TRIFACTORS

Global description of TriFactors Software:

CEA is developing a simulation tool, TriFactors, to assess the performance of photovoltaic power plants, with particular emphasis on bifacial systems. It is implemented in Matlab.

This tool consists of two parts. Firstly, an optical model estimates the irradiance reaching the solar panel based on weather data and a scene definition. The description of the reflected irradiance in the simulation is based on 3D view factors. Secondly, an electrical model estimates the conversion of solar energy into electrical energy, taking into account mismatch effects, through the generation of IV curves.

The steps of the optical part is divided as follows:

1) Scene definition (number of rows and columns of modules, tilt, azimuth).
2) Creation of a ground mesh.
3) Calculation of all the view factors.

Then, for each time step:

1) Estimation of the shadows on the ground and on the modules.
2) Calculation of the diffuse irradiance from the sky using transposition models (Perez, Hay, etc.).
3) Reconstruction of the irradiance on the modules based on direct, diffuse, and reflected contributions.

Description of Trifactors Input Data:

Before starting a simulation, it is required to complete an Excel document to define the main parameters.

This file contains a description of the module, the system and the location of the plant. The file also contains simulation parameters like the meshing granularity and other parameters for the thermal and electric models.

	A	B	C	D	E
1					
2		getParamPlantSpec_Bifa			
3					
4	Configuration of the system	Distance between two rows	6	m	/!\
5		Distance between two columns	0,75	m	
6		Height of the modules	2	m	Static Mode : Minimum height - Tracking Mode : Height of the static point of the module
7		Tilt of the modules	30	°	
8		Azimuth of the modules	0	°	-90° East / 0° South
9		Landscape or portrait	Landscape		Landscape or Portrait
10		Number of modules horizontally per block	5		
11		Number of modules vertically per block	2		
12	Module	Length	1,69	m	
13		Width	1,01	m	
14		Number of bypass diodes	3		
15		IAM model	ashrae		(for now "ashrae" or "measures")
16		Parameter "b" of the IAM Ashrae Model or measures xls file nan	0,05		between 0 and 1 or xlsx filename
17	View Factors	Dist_Max	5	m	See documentation
18		Algo	Matt	"Matt" or "Lauzier"	
19	Meshing	Number of spatial ground periods along x-axis	5		
20		Number of spatial ground periods along y-axis	5		
21		Number of ground mesh elements along x-axis per period	5		
22		Number of ground mesh elements along y-axis per period	6		
23		Number of parallel divisions by bypass	2		
24		Number of perpendicular divisions	10		
25		display VF Figures	1		
26					

Description of the scene : module & system

Accuracy of the simulation : meshing and cell analysis

Figure 1 – Example of input parameter file sheet #1

	A	B	C	D	E
1					
2		get ParamSimu_Bifa			
3					
4	Location	latitude	45,64	°	
5		longitude	5,88	°	
6		altitude	235	m	
7		Horizon line filename	HorizonLine.xlsx		
8		Surroundings Albedo	0,2	Numerical value or csv/xlsx file	
9		Near ground Albedo	0,4	Numerical value or csv/xlsx file	
10	Time	timeStart	07/12/2021 04:00	dd/mm/yyyy hh:MM:ss	
11		timeEnd	12/12/2021 03:55	dd/mm/yyyy hh:MM:ss	
12		timeStep	5	minutes	
13	Meteo	Meteo (Gh, or Dh + Bh - W/m²)	irradiance_incas_12_21.mat		
14		Tamb (°C)	temperature_incas_12_21.mat		
15		Time label definition	0	0 if it's the beginning of the interval, 1 if it's the middle, 2 if it's the end	
16		TLAM2	2,5	For Clear Sky model, if no irradiance are informed	
17		Decomposition Model	Perez		
18	System configuration	Number of block per column (i.e Number of rows)	3		
19		Number of blocks per rows (i.e. Number of columns)	3		
20	Module	Number of cells per module	60		
21		Ideality factor (supposition according the technology)	1,3		
22		Opacity	100	%	100% : no light passing through - 0% No solar cells (i.e. just glass)
23		Thermal model	Linear	"NOCT" or "Linear"	
24		Alpha	0,015829	See documentation the thermal model	
25		Beta	-3,25763	See documentation the thermal model	
26		Coefficient temperature Isc	0,044	%/°C	
27		Coefficient temperature Voc	-0,31	%/°C	
28		Coefficient temperature Pmpp	-0,41	%/°C	
29		Name of the flash tests file	BIPPP028_Update.mat		
30		Bypass voltage	-0,7	V	
31		Monofacial module	0	0 or 1	
32		Incident Irradiances only	0	0 or 1	
33		IVOptimisation	1	0 or 1	
34		Precision of the IV curve	1,00E-03	A	1e-3 : mA, 1e-6 µA ....
35		Precision of the irradiance	5	W/m²	
36		Precision of the temperature	0,5	°C	
37		display Top View of the System	0	A figure by simulation	
38		display Optimised 3 Points Figures	0	A figure by simulation (if bifacial only)	
39		display Time Shift	0	A figure by simulation	

