Feasibility Study on Solar Process Heat in Jordan Using the Software greenius

Knowledge for Tomorrow

German Aerospace Center (DLR)

Institute of Solar Research Lisa Willwerth



The software tool greenius

- Free & easy
- Simulation of different renewable energy systems for heat or electricity generation
- Main focus on concentrating solar technology
- Customized for fast and simple calculations
- Based on hourly performance simulation of a typical year
- Utilization for e.g. feasibility studies or technology comparisons
- User support by DLR

Homepage of **greenius**:

none Parabolic Trough Powerplant E) Trough Powerplant with Storage Parabolic Troughs for Process Heat Process Heat with non-concentrating collectors Chiller with Parabolic Troughs Chiller with non-concentrating collectors Power Tower System 86 2 **Dish Stirling Systems** 1 Grid Connected Photovoltaic System Concentrating Photovoltaic System 1 眷 Wind Power Park Fuel Cell 1 Fuel Cell with Storage 12 Import Data éş, <u>0</u>K Cancel

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http://freegreenius.dlr.de/

Select Technology



General structure of greenius





Typical Operation Yes Edit View Visu

General Results

greenius User Interface



Nation : Spain	
The electricity tariff for injection from renewables is 0.27 €/kWh. The tuel price is 0.05 €/kWh and the discount rate 6.0 %.	
The utilization of 12.0 % fossil fuel is allowed.	
Location : Spain - Andasol The location of the project will be in Spain - Andesol.	
It is located on 37.13 $^{\circ}N$ -3.06 E, 1100 m above sea level (timezone 1.0 h). The specific grading and land costs are 1.2 C/m² and 2.0 C/m².	
Load Curve and OS	
No Load curve is defined. Operating strategy is: Load Curve Data 1 Every Load or Edition define load curve and change the operation mode.	
r reo cola or Lanko demo loga conte energio ne operation mode.	
Meteo : Andasol	
It is located at 37.13"N -3.06"E, 1100 m (timezone 1.0 h). Temperature min. is 0.7 "C, max. 38.1" C, mean 17.4 "C. The annuel sum of clobal irradiation CHI is 1985 Wolv/m ² and the sum of direct normal irradiation DNI is 2111 Wolv/m ²	
The annual sum of diffuse irradiation Diffic 571 KWh/m ² Max wind speed is 14.4 m/s, mean is 3.0 m/s.	
Ready	





Direct Solar Steam Generation with Fresnel Collectors



Feasibility Study – Using Solar Thermal Steam Generation as Fuel Saver

- Solar energy is used to save fossil fuel for steam generation
- Basic solar field parameters:

Parameter	Value	Comment
Nominal Steam Production	900kW	1.4 t/h of sat. steam @212°C/20bar
Solar Field Aperture Area	1760 m²	
Required Land Area	3000 m²	e.g. 75m x 40m



Solar Radiation Profile of Jordan

Annual DNI (Direct Normal Irradiation)

- in Ammãn (meteonorm 7): 2438 kWh/m²
- in Ma'ãn (enerMENA measured data): 2736 kWh/m² (2011-2015)
- Used for simulation: 2460 kWh/m²

very high potential!





Economic Boundary Conditions

Parameter	Value	Comment
Fossil Steam Generation Cost in 2017	81.7 €/MWh _{th}	Only running cost; boiler efficiency 80%; ex. Rate 0.75 JOD/€
Turn-Key Investment Cost	766 000 €	i.e. 435 €/m² (Industrial Solar costs – 10% incentives)
Running Cost per year	12 000 €	+1% per year
Equity Ratio	20%	
Debt Ratio	80%	
Debt term	10 years	
Debt funding interest rate	4%	



Impact Factor: Future Diesel Price

Diesel Price Jordan [€/I]



Technical Key Results

Result	Value	Unit
Annual DNI	2460	kWh/m²
Annual Solar Heat Output	1034	kWh/m²
Annual Solar Steam Generation	2765	t
Annual Field Efficiency	42	%



Typical Steam Production Summer







Typical Steam Production Winter







Annual Steam Production Profile





Expected Life Time Savings and Costs of Solar Field





Economic Key Results and Cumulated Cash Flow



Economic Key Results	Base Case	6% Interest	100% Equity	
Payback Time	2.3	2.7	4.8	Years
Internal Rate of Return (IRR)	52	47	23	%
Levelized Heat Cost	41.4	41.4	41.4	€/MWh _{th}



Summary

- Jordan has very attractive solar irradiation conditions
- First solar field has already been built
- Technology
 - Direct steam generation (DSG) in Fresnel collectors is efficient and reliable
 - Steam generation varies significantly between summer and winter
 - Turn-Key collector field costs about 435 \$/m² (depend on field size)
 - Field efficiency reaches 42%
- Economics
 - Solar collectors produce steam much cheaper (41€/MWh) than Diesel boilers (81€/MWh only fuel costs)
 - Comparison depends significantly on fossil fuel costs
 - Payback time for investments in solar collectors is 2-3 years (20% Equity)
 - Even with constant fossil fuel prices payback time is below 3 years