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Welcome!

Webinar #7: MODELLING SOLAR THERMAL SYSTEMS 27 JULY 2017

Agenda:

- * Introduction
- * Solar Components in Thermoflex-PEACE
- * Design Mode
- * Off-design simulation: controls @ operating points
- * Link to Excel, "dynamic" simulation and annual yield
- * Hybrid plants and other examples
- * Q & A Session



Thermoflow Training and Support

- Standard Training
- On-site training course
- Advanced Workshop
- Webinars when new version is released
- Help, Tutorials, PPT, Videos
- Technical Support

→ Feature Awareness Webinars



Feature Awareness Webinars

- 1- Assemblies in TFX
- 2- Scripts in Thermoflow programs, GTP-GTM-TFX
- 3- Multi Point Design in GTP-GTM
- 4- Reciprocating Engines in TFX
- 5- TIME in GTM
- 6- Matching ST Performance in STP
- 7- Modeling Solar Systems in TFX



Solar Thermal Development in TFX

Tflow18: Parabolic Trough + HT Fluid + Heat Exchangers Tflow19: Linear Fresnel Collectors, DSG Tflow20: SF with two-tank thermal storage Tflow22: Solar Tower and Heliostats Tflow26: Solar PV



Solar Components in TFX-PEACE







5



Solar Components in TFX-PEACE - 2



6



Example: 50 MW Parabolic Trough w/ Molten Salts storage



Solar part





Water-Steam Cycle





Design, TD Mode

Main Inputs

- Ambient Conditions (affecting the cycle efficency and heat input)
- HTF Specification & minimum Pressure
- Solar Field type, HTF exit Temperature, (HTF mass Flow)
- Splitter: Fraction of HTF to Steam Generator Reheater
- Superheater / Reheater: Exit Steam Temperature
- Evaporator: Pinch Point / (Steam mass Flow)
- Economizer: Water exit Temperature or Approach Subcooling
- Pressure Drops: user assumptions or defaults



HTF Specification

📆 Input Menu - Edit Mode							
File GTP/GTM/STM		Con Mator			Formation	Designation (
Site Menu Components	Miscellaneous	Gen/Motors	Plant Assembly	Non-riowsheet	Economics	Regional Losts	
HTF Specification [54] HTF Specification Pressure Mass flow Flow multiplier value (= outlet flow/inlet flow) Flow divider value (= inlet flow/outlet flow) Price of Heat output (ignore) Price of Heat output (ignore) Flow priority Very weak Function Enforce continuity	11 bar 4.536 kg/s 1 0 euro/GJ 0 euro/GJ ▼	Fluid Definition Fluid Definition Fluid User-defined fluid	▼ Library uid properties				
Pluid Library DOWFROST (Propylene Glycol) DOWFROST HD (Propylene Glycol) DURATHERM DURATHERM 600 DURATHERM 450 DURATHERM 450 DURATHERM 450 DURATHERM 450 DURATHERM XLT DURATHERM XLT DURATHERM XLT DURATHERM MIT Paratherm NF Paratherm MR Paratherm MG Paratherm MG Paratherm MG Paratherm LR Solutia THERMINOL D-12 THERMINOL 55 THERMINOL 55 THERMINOL 59 THERMINOL 59 THERMINOL 72 THERMINOL 75 THERMINOL 75	3 by wt	CURREN THERMIN Minimum te Maximum te	T SELECTION IOL VP-1 emperature 12,78 C emperature 398,9 C				



Flow Specification

HTF to Steam Generator

- HTF mf (strong) + Evaporator Pinch
- HTF mf (strong) + Steam mf
- Evaporator Pinch + Steam Production

→ Steam mf
→ Evaporator Pinch (if > "mínimum pinch")
→ HTF mf

HTF to Reheater

- Fractions from Splitter (Strong)
- Component sets Shell Flow+ Cold End Approach Diference (minimum Flow)

Control Loop to determine HTF / Steam mf to achieve a Power Output



Control Loop



Primary Control: Shell-Tube Evaporating HX (PCE) [44] : Desired steam production = 56,15 kg/s

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Design, ED Mode

Main Inputs

- Solar Field
 - Irradiance
 - Collector Design
 - Flow Path
 - Storage
- Heat Exchangers: Hardware
- Pressure Drops: computed (check pipes DP)



