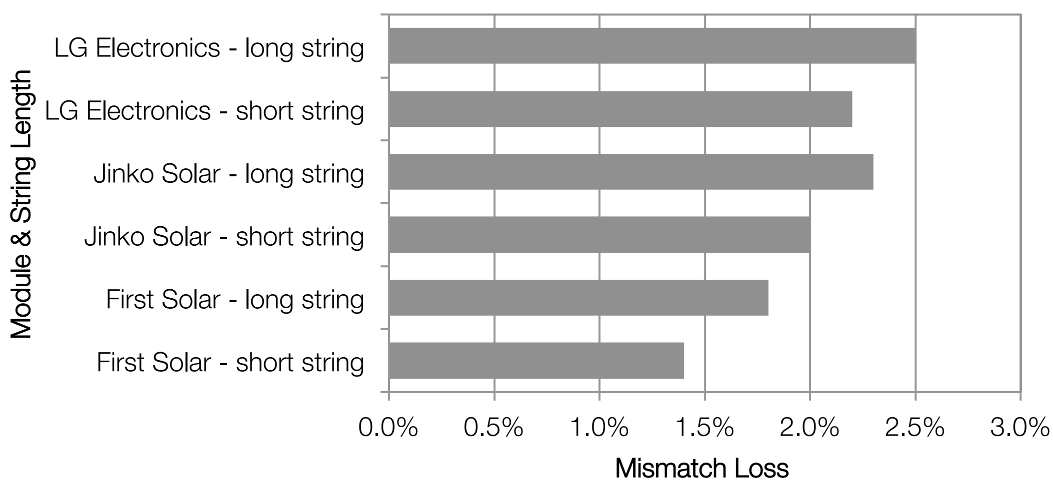

Figure 2: Impact of System Design on Mismatch Losses

We can also run sensitivity analyses to understand the relative impact of the mismatch parameters. Irradiance variation has the largest impact on mismatch, accounting for the vast majority of mismatch losses (evidenced by the fact that overall mismatch losses go to almost zero if irradiation variance goes to zero):

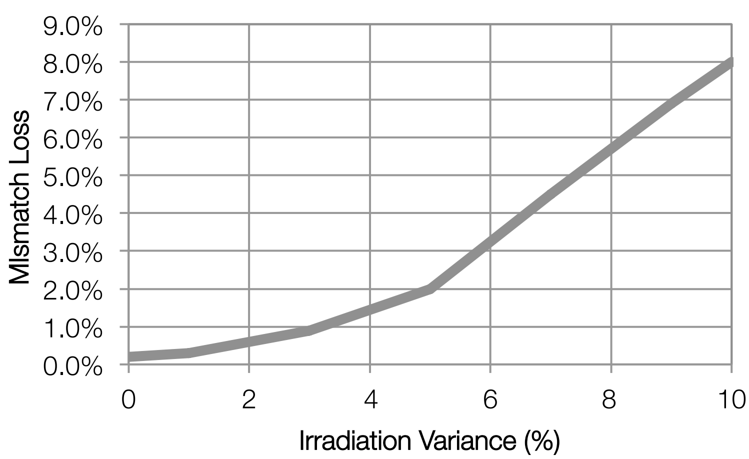

Figure 3: Mismatch Sensitivity to Irradiation Variance

[1] "Short" strings are based on a 600V target, while "long" strings are based on a 1,000V target.

The binning losses have a far smaller impact on the mismatch losses, but we can still see a modest (~0.2%) difference in mismatch based on module binning range:

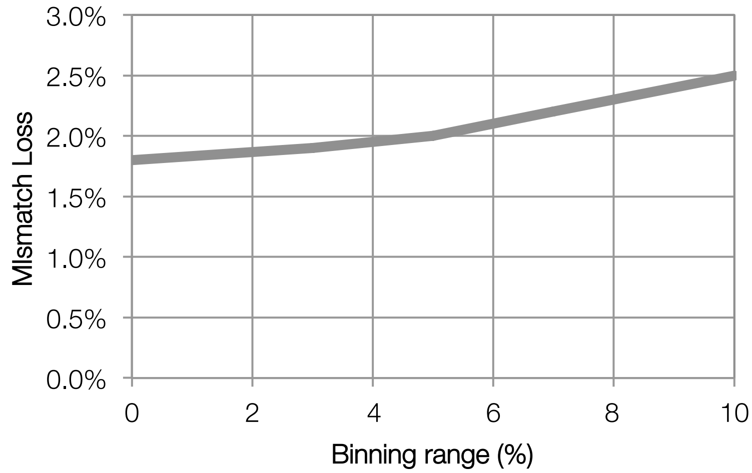

Figure 4: Mismatch Sensitivity to Module Binning Range

The temperature range, on the other hand, has almost no impact on the overall mismatch losses (though this may be remedied in the future with more sophisticated methods for applying temperature gradients).

Ultimately, we can overlay the sensitivity curves on top of each other to see that the irradiation variance accounts for approximately 90% of the baseline mismatch losses in HelioScope simulations:

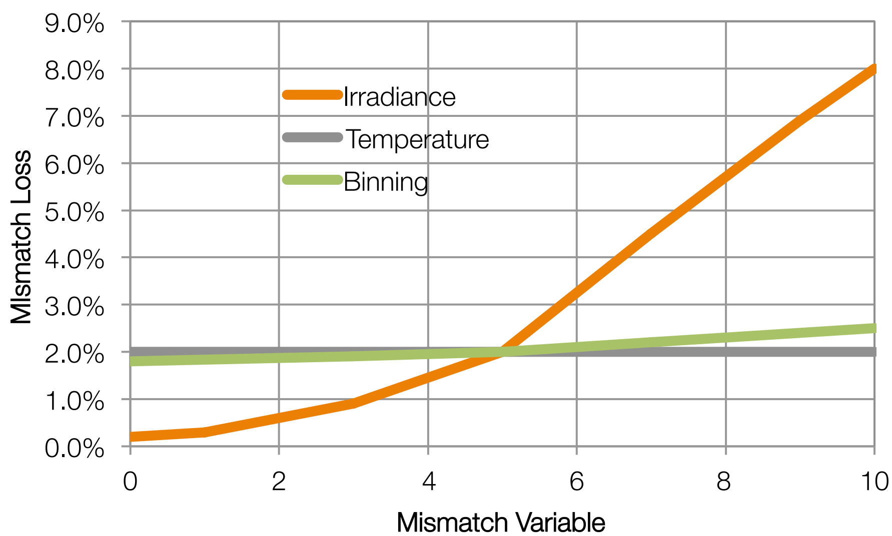

Figure 5: Mismatch Sensitivity to Irradiation Variance