Main Parameters | getParamPlantSpec | **getParamSimu**

Information on system environment

Input data

Parameters for thermal and electrical modeling

Figure 2 – Example of input parameter file sheet #2

In addition, four additional input parameter files have to be provided:

I) The horizon line (optional). If not provided, we assume no horizon line.

II) Meteorological data: GHI (needed), DHI/BHI (optional)

III) Ambient temperature (needed for thermal/electrical result)

IV) Flash test information (needed for electrical result)

Description of Trifactors Output Data:

The output of a simulation is made of several Excel files including, for each time step, the following information:

a) Irradiance on both rear and front faces
b) Module temperature
c) DC power, current and voltage

UT	IrraFrontCel	IrraFrontCel	IrraFrontCel	IrraRearCell	IrraRearCell	IrraRearCell	IrraFrontMo	IrraFrontMo	IrraFr
01/01/2021 00:30	0	0	0	0	0	0	0	0	
01/01/2021 01:30	0	0	0	0	0	0	0	0	
01/01/2021 02:30	0	0	0	0	0	0	0	0	
01/01/2021 03:30	0	0	0	0	0	0	0	0	
01/01/2021 04:30	0	0	0	0	0	0	0	0	
01/01/2021 05:30	0	0	0	0	0	0	0	0	
01/01/2021 06:30	0	0	0	0	0	0	0	0	
01/01/2021 07:30	0	0	0	0	0	0	0	0	
01/01/2021 08:30	374.1100084	81.0432857	309.4950796	21.4462338	16.1671267	18.6132735	380.0276358	81.1697247	314.0
01/01/2021 09:30	434.1399236	426.3995768	429.2379659	40.4631065	33.8895046	35.0110729	449.1378233	441.2317255	444.1
01/01/2021 10:30	281.9350708	275.7597189	278.5592976	55.8063634	44.4101912	45.7423436	303.1355428	296.6750352	299.6
01/01/2021 11:30	117.5435307	110.9189664	113.8727968	71.0557155	63.4504590	65.3179876	141.5790971	134.6413071	137.8
01/01/2021 12:30	64.2160798	56.3756472	59.0916054	130.930779	123.840902	127.051869	65.5093886	57.1486975	60.13
01/01/2021 13:30	62.0379679	48.9017108	51.4503247	269.352398	263.551773	266.135965	63.0534654	49.4365418	51.98
01/01/2021 14:30	41.0354850	34.8307867	35.8711037	424.618401	411.196783	417.604651	41.8617479	35.5140852	36.57
01/01/2021 15:30	20.9868115	16.7703136	18.6411381	314.965989	81.1928024	162.709787	21.2922774	16.8944306	18.83
01/01/2021 16:30	0	0	0	0	0	0	0	0	
01/01/2021 17:30	0	0	0	0	0	0	0	0	
01/01/2021 18:30	0	0	0	0	0	0	0	0	

Figure 3 – Example of output

Application to a real case PV-plant:

The description of the scene by Trifactors allows only the simulation with a rectangular-shape PV-plant. In order to estimate the production of any specific large power plant, the tool uses a block representation. Initially, it estimates the production for a smaller-scale power plant (e.g., 3x3 block arrangement). Then, this result is extrapolated to the scale of a large power plant, taking into account the number of modules at the different borders of the plant.