Irradiance

Irradiance Creatification	7
madiance specification	
 Estimated from site data 	
C User-defined DNI + Local Time	
C User-defined DNI + Sun Position	
User-defined at aperture	
	-



Irradiance Specification	Site location and current time		_	
C Estimated from site data	Latitude (>0=North)	39,5	degrees	
User-defined DNI + Local Time	Longitude (>0=East of Greenwich)	109,5	degrees	
C User-defined DNI + Sun Position	Standard time zone (>0=East of Greenwich)	8	hours	
C User-defined at aperture	Day of the year	173	(junio 22)	L
	Local standard time (24 hour clock)	12	hours	Day 82 ~ Vernal equinox
	Direct normal irradiance (DNI)	850	W/m^2	Day 173 ~ Summer solstice
	✓ Include aperture shadowing		-	Day 264 ~ Autumnal equinox Day 356 ~ Winter solstice

Irradiance Specification	User-defined Direct Normal Irrad	iance —			
 Estimated from site data 	Direct normal irradiance (DNI)	850	W/m^2		
C User-defined DNI + Local Time	Solar zenith angle	60	degrees		
User-defined DNI + Sun Position	Solar azimuth angle	180	degrees		
○ User-defined at aperture Include aperture shadowing					

Irradiance Specification	User-defined Direct Irradiance Normal to Aperture
C Estimated from site data	Aperture normal direct irradiance 819,4 W/m ²
O User-defined DNI + Local Time	
C User-defined DNI + Sun Position	
 User-defined at aperture 	

Thermoflow Collector Design, Physical Model

Solar Field[1]		 Engineering Design 	
ED Mair	n Inputs	Irradiance Collector Design Flow Pati	h Hardware
lominal optical ef able. This accou bsorption and of fficiency for non-	ficiency correction factor ints for scattering, her reductions in reflective incident ray strikes. This is	Collector Cross Section and Field Layout C Automatic C User-defined	
ot a geometric c ffect' which is ac ther inputs	orrection for the 'cosine counted for based on	1. Number of efficiency correction factor data points	91
Incident	Efficiency	2. Receiver tube outside diameter	70 mm
Angle (deg)	Correction (-)	3. Receiver tube wall thickness	4.2 mm
0	1	4. Reflector aperture width	5 m
1	0.9994	5. Reflector geometric concentration ratio (aperture width / receiver diameter)	71.43
2	0.9988	6 Ballaster in ande	80 Demos
3	0.9981	o, menologi ani drige	
4	0.9974	7. Reflector focal length	1.49 m
5	0.9966	8. Number reflector rows per flow path	2
6	0.9957	0. Number reflecter com banks	
7	0.9948	3. Number reflector row banks	2
8	0.9939	10. Active reflector length as percent of total length	95 🗶
9	0.9928	11. Deflecter row elter / Anethro with	2
10	0.9917	11. Herector tow price 2 Apendie widen	
11	0.9905	12. Reflector cleanliness factor	1
12	0.9893	13 Row (tracking axis) rotation from due North	0 Decrees
13	0.988	14 Days (searching wind) the form becomental	
14	0.3866	14. Now (tracking axis) bit from horizontal	Uegrees
15	0.9836	15. Receiver tube emissivity	0.15
17	0.982	16. Receiver place envelope emissivity	0.9
18	0.9803	The recent of grade entropy concerning	FC 70
19	0.9785	17. Assumed convective heat transfer coefficient outside glass envelope	56.70 W/m 2-C
20	0.9766	18. Assumed receiver support fin efficiency	5 🎗
21	0.9746	19. Receiver support spacing along reflector row	4 m
22	0.9726	20. Overall heat loss correction factor	1
23	0.9704	20. O YORK HOLK ASS CONCURNINGLO	
24	0.9681	21. Number of computational segments along receiver	50
25	0.9657		







