

Agrivoltaic Simulation User Guide

A. Tool Overview

The Agrivoltaic Simulation tool uses a graphical user interface (GUI) developed through Rappature, a toolkit supporting **Rapid application infrastructure** on the nanoHUB working space [2]. It operates by inputting solar panel parameters, its electrical characteristics, geometries and patterns to output radiation shadow maps, list of outputs, with power and radiation plots.

The tool consists of three input pages, which covers the simulation mode, solar panel parameters, and the time-location settings, respectively. The simulation mode is planned to provide different approaches in the second page inputs. The second page, where solar panel parameters are input, will be where the type of tracking, patterning, electrical parameters and more detailed system parameters are input. The third page then inputs the time range, whether single-day or over a few months, the desired date, and a choice of location.

B. Mode Selection

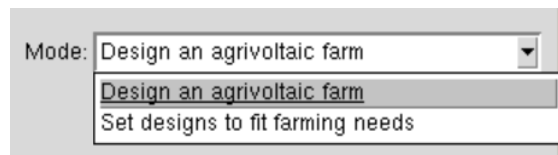


Figure 1-Simulation mode selection

In this first page, select whether to ‘design an agrivoltaic farm’ or ‘set designs to fit farming needs’, which will design a system according to a present farm’s constraints (This second mode is still planned for development as of August 9, 2019).

C. Solar Panel System Parameter Input

At this second page, fill in the desired choices and values for solar panel dimensions, pattern, and electrical parameters. Currently the edge effect function is also under development.

The figure displays two side-by-side screenshots of a software interface titled "Design an agrivoltaic farm". Both screenshots show the same set of parameters, but with different selections for the "Mode" parameter. In the left screenshot, "Single-axis Tracking" is selected and circled in blue. In the right screenshot, "Fixed-tilt" is selected and circled in blue. Other parameters are identical in both: "Edge Effects" is set to "no", "Number of Panels" is 1, "Panel Tilt" is 40deg, "Pattern" is Checkerboard, "Center Position" X is 4m and Y is 3m, "Length" is 4m, "Width" is 1m, "Height" is 4m, "E-W Period" is 6, and "N-S Period" is 8. At the bottom of each window are buttons for "< Agrivoltaic Simulation" and "Date and Location >".

Parameter	Left Screenshot	Right Screenshot
Mode	Single-axis Tracking	Fixed-tilt
Panel Tilt	40deg	40deg
Pattern	Checkerboard	Checkerboard
Center Position X (m)	4	4
Center Position Y (m)	3	3
Length	4m	4m
Width	1m	1m
Height	4m	4m
E-W Period	6	6
N-S Period	8	8

Figure 2-Solar panel parameter input page (Single-axis tracking vs. Fixed-tilt)

Y (m): 3

Length: 4m
Width: 1m
Height: 4m
E-W Period: 6
N-S Period: 6

Checkerboard Pattern Parameters

East-West segments: 1
North-South segments: 1

Electrical Parameters

Open circuit voltage: 0.7V
Short circuit current: 30mA/cm²
Fill Factor: 0.8

Backtracking: yes

Tracker Range: 90deg

< Agrivoltaic Simulation Date and Location >

Here, center position (X and Y) is the center point of the panel system being simulated. Length, width and height are the dimensions of the panel system being setup. E-W and N-S period is represents the size of the plot of land being simulated.

In the Pattern Parameter sections, it defines the segment numbers on the system, defining the number of the checkerboard's alternating rectangular panel segments for both East-West and North-South directions.

Backtracking is a form of optimization that would minimize shading between nearby panels.

Figure 3-Lower half section of second input page

Stripes Pattern Parameters

Number of Stripes: 2
Module Width: 0.3m
Gap Width: 0.3m

Figure 4-Stripes Pattern Parameters

At the stripes pattern parameter input, there will be an option to set the number of stripes (under development) for the landscape stripes pattern. This parameter section also accounts for the width of the module and gap between modules for the stripes pattern.

