

Welcome!

Webinar #34: PV Solar Fields in Thermoflow

15 September 2022

Agenda:

- * Introduction
- * PV Field model in THERMOFLEX / NOVO PRO
- * PV Field design, configuration & options
- * PV Panels Library & Irradiance specification and database
- * PV Field annual yield calculation, Economics and available outputs
- * Operation modes and combination with other technologies
- * Q & A Session



Thermoflow Training and Support

- Standard Training
- On site training course
- User's Meetings / Advanced Workshops
- Webinars when new version is released
- Help, Tutorials, PPT, Videos
- Technical Support

→ Feature Awareness Webinars

Feature Awareness Webinars

- 1- Assemblies in TFX, June 2016
- 2- Scripts in Thermoflow programs, GTP-GTM-TFX
- 3- Multi Point Design in GTP-GTM
- 4- Reciprocating Engines in TFX
- 5- TIME in GTM

Thermoflow

- 6- Matching ST Perfromance in STP
- 7- Modeling Solar Systems in TFX
- 8- Combining THERMOFLEX & Application-Specific Programs
- 9- Methods & Methodology in GT PRO & STEAM PRO
- 10- Supplementary Firing & Control Loops in GT PRO & GT MASTER
- 11- The Wind Turbine Feature in Thermoflex
- 12- Modelling GT's in Thermoflow programas-1
- 13- Thermoflex for on line and off line performance monitoring
- 14- Tflow 27, what's new
- 15- Modelling GT's in Thermoflow programas-2
- 16- Multi Point Design in GTP-GTM
- 17- Total Plant Cost in TFX
- 18- Steam Turbine Tunning
- 19- User Defined Components in TFX
- 20- Cooling System Optimization

34- PV Field in Thermoflow

©Thermoflow Inc. 2022 – Webinar: PV Fields, 15 Sep. 2022 by IGNACIO MARTIN



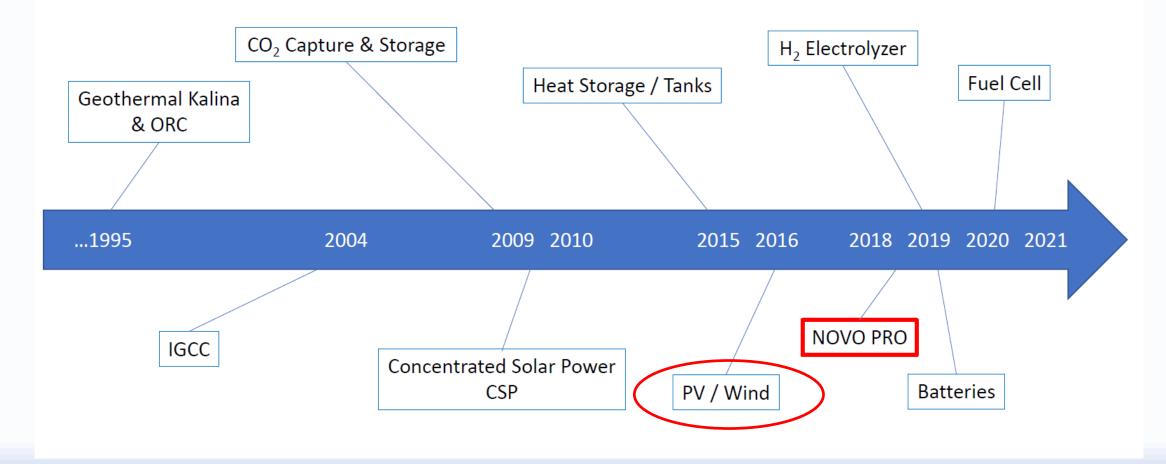
Previous Webinars on Solar

- FAW #7, July 2017, Modelling Solar Systems, focus on solar thermal, CSP
- FAW #26, April 2018, The Photovoltaic Field Feature in THERMOFLEX



<u>Thermoflow's Products contribute to the "Green Transition"</u>

Highlights / Milestones...



©Thermoflow Inc. 2022 – Webinar: Hydrogen Applications, 30 Jun, 2022 by IGNACIO MARTIN



NOVO PRO Background & Evolution

- Thermoflow main programs released between 1987 (GT PRO) and 1998 (GT MASTER, PDE, STEAM PRO, STEAM MASTER, REMASTER, PEACE, THERMOFLEX)
- NOVO PRO version 1.1 was released with Thermoflow 28, in September 2018.
 Upgrades 1.2 in Mar-19, 1.3 in May-19, 1,4 in Jun-19, 1.5 in Sep-19, 1.6 in Feb-20
- Version 1.7 released with Tflow29 in Apr-20
- Version 1.9 released with Tflow30 in March-22. Current Revision (as of today)
 September 8, 2022