Collector Design, Data-Defined

Solar Field w/ Sto	orage (Data-De	efined) [1]			•	Engir	neering Design	•	
ED Main In	puts	Irradian	nce Collector Deta	ils	Flow Path Har	dware	Storage		
Click to choose a bu layout and efficie	uilt-in collector and ency inputs accord	reset all dingly	Field Layout	Collector details we Current definitions	ere initialized usi s may include us	ing built-in er-defined	n collector = 'Novatec Solar - Evapo I modifications.	prative Se	
Angle	IAM	IAM	1. Number of IAM data points		10				
Degrees	Longitudinal	Transverse	2. Line collector type: 0=parabolic trough	n, 1=linear fresnel	1				
0	1	1	3. Receiver tube outside diameter		70 m		Choose collector t	type	×
10	0,97791	0,97894	A. Dessiver take wall this was		A 191		Choose a collector and p	press 'OK'. Related program inputs	
20	0,92189	0,95382	4. Necelver (ube waii (nickness		4,131	m	will be updated with data	a for the chosen collector.	OK
30	0,83049	0,94864	5. Aperture width (sum of primary reflecto	r widths)	12 m		Afterwards, you can alte	r these parameters as needed to	
50	0,5336	0,86104	6. Aperture width / Collector unit width (F	resnel only)	0,75 •		suit your needs.		Cancel
60	0,32563	0,7036	7. Collector unit width (for information Fre	snel only)	5 m				
70	0,1173	0,48456	8. Collector focal length		7,4 m		O Novatec Solar - Eva	porator Section (linear Fresnel)	
80	0,01103	0,23609	9. Number collector rows per flow path		1.		C: Novated Solar - Sup	erheater Section (linear Fresnel)	
90	0	0	10. Number collector row banks		1.				
							C Eurotrough II - parab	olic trough	
			11. Active reflector length as percent of to	otal length	35 %		C LUZ II - parabolic tro	uah	
			12. Collector unit row pitch / collector uni	t width	1,281		0.0		
			13. Reflector cleanliness factor		0,95		Generic parabolic tro	bugh	
			14. Row (tracking axis) rotation from due	North	0 de	egrees	L		
			15. Row (tracking axis) tilt from horizontal		0 d e	egrees			
			16. Coefficient A1 in heat loss per unit len	oth equation	1,06 W	//m-C			
			17. Coefficient A2 in heat loss per unit len	oth equation	1,2E-8 W	//m-K^4			
			18. Overall heat loss correction factor		1				
			19. Number of computational segments a	long receiver	10				

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Heat Exchangers Hardware

Shell-Tube Evaporating HX (PCE) [44]	✓ Engineering Design	Shell-Tube Superheater (PCE) [43] - SH	Engineering Design
Design Main Inpu	s	Design Main Inputs	Ì
Design Method	Design & Other Parameters Number of passes 2 Desired tube-side velocity 2.21 Tube internal fouling resistance 5.812E-5 Overall heat transfer coefficient correction factor 1 Boiling surface roughness 1.524E-6 Tube-side pressure drop correction factor 1 Shell inner diameter / tube bundle diameter 1.8 Tube-side sizing pressure / current pressure 1 Shell-side sizing pressure / current pressure 1 Minimum pressure for sizing with gas/vapor in tube 10	□Design Method	Design & Other Parameters Number of tube-side passes Desired tube-side velocity Tube internal fouling resistance 0 m ² -2-C/W Dverall heat transfer coefficient correction factor Tube-side pressure drop correction factor Tube-side pressure drop correction factor Tube-side sizing pressure / current pressure Shell-side sizing pressure / current pressure Maximum allowable shell-side pressure drop Minimum pressure for sizing with gas/vapor in tube 10 bar 10 bar
		Shell type Two pass shell	I wo Pass Shell



Storage System

- Solar Multiplier
- Hours of Storage
- HX Size (%)
- Delta T cold / hot side
- Sizing LMTD
- Molten Salts specification
- Pressure Drops