D. Date and Location Settings

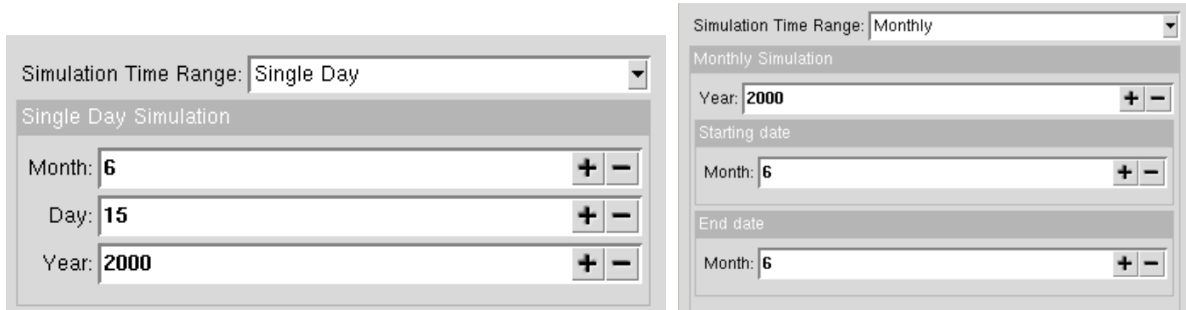


Figure 5-Comparison between ‘Single Day’ and ‘Monthly’ simulation time range

At this point, input the desired date range or date, for a single day simulation as seen in Figure 5. A single day simulation would select a desired date and only calculate for the date selected. The monthly simulation (under development) covers representative parameters where it picks the 15th of every month within the range of the simulation. In this example with default parameters in Figure 6, will be a section for when a different location is desired. Otherwise, this walkthrough guide will use the default location at ‘West Lafayette, IN’ seen in Figure 7.

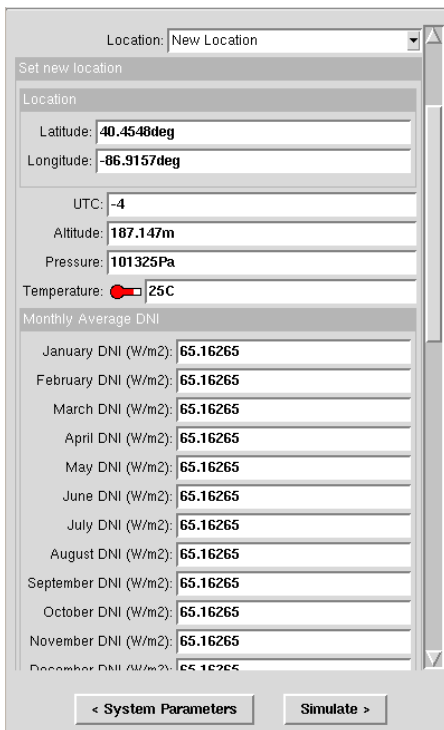


Figure 6-New location input parameters



Figure 7-Default date and location

E. Output Data

The simulation tool will take the inputs obtained from the three input pages and output into contour shadow maps, raw output variable data, power spatial density curves and irradiance models. Using the default input parameters shown in the previous steps, except for the differences in the panel tilt's mode, we will obtain 2 outputs for comparison.