Please check for new Revisions regularly, specially for NOVO PRO

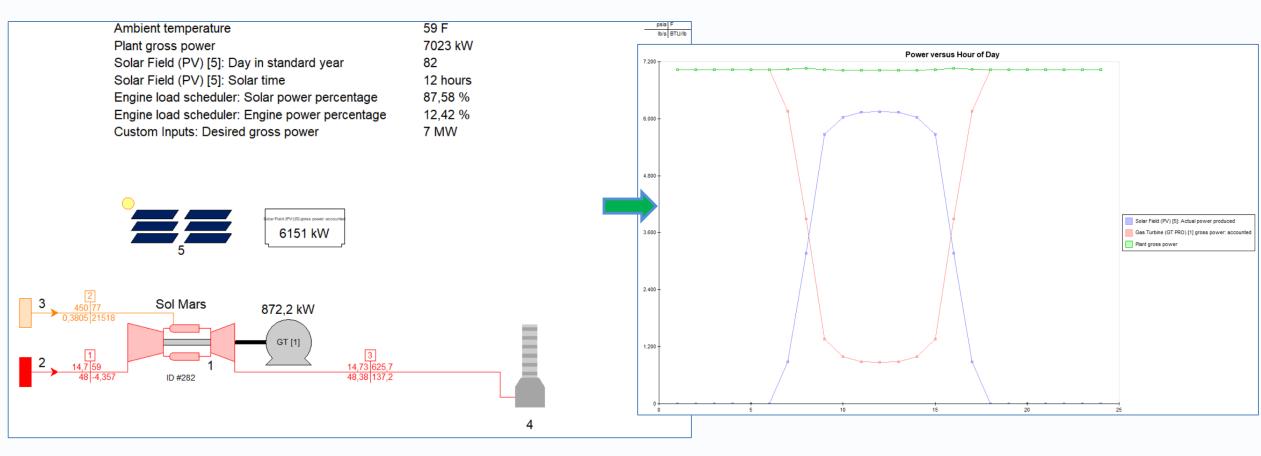


PV Field in THERMOFLEX – NOVO PRO

- THERMOFLEX:
 - More intended for **1 point calculation**, either the design point for sizing the components and system at the Design Mode, or one off design condition at Off Design mode.
 - Allows to combine with any other components within the TFX library in order to size a system and calculate performance at different conditions / operation modes
 - The user can make use of advanced TFX features like Scripts, Control Loops, Searcher, etc. to create the logic of how to operate the components and the system under different scenarios
 - Use ELINK / Macros to simulate 24 hours performance, or longer periods

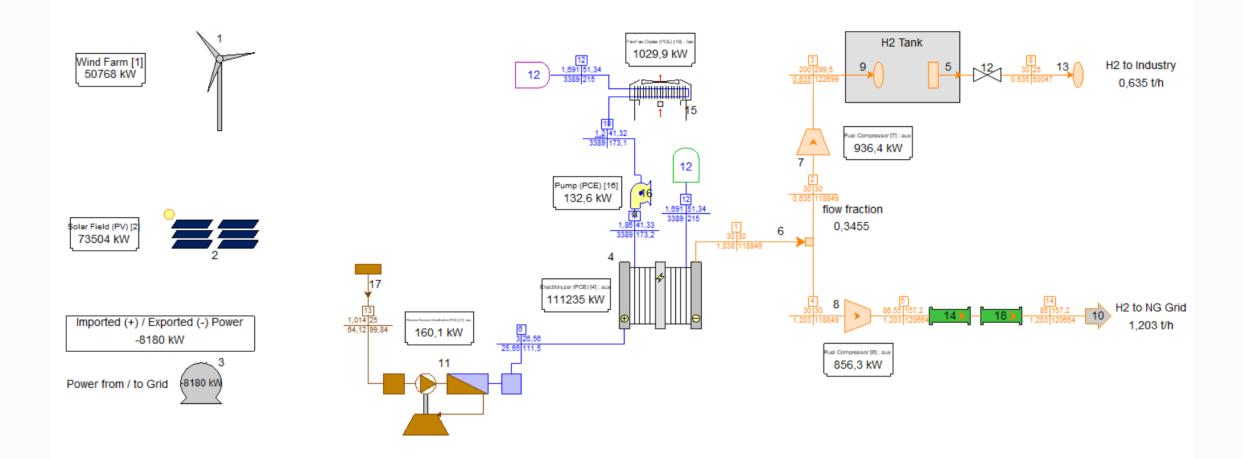


Example in TFX: Gas Turbine + PV, 24 hours operation, Scripts





Example in TFX: Wind+PV+Desalination+Electrolyzer+H2 Storage



©Thermoflow Inc. 2022 – Webinar: PV Fields, 15 Sep. 2022 by IGNACIO MARTIN



PV Field in THERMOFLEX – NOVO PRO

- NOVOPRO:
 - Calculates 8,760 hours of the year
 - Allows to define an hourly electric demand and various sources to supply it
 - Allows to combine power generation with Hydrogen production by Electrolysis
 - Allows to combine PV with storage systems
 - Allows to combine PV with thermal power for back up



PV Field in NOVO PRO

- Operating Mode:
 - Microgrid
 - Plants Only
- Plant Criteria:
 - Ambient Database \rightarrow Select site
 - Electricity & Fuel prices
 - Grid Frecuency
- Economics:
 - Financial Assumptions



PV Field in NOVO PRO, Main Inputs

- Size of the Field (MW)
 - DC
 - AC
- Panel Model
 - User Defined
 - Library
- Row Tilt
 - Fixed Tilt
 - Variable Tilt
 - 1D Tracking