ED Mode, Outputs



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ED Mode, Outputs



Shell-Tube Superheater (PCE) [46] - Recalentador Image: Constraint of the second of	
Number of units 1 I. Tube Description (per unit) Image: Constraint of the section of	
1. Tube Description (per unit)	
1. Tube Description (per unit)	
Tube type Bare Tube	1
Tube material Carbon steel	1
Total external heat transfer area 1.760 m^2	1
Nameplate tube flow pressure 16,08 bar	1
Tube outer diameter 19,05 mm	1
Tube inner diameter 16,56 mm	1
Tube wall thickness 1,245 mm	1
Tube layout in crossflow Rotated Square	1
Number of tubes per pass 1471	1
Number of passes 2	1
Number of tubes in heater 2942	1
Tube length per pass 10,02 m	1
Tube pitch 29,53 mm	1
Heat transfer area ratio (Ao/Ai) 1,15	1
	1
2. Shell Description (per unit)	1
Nameplate shell flow pressure 12,36 bar	⊢
Shell material Carbon steel	1
Shell length 10,02 m	1
Tube bundle diameter 1.830 mm	1
Shell inner diameter 1.840 mm	1
Shell wall thickness 9,525 mm	1
Tube sheet thickness 11,11 mm	1
Overall length 11,7 m	1
Shell type Two pass shell	1
Number of baffles 26	1
Baffle spacing 371 mm	1
Baffle cut / equivalent pass diameter 18 %	1
Equivalent pass diameter 1307,2 mm	1
Shell outer diameter 1861,2 mm	1
3. Weight (per unit)	
Tube dry weight 16.123 kg	-



ED Mode, Outputs

PEACE Output - Simplified		- 🗆	×
File Edit			
Financial			
Cost Report Cash Flow			
Cost Summary	Cost Breakdown		
Cost Summary		Estimated Cost	
1. Sum of Costs for Equipment and PEACE Components		214.692.700	euro
2. Sum of User-defined Costs		0	euro
3. Sum of PEACE Components, Linked Files, and User-defined Costs (Contractor's Inter-	214.692.700	euro	
Contractor's Soft & Miscellaneous Costs	10.890.050	euro	
4. Contractor's Price	225.582.800	euro	
Owner's Soft & Miscellaneous Costs	19.322.340	euro	
5. Total - Owner's Cost (0,75 euro per USD) - See Cautionary Note Below		244.905.100	euro
6. Plant Net Electric Output		46,24	M₩e
Cautionary Note:			
In Simplified PEACE mode, THERMOFLEX does not provide complete plant cost estim	nates		
as is done in the Comprehensive PEACE mode or in GT PRO and STEAM PRO.			
In Simplified PEACE mode, THERMOFLEX only includes capital cost estimates for PEA	ACE components and for linked GT PRO, GT MASTER, and		
STEAM MASTER files. Complete plant cost estimates often contain features not inclu	uded in the THERMOFLEX		
model. It is the user's responsibility to carefully review the cost estimate and its scop	e to ensure suitability		
to the project at hand.			
Costs for features not included in the model should be included via the user-defined of	cost inputs available from:		
'Edit Inputs' -> 'Economics & Regional Costs' menu -> 'User-Defined Costs' tab.			
* Cost estimates as of August 2016.			

📕 PEACE Output - Simplified				- 🗆	-	<
File Edit						
Financial						
Cost Report Cash Flow						
Cost Summary		Cost	Breakdown			
Cost Breakdown	Unit Cost	Cost Adj. Factor	Ref. Cost	Est. Cost		
Wet Cooling Tower (PCE)			1.357.428	1.472.806	euro	
Wet Cooling Tower (PCE) [28]	1.357.428	1				
Pipe (PCE)			951.348	1.092.052	euro	
Pipe (PCE) [9]	21.991	1				
Pipe (PCE) [12]	21.991	1				
Pipe (PCE) [15]	26.073	1				
Pipe (PCE) [18]	34.464	1				
Pipe (PCE) [21]	44.167	1				
Pipe (PCE) [24]	129.147	1				
Pipe (PCE) [29]		1				
Pipe (PCE) [35]	139.441	1				
Pipe (PCE) [36]	66.112	1				
Pipe (PCE) [37]	85.835	1				
Pipe (PCE) [53]	188.671	1				
Shell-Tube Economiser (PCE)			217 735	232 253	euro	
Shell-Tube Economiser (PCE) [45]	217.735	1	211100	202.200	Curo	
						1
Shell-Tube Evaporating HX (PCE)			744.996	800.112	euro	
Shell-Tube Evaporating HX (PCE) [44]	744.996	1				
Shell-Tube Superheater (PCE)			548.888	587.184	euro	
Shell-Tube Superheater (PCE) [43] - SH		1				
Shell-Tube Superheater (PCE) [46] - Reheater	295.602	1				
			170 010 000	100 500 500		
Solar Field w/ Storage	170.010.000		173.219.300	192.588.500	euro	
Solar Field w/ Storage [39]	173.219.300	1				
						-