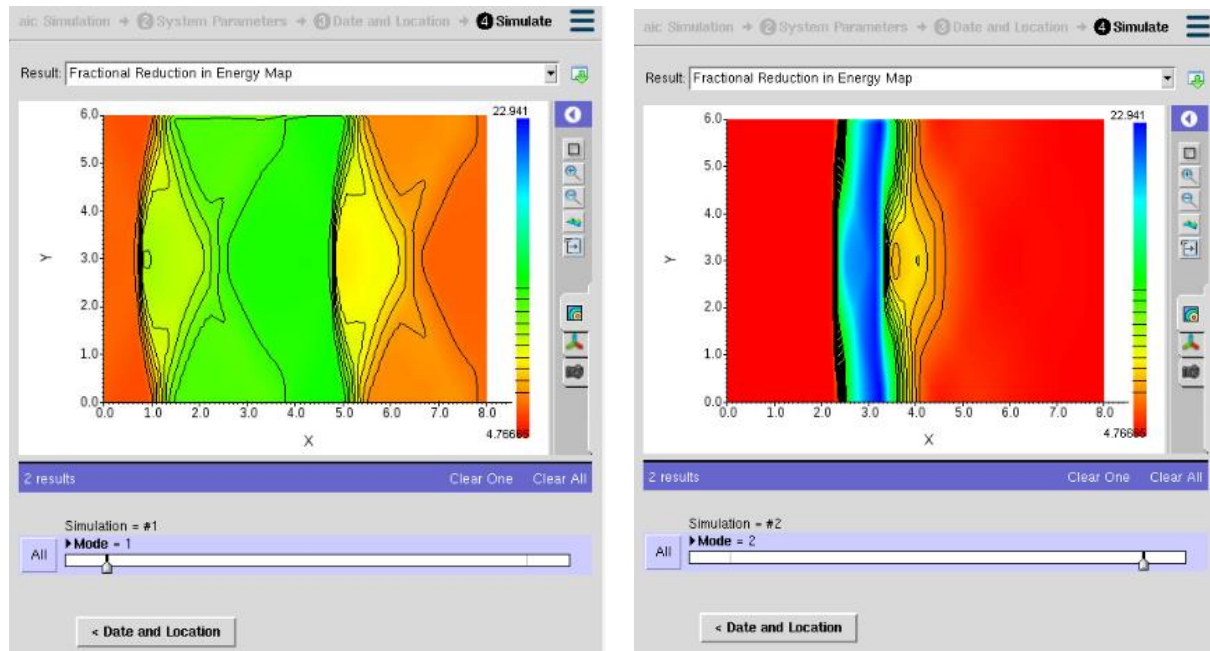


Figure 8-Shadow map output comparison for single-axis tracking(left) and fixed-tilt at 40°(right)

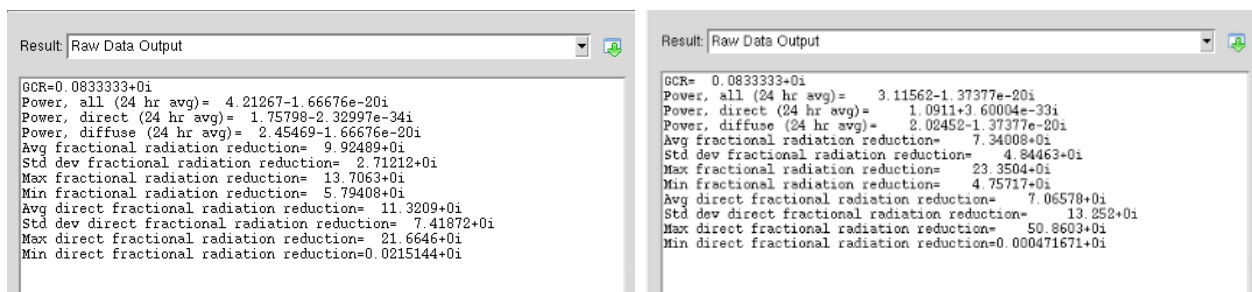


Figure 9-Raw Data output comparisons for single-axis tracking(left) and fixed-tilt at 40°(right)