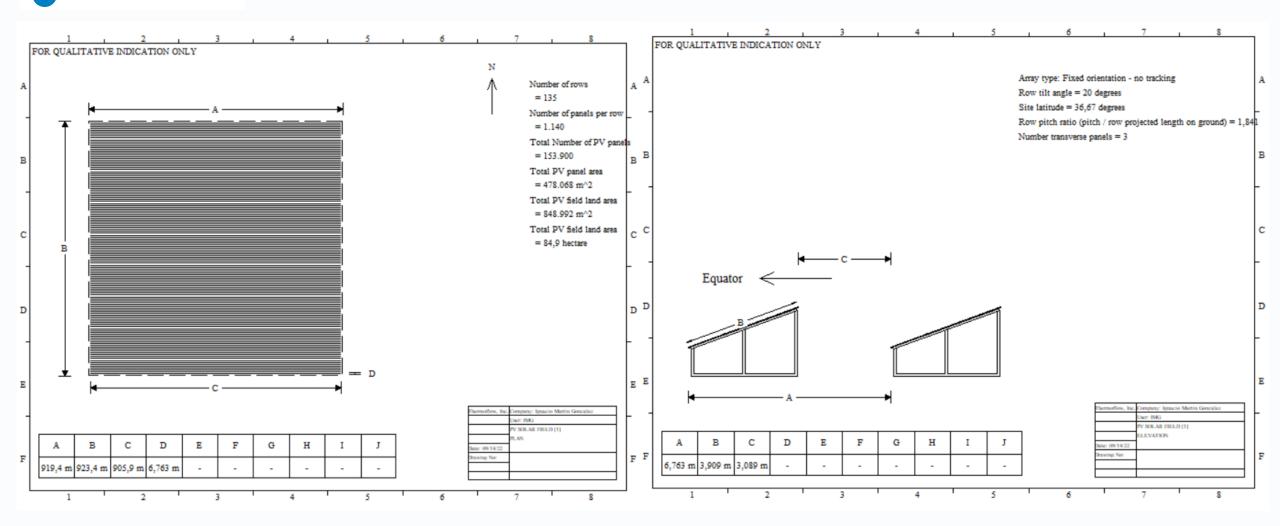
PV Field in NOVO PRO, Main Outputs

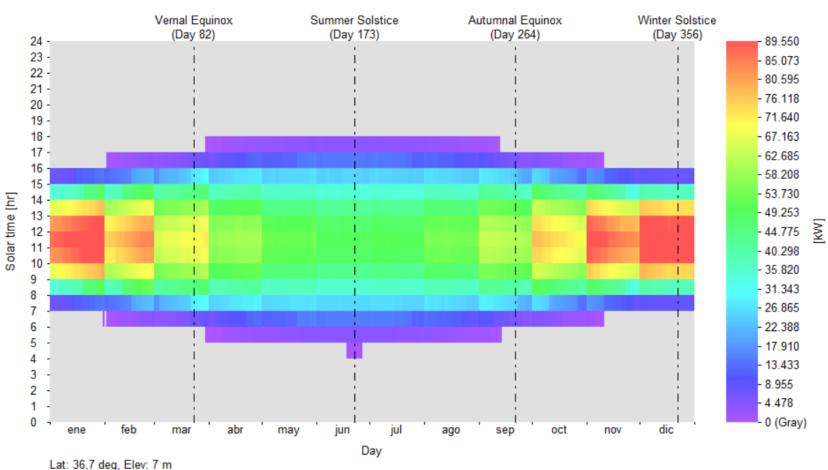
- Annual Performance, table
- Specification, table
- Site Plan / Elevation View
- Power Delivered (Map, Graphic, Data)
- Capacity Factor (monthy, weekly)
- Energy Output Graphs (monthly, weekly, daily), Histogram, Distribution
- Irradiance Data (GHI-DHI-DNI), Maps, Graphs, Data; hourly, daily, monthly
- Others
 - Performance Ratio (monthly)
 - Row Shading
 - Inverter Efficiency

Design Outputs - PV Solar Field [1]	Performance		
- Performance	PV Solar Field [1]		
- Specification	1. Estimated Annual Performance		
Site Plan Elevation View	Annual inverter output	163.214	MWh
- Power Delivered	Annual transformer output	162.398	MWh
- Capacity Factor (AC) (Monthly)			
Capacity Factor (AC) (Weekly)	Annual AC capacity factor (inverter AC output / inverter rated AC capacity)	20,7	%
- Energy Output (AC) (Monthly)	Annual DC capacity factor (panel DC output / panel rated DC capacity)	20,21	%
Energy Output (AC) (Weekly)	Annual AC performance ratio (based on inverter output)	0,9033	
Energy Output (AC) (Daily)			
- Energy Output Histogram (AC) (Daily)	Annual inverter clipping loss as percent of unclipped inverter output	0,2458	%
 Energy Output Cumulative Distribution (AC) (Daily) Performance Ratio (Monthly) 	Annual inverter clipping loss	402,2	M₩h
- Row Shading	Number inverter-limited operating hours per year	122	hours
- Inverter Efficiency			
- Hourly GHI	Irradiance method: User-defined GHI and DHI specified		
Hourly DHI	Site latitude	36,67	degrees
Hourly DNI	Elevation	7	m
- Average Daily GHI	Annual average user-defined global horizontal insolation (GHI)	4,5	kWh/m2-day
Average Daily DHI Average Daily DNI	Annual average user-defined diffuse horizontal insolation (DHI)	1,5	kWh/m2-day
- Monthly Total GHI			
- Monthly Total DHI	Maximum panel operating temperature	42,89	С
Monthly Total DNI	Maximum panel operating temperature above ambient	22,26	С
Messages			
	Maximum panel DC output as percent of nominal rating	108,1	%
	Maximum plane of array irradiance	1.116	W/m2

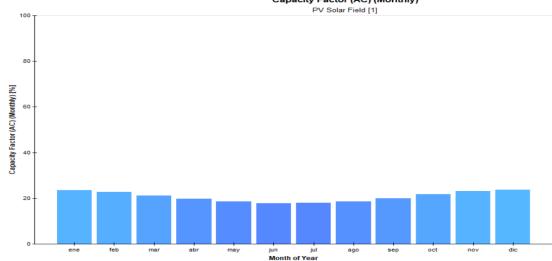
Design Outputs - PV Solar Field [1] Performance ecificati Site Plan Elevation View Power Delivered Capacity Factor (AC) (Monthly) Capacity Factor (AC) (Weekly) - Energy Output (AC) (Monthly) Energy Output (AC) (Weekly) Energy Output (AC) (Daily) Energy Output Histogram (AC) (Daily) - Energy Output Cumulative Distribution (AC) (D - Performance Ratio (Monthly) - Row Shading Inverter Efficiency - Hourly GHI Hourly DHI Hourly DNI - Average Daily GHI Average Daily DHI Average Daily DNI - Monthly Total GHI - Monthly Total DHI - Monthly Total DNI Messages