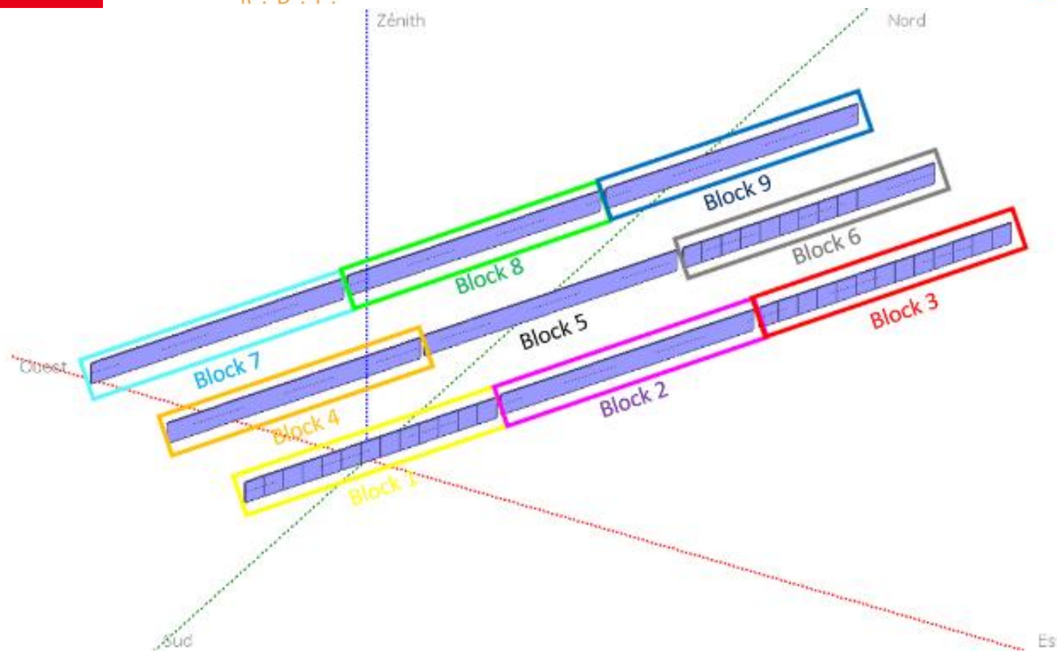

Figure 4 – small scale 3x3 arrangement

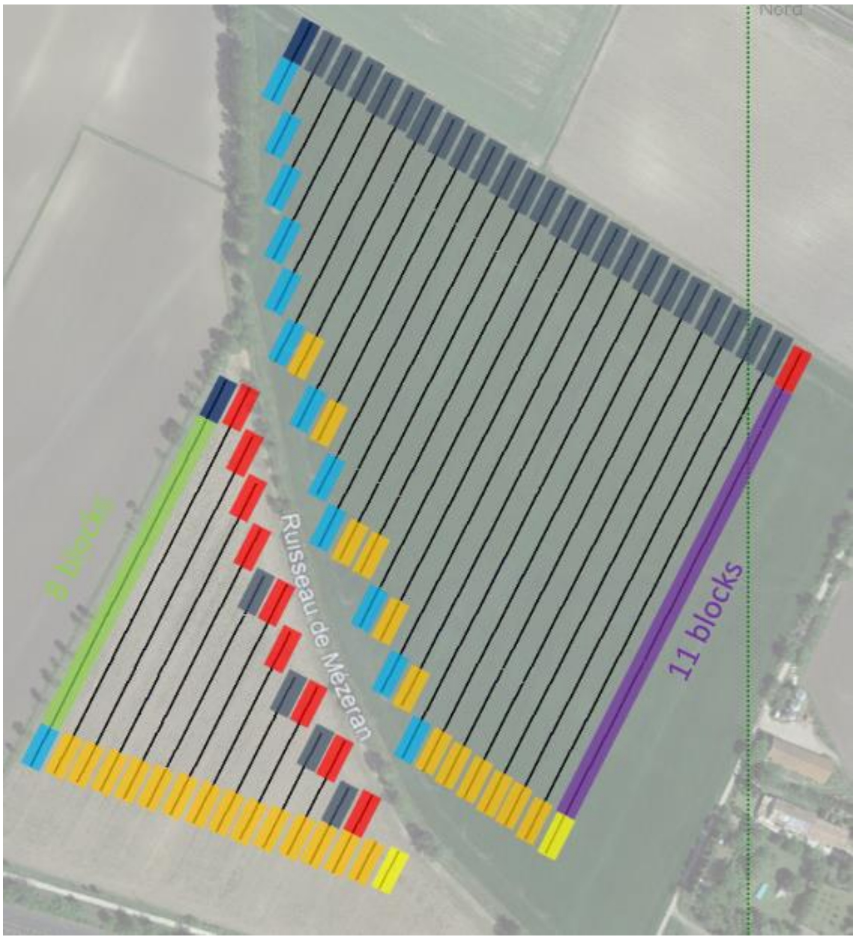

Figure 5 – Entire PV plant simulated

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