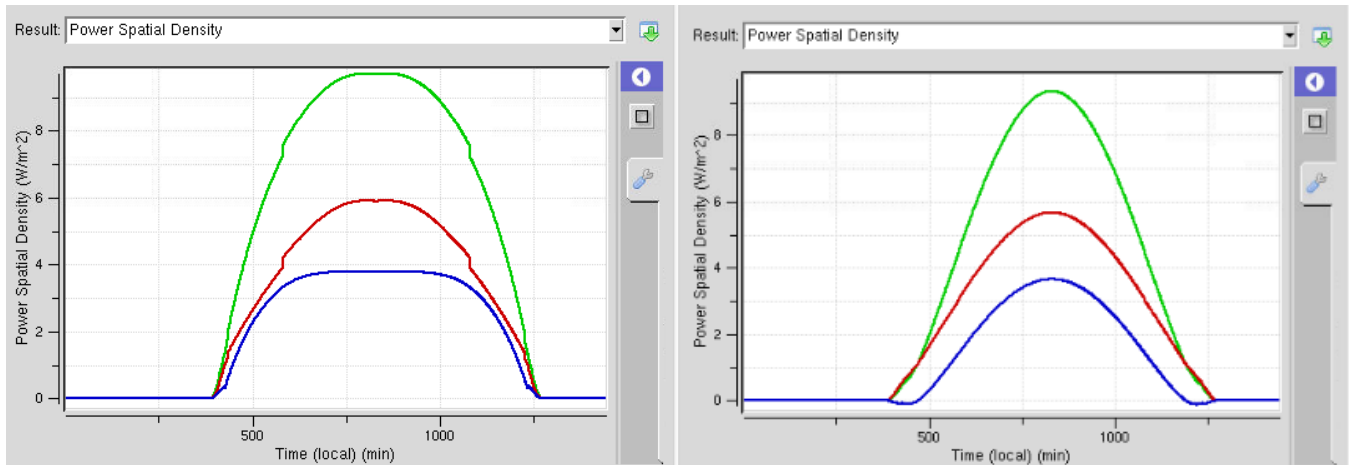


Figure 10-Power Spatial Density multi-line plot for a single day for single-axis tracking(left) and fixed-tilt at 40°(right)

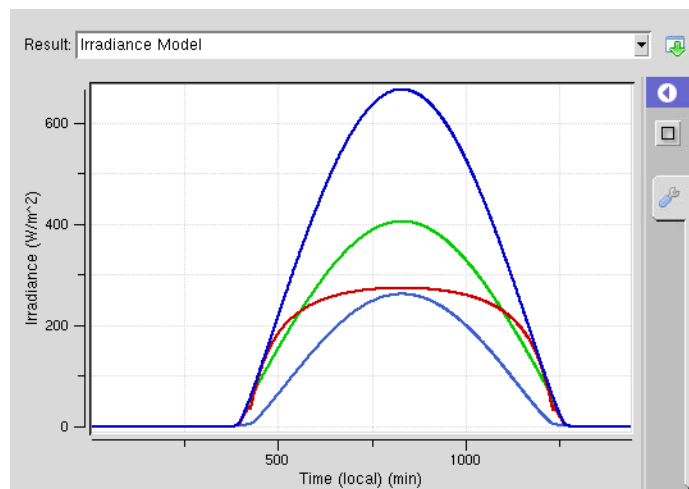


Figure 11-Irradiance Model for a single day simulation for single-axis tracking and fixed-tilt at 40° on June 15, 2000

Hans Torsina, Allison Perna, Peter Bermel

School of Electrical and Computer Engineering, Purdue University

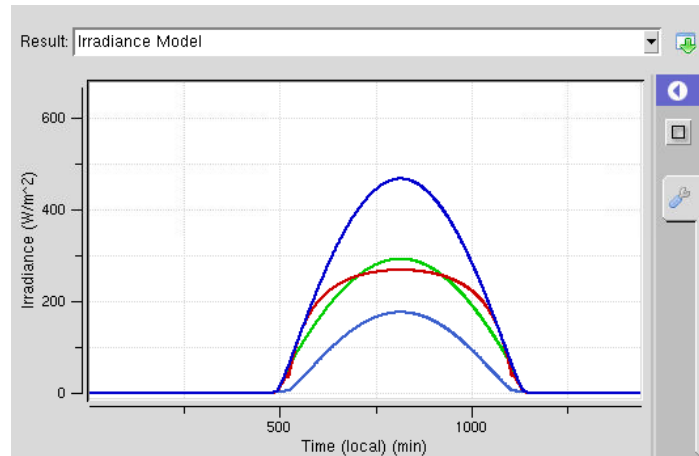


Figure 12-Irradiance Model for a single day simulation for single-axis tracking and fixed-tilt at 40° on October 15, 2018

The irradiance model would be the same day due to both simulations being done for the same date. For a different date such as in October 15 at Figure 12, the peaks of the irradiance model would be lower than for June seen at Figure 11.

These 4 types of outputs conclude the walkthrough guide of the tool with comparisons between a fixed-tilt system and single-axis tracking system.