Total owner's specific cost \$/kW AC Total owner's cost	100.505.0	_	
Total owner's specific cost \$/kW DC	_	_	USD/
User-defined overall estimated site-specific cost adjustment factor	1.0		ICD /
Engineering, planning, project management cost	10.143.0	1	130
	10.143.0		ICD
NOTE: Transmission line length set to zero, so interconnection cost EXCLUDES transmission line!	3.666.0 NO1	_	530
Utility interconnection cost	3.686.0	_	
Electrical erection equipment, material, and installation cost Electrical erection equipment, material, and installation cost	2.863.0		
Foundation equipment, material, and installation cost Mechanical erection equipment, material, and installation cost	9.270.0		JSD JSD
Site preparation equipment, material, and construction cost Foundation equipment, material, and installation cost	1.500.0	_	JSD
Shipping cost for equipment and inverters Site preparation equipment, material, and construction cost	1.888.0	_	
Shipping cost for equipment and inverters	6.469.0	_	
Inverters cost	6.480.0	_	
Equipment cost (excluding inverters)	58.207.0		
Inverter AC rating	_	00 k	
Total nameplate panel DC rating	100.0	35 k'	w
6. Total Owner's Cost (computed using a simplified specific cost breakdown)		-	
r net your own coste	1.550.0	-	550
First year 0&M costs	1.350.0		
First year land cost		οι	JSD
5. First Year Land and O&M costs		+	
mineral magned environey (comented)	- 34,		
Inverter weighted efficiency (EU method)		86 %	
Inverter weighted efficiency (CEC method)	_	44 %	
Inverter efficiency at rated AC output		95 %	
Inverter AC rating	90.0	00 k	W
4. Inverter Details		+	
Width (smaller dimension)	1,30	3 m	
Length (larger dimension)	2,38	4 m	
Single panel area	3,10	6 m^	2
Nominal BC capacity at rating condition		2 % 0 W	
Panel Model Nominal efficiency at rating condition	CS7N-650M 20,9		
Panel Manufacturer	CanadianSol		
Panel ID Number	136	_	
3. Panel Details			
Transo or partor por 1977	114	-	
Row azimuth angle Number of panels per row	18	0 deg	grees
Row tilt angle		0 deg	
Row pitch		3 m	
Row length	905,		
Number of rows	323,		
PV field length along east-west boundary PV field length along north-south boundary		4 m 4 m	
Land aspect ratio	0,995		
Total land area occupied by the PV field	848.99	2 m^	2
Total land area occupied by the PV field	84,	9 he	ctare
2. Field Details Field Configuration: Fixed orientation - no tracking			
Inverter AC rating / Panels DC rating	0,899	7	
Inverter AC rating	90.00		
Total PV panel area Total nameplate panel DC rating	478.06		
Total number of PV panels	153.90		-
1. Summary			
PV Solar Field [1]			

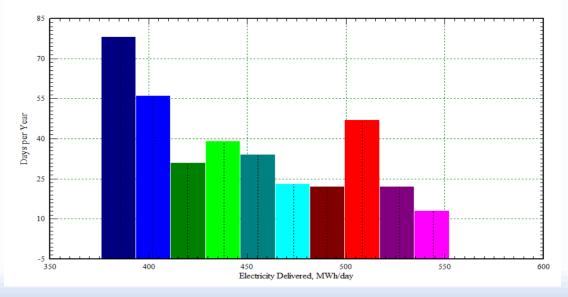


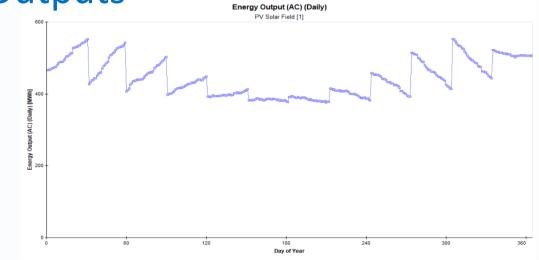


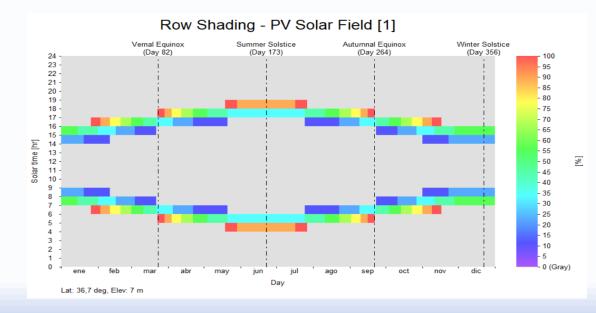
Power Delivered - PV Solar Field [1]

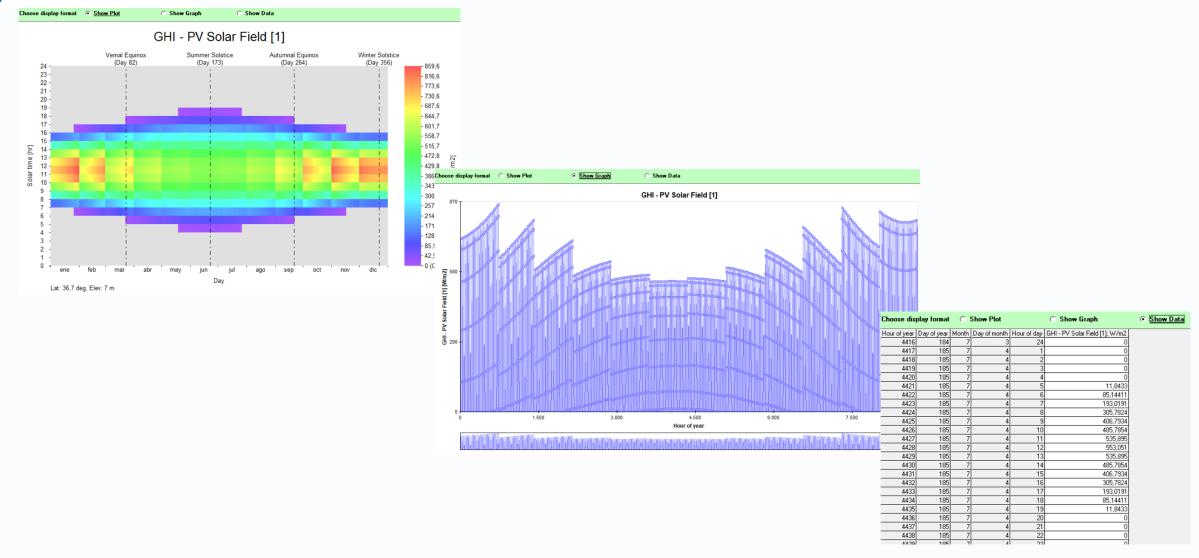


Energy Output Histogram (AC)











User Defined

PV Field in NOVO PRO, PV Panel Selection

User-Defined Panel	
DC values specified at Standard Te	est Conditions (STC)
Nominal efficiency	21,73 %
Nominal power	675 W
Length (larger dimension)	2,384 m
Width (smaller dimension)	1,303 m