Off Design

- Resizing
 - Resizing the Solar Field (Check Pipes, Pumps involved)
 - Storage System Tank Temperatures and capacity
 - Resizing the Heat Exchangers (number of tubes & length / Shell geometry)
- Inputs
- Controls
- Operating Modes
- Link to MS Excel for "dynamic" simulation

Resizing the Solar Field



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Resizing the Storage System





Off-Design

Main Inputs

- Power Output
- Ambient Conditions
- Irradiance
- Time period each run represents
- Hot Tank Level
- Solar Field / Storage System status

Off Design Controls

- Solar Field

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- Desired Delivery mass Flow
- Number of operating Flow paths
- Low Heat Input Field shutdown (% of design)
- High Heat Input field Flow limit (% of design)
- Storage System
 - Working / out of service
 - Hot Tank level
 - Maximum mf (% of design)
- Flow determination
 - Control Loop for Desired Delivery mf to satisfy Power Output demand
 - HX Flow specification (network / component)
 - Controlled Splitter: parameter matching (TSH = TRH)



Off Design, Control Loop





Off Design Flow Diagram





Off Design simulation

- 1. Check Operating Modes in TFX, define the Control Loops for each case
- 2. ELINK, define variables, limits, logic functions to operate at each mode
- 3. Run a 24 hours case for Summer and Winter conditions
- 4. Calculate the Annual Yield



Off-Design Operating Modes

			5	0	
Inputs Irradiance High Very Hig	h High	High	Low	No	
Power demand 100 100	100	100	100		
Storage in service 1 1	0	1	1	1	
Hot Tank level <100 <100		100	>min	>min	
Outputs Power 100 100	100	100	100	Х	
Charging 1 1					
Discharging			1	1	
Defocus 1	1	1			

Off-Design simulation, mode 2



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Off-Design simulation, mode 4







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ELINK: Operating Modes

a	В	С	D	Е	F	G	Н	I I	J	К	L
			Base Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	
	H ELINK 25.0 (5										
	10										
				2	3	3b	4	5	6		
	Computation N	vlessage ->	Messages	Messages	Messages	Messages	ОК	Messages	Messages	Messages	
	INPUT VARIABLE DESCRIPTION	Units	Input	Input	Input	Input	Input	Input	Input	Input	
	Solar Field w/ Storage[39] Storage system status: 0=working, 1=c	ut-of-servio	Û	1	Û	Û	Ö	Ö	Ö	Ū.	
:	Control Loop [1] Enabled 0:No 1:Yes		1	0	1	1	0	1	1	0	
ı	Set point of Control Loop [1]	kW	50000	50000	50000	50000	50000	50000	50000	50000	
	Primary control input lower bound for control loop [1]	k g/s	500	500,	500,	500,	500,	500,	500,	500	
i	Primary control input upper bound for control loop [1]	k g/s	700	700,	700,	700,	700,	700,	700,	700	
i	Solar Field w Storage [39] Desired delivery massflow	k g/s	525,	700,	700,	700,	0,	700,	700,	0,	
	Solar Field w/ Storage[39] Hot tank level at start of this period	%	50	24	50	50	24	50	50	24	
i i	Solar Field w Storage[39] Hot tank temperature	С	386	386	386	386	386	386	386	386	
1	Solar Field w/ Storage(39) Cold tank temperature	С	292	292	292	292	292	292	292	292	
)	Solar Field w Storage[39] Maximum tank-side flowrate as % of n	%	100	100,0	100,0	100,0	84,6	84,6	84,6	84,6	
I	Solar Field w Storage[39] Time period this run represents	hours	1	1	1	1	1	1	1	1	
2											
3	OUTPUT VARIABLE DESCRIPTION	Units	Output	Output	Output	Output	Output	Output	Output	Output	
1	Gross power	kW .	49995	31342	49995	49992	0	50007	41745	49995	
5	Net power	k₩	43106	27140	44668	42979	-6,761	44929	36895	43106	
j.	Gross electric efficiency(LHV)	~	38,88	37,86	38,88	38,88	U	38,78	38,37	38,88	
6	Net electric efficiency[LHV]	76	33,52	32,79	34,74	33,43	U	34,84	33,92	33,52	
5	Gross heat rate(LHV)	Karkwn	9259	9508	9259	9259	U U	9284	9382	9259	
3	Net ruel input(LHV) Calas Field of Chase as (20) Delivery as a selferi	KW kala	128380	82780	128080	128080	*****	128362	108787	128080	
)	Solar Field w Storage(39) Derivery massriow	кgrs	929,	209,7	525,	929,	U	069,9	446,5	929,	
	Solar Field w Storage(39) Percentage of active aperture					0.010					
	Celes Field of Press and Stars	/。	U	U	U	9,819	U	U	U	U	
	Solar Heig wr Storage(39) Storage operation flag: (U=off,			0	-	-	-	-	-	-	
-	i = charging, - i = discharging) Salar Field wi Starage (20) Field eide abaraina flaw	kala	524.7	0	222.1	F07.0	110.2	-1	-1	E24.7	
5	Solar Field w Storage[33] Field-side charging flow	kodo	024,7 0	0	232,1	037,9	110,3	255.4	446.5	024,7	
+	Solar Field w Storage[33] Techside obstaining flow	kojs	911.9	0	404.5	935	192.2	200,4	446,0	911.9	
2	Solar Field w Storage[33] Tank-side discharging flow	kojs	0	0	404,0	0	132,2	374.6	791	0	
7	Solar Field wil Storage[39] Ending hot tank level	Ngrs V	71.06	24	59.34	716	28.44	374,0 /135	21.72	71.06	
2	Solar Freid Wi Storage(55) Erfahrig hot tarik rever	/°	71,00	24	55,54	71,0	20,44	41,00	0,70	71,00	
à.											
í.											
Ē											
2	Low Irradiance limit		425								
3	Hot Tank minimum level		25								
1	Very Low irradiance limit		150								
5	Field Shut down limit		100								
2											