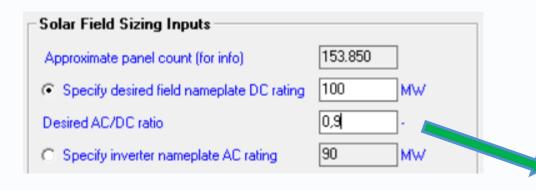
O Manufacture	er C Lowest to highest power	 Highest to lowest power 	Show new specs on	Ŷ	
ID	Manufacturer	Model	Rating ₩	Efficiency %	Area m^2
ther PV Pane	els				
-1	User-defined PV Panel				
1530	GCL	GCL-M12/66H-675	675	21,7	3,106
1364	CanadianSolar	CS7N-670MS	670	21,6	3,106
1529	GCL	GCL-M12/66H-670	670	21,6	3,106
1363	CanadianSolar	CS7N-665MS	665	21,4	3,106
1528	GCL	GCL-M12/66H-665	665	21,4	3,106
2060	Talesun	BISTAR TP8F66M-665	665	21,4	3,106
1362	CanadianSolar	CS7N-660MS	660	21,2	3,106
1527	GCL	GCL-M12/66H-660	660	21,2	3,106
947	Custach Dower	CT DECRE DEC Autoria	660	21.2	2 106

Library

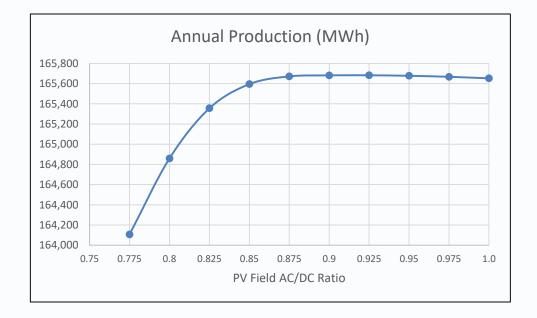
Data for each listed panel was gathered from publicly available spec sheets published by panel manufacturers

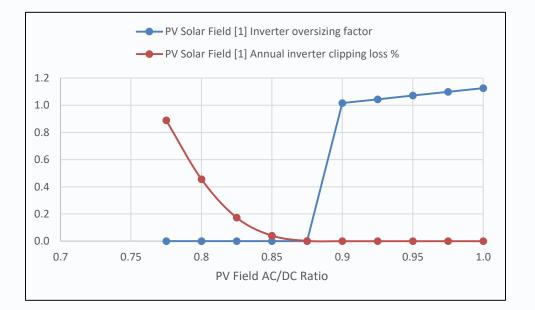
Note: Data for included panels is provided for information only! There is no guarantee that any panel listed here, with the associated specs, is still available at this or any performance level. It is solely the user's responsibility to verify the availability, suitability, and performance details for any panel used to build a performance and cost model. Data you receive from a vendor can be entered by selecting the 'User-defined PV Panel' entry atop this list and editing the characteristics on the Configuration tab.

Thermoflow PV Field in NOVO PRO, AC/DC Ratio



Performance		
PV Solar Field [1]		
1. Estimated Annual Performance		
Annual inverter output	165.682	M₩h
Annual transformer output	164.853	M₩h
Annual AC capacity factor (inverter AC output / inverter rated AC capacity)	21,01	%
Annual DC capacity factor (panel DC output / panel rated DC capacity)	20,5	%
Annual AC performance ratio (based on inverter output)	0,8915	
Annual inverter clipping loss as percent of unclipped inverter output	0	%
Inverter oversizing factor	1,016	

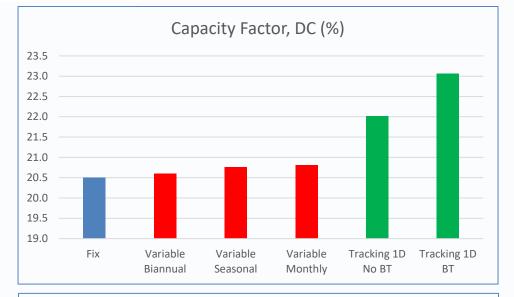


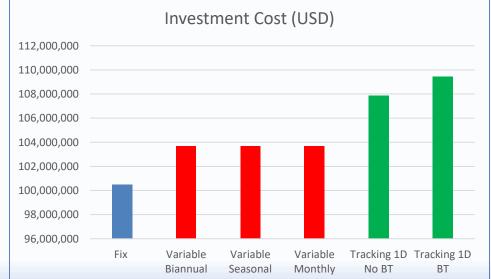


Thermoflow PV Field in NOVO PRO, Effect of Variable Tilt / Tracking

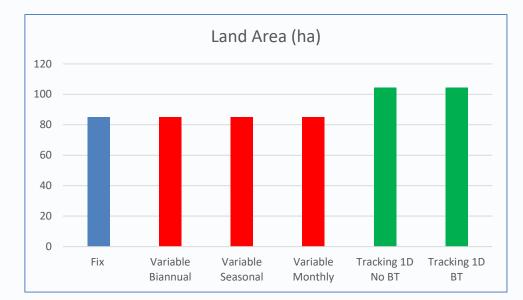
Row Tilt	Row Configuration - Fixed Tilt Rows	
 Fixed tilt 	Transverse panel count 3	
○ Variable tilt	Method to specify panel tilt angle and row spacing	4 transverse panels
C 1D tracking	C User-defined Minimum inter-row corridor	panels t
	Row tilt angle (from horizontal) 18 degrees Row spacing factor (row pitch / min pitch) 1,819 -	row tilt angle
Row Tilt ○ Fixed tilt ● Mariable till	Variable Tilt Adjustment Frequency O Biannual (centered on solstices) Seasonal (centered on equinoxes and solstices) O Monthly (calendar months)	row pitch
C 1D tracking	Row Configuration - 1D Tracking Rows	
C Fixed tilt	Transverse panel count 3	
 Variable tilt 1D tracking 	Automatic User-defined Minimum inter-row corridor Row spacing factor (row pitch / min pitch) 1,841 -	max tilt
	Tracking Details North-South rows Maximum tilt from horizontal 60 degrees	minimum pitch inter-row corridor
	Use backtracking C No 🔍 Yes	row pitch

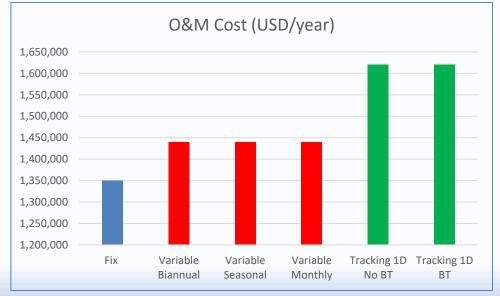
Thermoflow PV Field in NOVO PRO, Effect of Variable Tilt / Tracking











Thermoflow PV Field in NOVO PRO, Irradiance Specification

rradiance Method	Inputs for Estimated Irradiance				
Estimated with specified cloud cover factor	Site latitude	36,67 degrees			
C User-defined monthly insolation data	Annual average cloud cover factor	/m			
	Albedo of surroundings Threshold solar altitude for beam irradiance	0,2 0 degrees			

👺 Typical Meteorological Year (TMY) Database	_		\times
ielect a location from the list below. Graphs of annual data for selected site are displayed on the [View Ambient] tab. Click 'Apply to iystem' button to instruct NOVD PRO to update hourly ambient inputs using TMY data for the selected location.		Apply to	o System
		Car	ncel

Irradiance Method	Solar Irradiance Database
 Estimated with specified cloud cover factor Use database User-defined monthly insolation data 	Change Location Current Location: Malaga, Lat: 36,7 deg, Long: -4,5 deg, Elev: 7 m Albedo of surroundings 0,2 Threshold solar altitude for beam irradiance 0 Irradiance adjustment factor for DNI & GHI 1

□Irradiance Method	- lleor-define	d Monthly Ins	olation	
	0261-deline	u monuniy ins	Ulation	
C Estimated with specified cloud cover factor	Site latitude			36,67 degrees
C Use database	Site altitude			7 m
 User-defined monthly insolation data 	Albedo of sur	roundings		0,2
	Threshold so	lar altitude for be	eam irradiance	0 degrees
		Daily Avg GHI	Daily Avg DHI	
	Month	kWh/m2•day	kWh/m2-day	
	enero	4,5	1,5	
	febrero	4,5	1,5	
	marzo	4,5	1,5	
	abril	4,5	1,5	
	mayo	4,5	1,5	
	junio	4,5	1,5	
	julio	4,5	1,5	
	agosto	4,5	1,5	
	septiembre	4,5	1,5	
	octubre	4,5	1,5	
	noviembre	4.5	1.5	

diciembre

1,5

	Select Station Location		View Ambient S	ummary for Sel	ected Station	
Use Ma	ap	Select Region for Site List Europe	•			
Station ID	Location	Site Name	Elevation, m	Latitude, *	Longitude, *	-
082610	ESP	Caceres	0405	39,47	-6,33	_
082860	ESP	Castellon	0082	39,95	-0,07	
603200	ESP	Ceuta	0038	35,89	-5,29	
084100	ESP	Cordoba	0051	37,84	-4,85	
082310	ESP	Cuenca	0200	40,07	-2,14	
081840	ESP	Gerona	0129	41,9	2,77	
084190	ESP	Granada	0559	37,18	-3.78	
082260	ESP	Guadalaiara	0608	40,63	-3,16	
083830	ESP	Huelva	0035	37,26	-6,95	
080940	ESP	Huesca	0180	42,08	-0,33	
084170	ESP	Jaen	0048	37,78	-3,79	
080010	ESP	La Coruna	0067	43,37	-8,42	
600300	ESP	Las Palmas	0025	27,93	-15,38	
080550	ESP	Leon	0363	42,59	-5,65	
081710	ESP	Lerida	0263	41,63	0,6	
080840	ESP	Logrono	0363	42,45	-2,33	
080080	ESP	Lugo	0259	43,25	-7,48	
082210	ESP	MADRID	0582	40,45	-3,55	
084820	ESP	Malaga	0007	36,67	-4,49	
603380	ESP	Melilla	0007	35,28	-2,95	
084300	ESP	Murcia	0062	37,79	-0,8	
080480	ESP	Orense	0256	42,33	-7,86	
080150	ESP	Oviedo	0339	43,34	-5,87	
080720	ESP	Palencia	0263	42,01	-4,54	
093060	FSP	PALMA	0008	39.55	2.73	

nermoflow PV Field in NOVO PRO, Irradiance Specification

Irradiance Database (more details in NOVO PRO Help, Chapter 6.9.2)

1.Data for **1020 locations in the United States** and selected territories comes from a database of Typical Meteorological Year (TMY) data compiled by **US NREL** and made publicly available on the NREL website (<u>rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3</u>).

2.Data for **80 Canadian** locations comes from **Meteorological Service of Canada**, Environment Canada, a part of the Government of Canada. The data are from Canadian Weather year for Energy Calculation (CWEC) database which is based on analysis to develop a Typical Meteorological Year (TMY). (www.climate.weather.gc.ca/prods_servs/engineering_e.html)

3.Data for locations in **Africa, Asia, Central America, Europe, South America, and Southwest Pacific** comes from weather data made available on the **EnergyPlus** website, <u>https://energyplus.net/weather</u>. EnergyPlus is funded by the U.S. Department of Energy's (DOE) Building Technologies Office (BTO), and managed by the National Renewable Energy Laboratory (NREL). EnergyPlus is developed in collaboration with NREL, various DOE National Laboratories, academic institutions, and private firms.