ELINK: 24 hours "dynamic" simulation





ELINK: Annual Yield calculation

		_				_	_								_	_	_		_		
- 4	Α	В	С	D	E	F	G	н		J	К	L	M	N	0	P	Q	R	S	Т	U
10																					
11			<u> </u>																		
12	Start Case	10	- o	ompute Cas	ses	Press	to Cancel														
13	End Lase	10		-		1			_												
19	Current Cas	10							-				_								
10					Daile	Hourle				amnl	o (Fl	ink/		urly (Simu	latio	n_En	tiro '	Voar	vlcm	
	Care	Veek of	Danof	Hour	Auerage	Auerage	H 336		3	ampi	CLI	111174	J HU	uny .	JIIIU	ιατιυ		ILII C	icai.	VIDILI	
16	Number	Year	Year	of Date	Temperatur	Temperatur	Factor				-		-								
17	-	Tear	i cai	or Day	remperator C	remperator C	1 40(0)														
12	10	1	1	10	.19	25	0.14	z. This row o	é data con	es from the l	oput Data Sta	ok based on	the 'Current C	'ase'. Dop't e	dit this bulk an	4					
19	10			10	-40	2,0	0,14	C THISTOWO	r data con	les nom die i	nput Data Ota	ok based on	the Conence	ase. Donce	dictris by nam	.					
20																					
21			INPL	TDAT	A STACK								OUTPL		TABLE						
1					Dail	Hourly		A	perture				00110	U DATA	TADLE			Steam			
					Average	Average			normal				Aperture		Net heat		Steam	Deliveru	Steam		
	Case	Week of	Day of	Hour	Temperatur	Temperatur	Haze		direct	Azimuth	Zenith	Altitude	tracking	Oil flow in	absorbed by	Solar field	Delivery	Temperatur	Delivery	Compute	
22	Number	Year	Year	of Day	e .	e	Factor	irr	adiance	angle	angle	angle	angle	field	oil	efficiency	Pressure	e	Flow	Date+Time	
23	-	-	-	-	.C	°C	-		Włm^2	Degrees	Degrees	Degrees	Degrees	kg/s	k₩	%	bar	С	kg/s		
24	1	1	1 1	1 1	-1,9	-6,7	0,14	3	16,611298	149,849396	66,360497	23,639502	48,9292679	112,622284	19983,2246	58,366562	121,96629	378,792755	11,76	8/19/16 17:48	
25	2	1	1 1	1 2	-1,9	-6,2	0,14		0	70,0407639	150,69028	-60,690269	-27,819592	0	0	0	122,00001	325,914734	0,00	8/19/16 17:48	
26	3	1	1 1	1 3	-1,9	-5,4	0,14		0	83,0701981	139,04192	-49,041912	-40,750237	0	0	0	122,00001	325,914734	0,00	8/19/16 17:48	
27	4	1	1 1	1 4	-1,9	-4,4	0,14		0	92,5584106	127,08339	-37,083385	-52,889126	0	0	0	122,00001	325,914734	0,00	8/19/16 17:48	
28	5	1	1 1	1 5	-1,9	-3,1	0,14		0	100,776154	115,19633	-25,196327	-64,40876	0	0	0	122,00001	325,914734	0,00	8/19/16 17:48	
29	6	1	1 1	1 6	-1,9	-1,9	0,14		0	108,757729	103,62126	-13,621261	-75,645477	0	0	0	122,00001	325,914734	0,00	8/19/16 17:48	
30	7		1	1 7	-1,9	-0,6	0,14		0	117,150589	92,59549	-2,5954826	-87,083626	0	0	0	122,00001	325,914734	0,00	8/19/16 17:48	