Thermoflow PV Field in NOVO PRO, Panel Performance adj. & DC Losses

Current Panel Efficiency = Nominal Panel Efficiency * $(1-D_1/100)$ * $(1-D_2/100)$ * $(1-D_3/100)$ * $(1-(T_{panel}[C] - 25[C])$ * $D_4/100)$

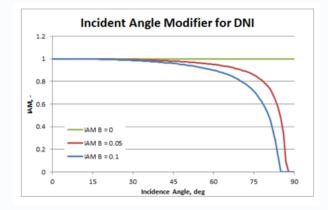
ſ	Panel Performance Adjustment & DC Losses							
	Derating for panel age	0 %						
	Derating for surface soiling	0 %						
	Derating for other effects	0 %						
	Adjustment for panel temp other than 25 0	C -0,34 %/C						
	C Assume constant DT 🕜 Estimate p	anel temperature						
	Panel operating DT above ambient 20	С						
	Overall heat transfer coefficient 20	W/m^2-C						

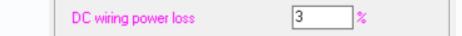
IAM = 1 - B * (1/COS(a) - 1)

Incident angle modifier coefficient

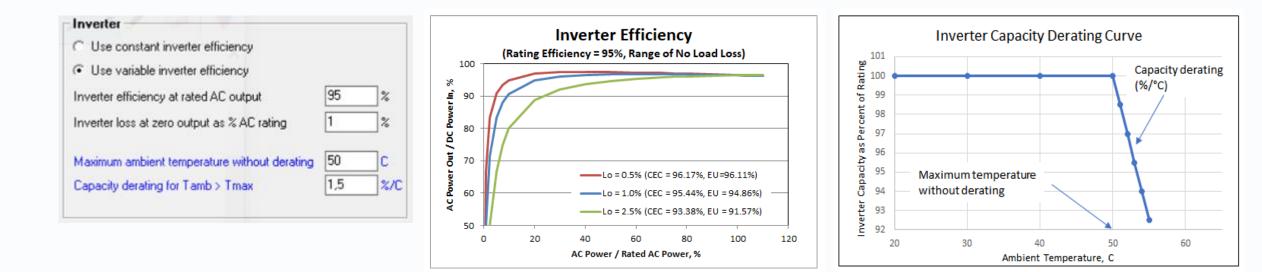
- "B" is the incident angle modifier coefficient, typical value is 0.05
- "a" is the incident angle measured from the normal

0,05





Thermoflow PV Field in NOVO PRO, Panel Performance adj. & DC Losses



Transformer	
✓ Include step up transformer	
Transformer efficiency	99,5 %



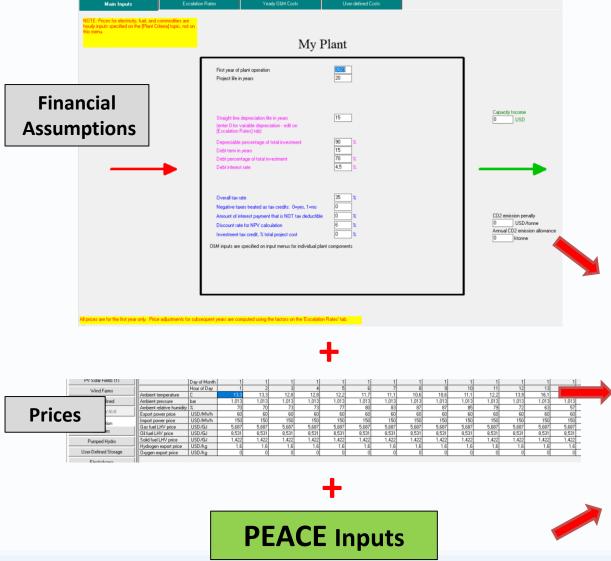
PV Field in NOVOPRO, PEACE Inputs & Cost Estimation

Main Inputs	Main Inputs Configuration		PEACE Inputs		
Total Owner's Installed Cost Method					
Specify breakdown using inputs listed t	below O Specify specific cost directly	User-defined total owner's installed cost - per kW D	C 1600 USD/kW		
Cost Breakdown					
User-defined overall estimated site-specific	c cost adjustment factor 1 -				
Inside the fence costs					
Crude estimate Crude Equipment cost (excluding inverter) - per		Crude estimate C User-defined Shipping to site as % inverter + equipment cost	10 %		
Crude estimate Crude Inverters cost - per kW AC		Crude estimate C User-defined Site work - per acre	22239 USD/ha		
Crude estimate Crude Foundation installation - per kW DC			92,67 USD/kW		
Crude estimate Crude Electrical installation (inside the fence) -		Crude estimate C User-defined EPC, Project Development - per KW DC	101,4 USD/kW		
Outside the fence costs					
Crude estimate C Us Utility interconnection - per KW AC	eer-defined 40,95 USD/kW	Utility interconnection spur length	km		
Include step up transformer					
C Crude estimate C Crude estimate Annual land cost for first year (escalates w	r-defined	First Year O&M Cost Fixed 0&M cost, per net AC kW capacity per year Variable 0&M cost, per kWh AC electric output	15 USD/KW 0 USD/KWł		
Annual Degradation	egradation 0.5 %				

5. First Year Land and O&M costs			
First year land cost	0	USD	
First year O&M costs 1.350.000			
6. Total Owner's Cost (computed using a simplified specific cost breakdown)			
Total nameplate panel DC rating	100.035	k₩	
Inverter AC rating	90.000	k₩	
Equipment cost (excluding inverters)	58.207.000	USD	
Inverters cost	6.480.000	USD	
Shipping cost for equipment and inverters	6.469.000	USD	
Site preparation equipment, material, and construction cost	1.888.000	USD	
Foundation equipment, material, and installation cost	1.500.000	USD	
Mechanical erection equipment, material, and installation cost	9.270.000	USD	
Electrical erection equipment, material, and installation cost	2.863.000	USD	
Utility interconnection cost	3.686.000	USD	
NOTE: Transmission line length set to zero, so interconnection cost EXCLUDES transmission line!	NOTE!		
Engineering, planning, project management cost	10.143.000	USD	
User-defined overall estimated site-specific cost adjustment factor 1			
Total owner's specific cost \$/kW DC 1.000			
Total owner's specific cost \$/kW AC 1.120			
Total owner's cost	100.505.000	USD	

Thermoflow

PV Field in NOVO PRO, Investment Analysis



Summary Graphics S	ummary Report	Messages (none)	Notes	Cost Report	Investment An	Plots	His	tograms	Input Data
Financial Summary	Cashflow								
Financial Summary									
Annual Electricity Exp	oort							164,9	GWh
Annual Fuel Imported								0	TJ
Annual H2 Exported								0	torino
Annual 02 Exported								0	torino
Total Investment								100.505.000	
Initial Equity								30.151.000	
Cumulative Net Cash								83.571.000	
Internal Rate of Retu								5,633	-
Internal Rate of Retu	1 2 ()						9,071	
Years for Payback of	Equity								years
Net Present Value								10.741.000	USD
· · · · ·		ut Fuel and Import Elect						0,0528	
Break-even Export P	ower Price @ Inpu	ut Fuel and Import Elect	ricity Prices (i.e. L	evelised Cost of Electr	icity)			52,82	USD/MWł
Break-even Hydroge	n Price @ Input Fi	uel and Import Electricit	y Prices (i.e. Leve	lised Cost of Hydroger	1]			N/A	USD/kg
NOTE:									
Break-even prices (LC	OE) shown above	are comparable betwe	en NOVO PRO c	ases with the same [Ed	conomics] inputs.				
HOWEVER, myriad us	er-adjustable finar	ncial assumptions, with	ut universally agr	eed defaults,					
are used to compute these outputs. Comparing them with values reported elsewhere IS NOT meaningful									
unless you ensure a comparable set of assumptions was used to produce those results. See help (F1) for details.									
Land cost is set to any	in this model								
Land cost is set to zero in this model.									
Including land cost can have a significant impact on these results. Land cost is editable on the [PEACE Inputs] tab for each renewable plant.									
Land Cost is editable 0	n die (FEACE Inp	us tab for each tenew	abie piani.						
Utility interconnection :	spur length is set t	o zero in this model.							
Including cost for a spur line can have a significant impact on these results.									
The spur length is edit	able on the [PEAC	E Inputs] tab for each	enewable plant.						

Thermoflow PV Field in NOVO PRO, Create Design / Modify Design

Create Design, Inputs

Main Inputs	Configuration				
User-Defined Panel	Row Configuration - Fixed Tilt Rows				
DC values specified at Standard Test Conditions (STC)	Transverse panel count 3				
Nominal efficiency20,92%Nominal power650W	Method to specify panel tilt angle and row spacing Automatic User-defined				
Length (larger dimension)2.384mWidth (smaller dimension)1.303m	Minimum inter-row corridor 0 m Row tilt angle (from horizontal) 20 degrees				
Panel Performance Adjustment & DC Losses	Row spacing factor (row pitch / min pitch) 1,841 -				
Derating for panel age 0 % Derating for surface soiling 0 % Derating for other effects 0 %	Array Azimuth Angle Specification O User-defined				
Adjustment for panel temp other than 25 C 0,34 %/C	Array azimuth angle (CW from due North) 180 degrees				
C Assume constant DT C Estimate panel temperature Panel operating DT above ambient 20 C Overall heat transfer coefficient 20 W/m^2-C	Inverter Use constant inverter efficiency Use variable inverter efficiency				
Incident angle modifier coefficient 0,05 DC wiring power loss 3	Inverter efficiency at rated AC output 95 % Inverter loss at zero output as % AC rating 1 % Maximum ambient temperature without derating 50 C				
Transformer ↓ Include step up transformer	Capacity derating for Tamb > Tmax 1,5 %/C				
Transformer efficiency 99,5 %					

Modify Design, Inputs

Main Inputs	Configuration			
User-Defined Panel	Row Details			
DC values specified at Standard Test Conditions (STC)	Fixed orientation - no tracking			
Nominal efficiency 20,92 %	Fixed array row tilt angle 20 degrees			
Nominal power 650 W	Transverse panel count 3			
Length (larger dimension) 2,384 m Width (smaller dimension) 1,303 m	Row spacing factor (pitch / min pitch) 1,841 Row pitch 6,763			
	Minimum pitch (for info) 3,673 m			
Panel Performance Adjustment & DC Losses	Inter-row corridor (for info) 3,089 m			
Derating for panel age 0 %	Number of rows 135			
Derating for surface soiling	Longitudinal panel-to-panel spacing			
Derating for other effects	Number panel positions per row 380			
Adjustment for panel temp other than 25 C -0,34 %/C	Row length 905,9 m			
Assume constant DT Estimate panel temperature	Array azimuth angle (CW from due North) 180 degrees			
Panel operating DT above ambient 20 C				
Overall heat transfer coefficient 20 W/m^2-C	Inverter			
Incident angle modifier coefficient 0.05	Inverter rated AC output 90 MW 90000 kW C Use constant inverter efficiency			
DC wiring power loss 3 %	Use variable inverter efficiency			
	Inverter efficiency at rated AC output			
Transformer	Inverter loss at zero output as % AC rating 1 %			
Include step up transformer	Maximum ambient temperature without derating 50 C			
Transformer efficiency 99,5 %	Capacity derating for Tamb > Tmax 1.5 %/C			

ermoflow PV Field in NOVO PRO, Microgrid / Plants Only

Plants Only mode:

- PV Field makes as much power as it can, and just send it to the grid
- Can be combined with other renewable (Wind, UD) and thermal power sources. All of them add their energy to the grid, and behave independently
- Can be combined with Hydogen production and / or Storage, but they behave independently and need a *Schedule* specification

Microgrid mode:

- A electric demand is defined every hour
- PV can be one of the alternatives to supply the demand, subject to priorities
- PV production can be lower (deficit) or higher (surplus) than the demand. *Deficit* can be supplied by other source (wind, backup thermal, storage) or imported. Surplus can be stored or used to make H2. Otherwise it would be absorbed by the grid when possible or *curtailed*.
- PV can be combined with Hydrogen production, subject to H2 "Loading Strategy"



Q & A Session

- Please forward your questions on the WebEx Chat
- Further questions by email to: info@thermoflow.com

- PP Presentation will be available on the Website / Tutorials
- Video will be available on the Service Center



Thank you!

IGNACIO MARTIN - SPAIN martin@thermoflow.com

©Thermoflow Inc. 2022 – Webinar: PV Fields, 15 Sep. 2022 by IGNACIO MARTIN