31	8			1 8	-1,9	0,6	0,14	61	3,5349731	126,486618	82,416489	7,5835128	80,5975723	0	17000.0500	0	122,00001	325,914734	0,00	8/19/16 17:48	
32	9			1 9	-1,9	1,7	0,14	20	31,897308	137,257782	73,489937	16,510071	66,4079666	96,1009674	1/209,6523	56,348091	121,97488	379,754669	10,10	8/19/16 17:49	
33	10				-1,9	2,0	0,14		200	143,843336	66,360437	23,639502	48,3232673	10252	13383,2246	08,366062	121,36623	3/8,/82/00	100.00	8/13/16 17:43	
25	11			1 12	-1,3	3,0	0,14		200	104,3	01,00	20,32	20,00	19202	57,31	122	373,1	10.99	100,30	4/30/14 17:13	
26	12		1 1	1 12	-1,3	3,1	0,14		200,1	195.7	60,04	23,30	-0,003E-06	19252	57,42	122	279.1	10,00	103,30	4/30/14 17:13	
37	14	-	1 1	1 14	19	25	0,14		316.6	210.2	66,36	23.64	-48.93	19983	58.36	122	378.8	11.76	112 70	4/30/14 17:19	
38	15	-	1	1 15	-19	17	0,14		281.9	222.7	73 49	16.51	-66 41	17209	56.35	122	379.8	10.1	96 15	4/30/14 17:19	
39	16	-	1	1 16	-1.9	0.6	0.14		68,53	233.5	82,42	7,584	-80.6	0	0	122	325.9	8.172E-08	0,00	4/30/14 17:19	
40	17		1 1	1 17	-1.9	-0.6	0.14		0	242.8	92.6	-2,595	87,08	0	0	122	325.9	8,172E-08	0,00	4/30/14 17:19	
41	18	1	1 1	1 18	-1,9	-1,9	0,14		0	251,2	103,6	-13,62	75,65	0	0	122	325,9	8,172E-08	0,00	4/30/14 17:20	
42	19	1	1 1	1 19	-1,9	-3,1	0,14		0	259,2	115,2	-25,2	64,41	0	0	122	325,9	8,172E-08	0,00	4/30/14 17:20	
43	20	1	1 1	1 20	-1,9	-4,4	0,14		0	267,4	127,1	-37,08	52,89	0	0	122	325,9	8,172E-08	0,00	4/30/14 17:20	
44	21	1	1 1	1 21	-1,9	-5,4	0,14		0	276,9	139	-49,04	40,75	0	0	122	325,9	8,172E-08	0,00	4/30/14 17:20	
45	22	1	1 1	1 22	-1,9	-6,2	0,14		0	290	150,7	-60,69	27,82	0	0	122	325,9	8,172E-08	0,00	4/30/14 17:20	
46	23	1	1 1	1 23	-1,9	-6,7	0,14		0	313	161	-70,98	14,14	0	0	122	325,9	8,172E-08	0,00	4/30/14 17:20	
47	24	1	1 1	1 24	-1,9	-6,9	0,14		0	2,732E-05	166	-76,04	-6,793E-06	0	0	122	325,9	8,172E-08	0,00	4/30/14 17:20	
48	25	1	1 2	2 1	-1,9	-6,7	0,14		0	46,8	160,9	-70,92	-14,15	0	0	122	325,9	8,172E-08	0,00	4/30/14 17:20	
49	26		1 2	2 2	-1,9	-6,2	0,14		0	69,91	150,6	-60,64	-27,84	0	0	122	325,9	8,172E-08	0,00	4/30/14 17:20	
50	27			3	-1,9	-5,4	0,14		0	82,96	139	-49	-40,78	0	0	122	325,9	8,172E-08	0,00	4/30/14 17:20	
51	28			4	-1,9	-4,4	0,14		0	92,47	127	-37,04	-52,93	0	0	122	325,9	8,172E-08	0,00	4730/14 17:20	
52	29			. 5	-1,9	-3,2	0,14		0	100,7	115,2	-20,15	-64,46	0	U	122	325,9	8,172E-08	0,00	4r30/14 17:20	
54	30		1 2	. 6	-1,9	-1,3	0,14		0	108,7	92.64	-13,98	-70,7	0	0	122	320,8	6,172E-08 9,172E-09	0,00	4730714 17:20	
		E	INK N	lain	Holp	nformati	on	Input+	Juter	it Data			•or 14					a to realla			
	- 4 P			ann	heib±i	mormati		mputt	Juch	it Data	(9									

^{hermoflow} Running your own software for detailed Solar Field

calculations?

 \rightarrow Replace the SF with a Heat Adder

→ELINK: enter the Heat Transfer, oulet state & Pessure Drop to the Heat Adder Add the associated Auxiliary Power



Solar Thermal info and examples

ome	Products	Licensing	Support	Training	Tutorials	Services	Careers
	Overview		1 2 %	Star SE	Cherry .		
Products >	Combined Cycle	rview					
THERM	Conventional	EACE: So	olar Therma	al Modeling			
These powe	erft Solar Thermal	Overview	design of thern	nal power systems,	and for simulation	on of off-design pla	nt performance.
THERMOFL THERMOFL	EX EX Special Utilities	Solar Field	III freedom to odel complete p	construct flowsheets ower plants of virtual	s using compone Ily every type, or to	nt models available model only a small	in its toolbox. subsystem such
as a pump a	nd Free Trial	Solar Resource	view of color th	ormal modeling featu	ree with exemples		
SAMPL	_ES	solar mermai mo	deling reatures in T	nermonow sonware,	presented at Solar	PACES 2009 conten	ence in Benin.
A large varie	ety of solar thermal m	odels can be bui	t with the tools prov	vided in THERMOFLI	EX and PEACE. A	selection is shown b	pelow.
Kramer Juno	tion SEGS VI Plant						
Hybrid Solar	-Fossil Power Plant						
Integrated S	olar Combined Cycle	1					
Air Condition	ning with Solar Heat						
Solar Therm	al Desalination						

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Solar Thermal Samples

THERMOFLEX

(S5-07)SolarThermal_ParabolicTrough:
(S5-07a)SolarThermal_Tower:
(S5-08)Integrated Solar Combined Cycle:
(S5-09)SolarThermalStorage_RankineCycle_OD:
(S5-09B) MoltenSaltThermalStorage_RankineCycle_OD:
(S5-10) SolarThermal_Fresnel_DirectSteamGeneration:
(S5-10a) SolarThermal_Fresnel_DSG_FossilBackup:
(S5-22)SolarPV with Gas Turbine Backup using Scripting:

EXCEL

(S5-09)SolarThermalStorage_AnnualOperation
(S5-08) Integrated Solar Combined Cycle
(S5-09b)MoltenSaltThermalStorage_RankineCycle_OD
(S5-10) SolarThermal_Fresnel_DirectSteamGeneration
(S5-10a) SolarThermal_Fresnel_DSG_FossilBackup
(ELINK4)Hourly Simulation - Entire Year



Q & A Session

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