Feasibility Study on Solar Process Heat in Lebanon: The FreeGreenius Software

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Overview

Software for calculation of solar energy supply and economics

Case study Lebanon

Why calculation software?

Calculate thermal power output of a solar installation during a day and the year for a given solar field and demand structure

Calculate economical data like pay back times

Optimise layout of a solar installation

Compare technologies

Homepage of greenius
http://freegreenius.dlr.de/

Greenius manual
http://freegreenius.dlr.de/images/greeniusdata/Greenius-Manual_4_1.pdf

Description of FreeGreenius

FreeGreenius is the freely available version of the software greenius which has been developed at the Institute of Solar Research of the German Aerospace Center (DLR) since several years.

⇒ Fast and simple performance calculations of Concentrating Solar Power (CSP) and other renewable energy systems based on hourly plant performance simulations.

⇒ Greenius is continuously extended e.g. to simulate also solar towers, solar process heat generation and solar cooling.

⇒ It offers a combination of fast technical performance calculations, economical calculations and user interfaces for parameter manipulation and analysis of the results.

⇒ Third party meteorological data and performance maps generated with other software tools may be integrated easily.

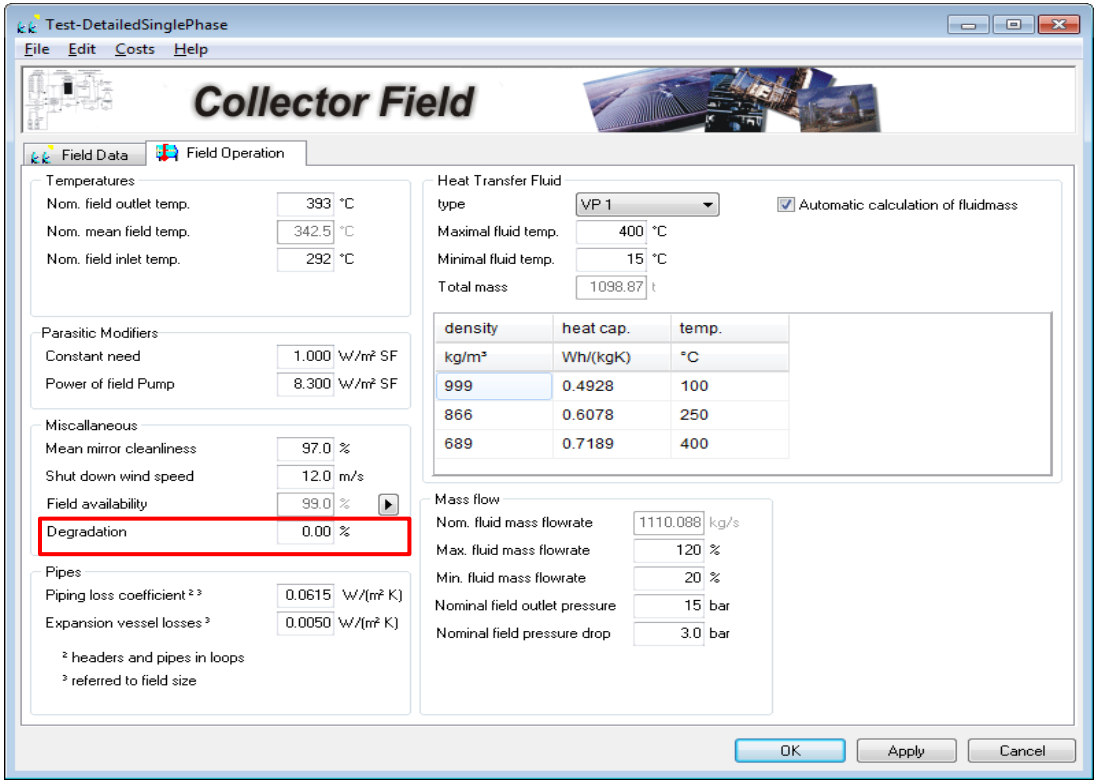
Description of greenius

Selected inputs for project site, technology, economics:

Position (to calculate sun position in regard to collector surface)
Local weather data file in hourly resolution
Demand profile, temperatures
Solar field size
Temperature range
Storage size
Investment costs
Costs for heat and electricity

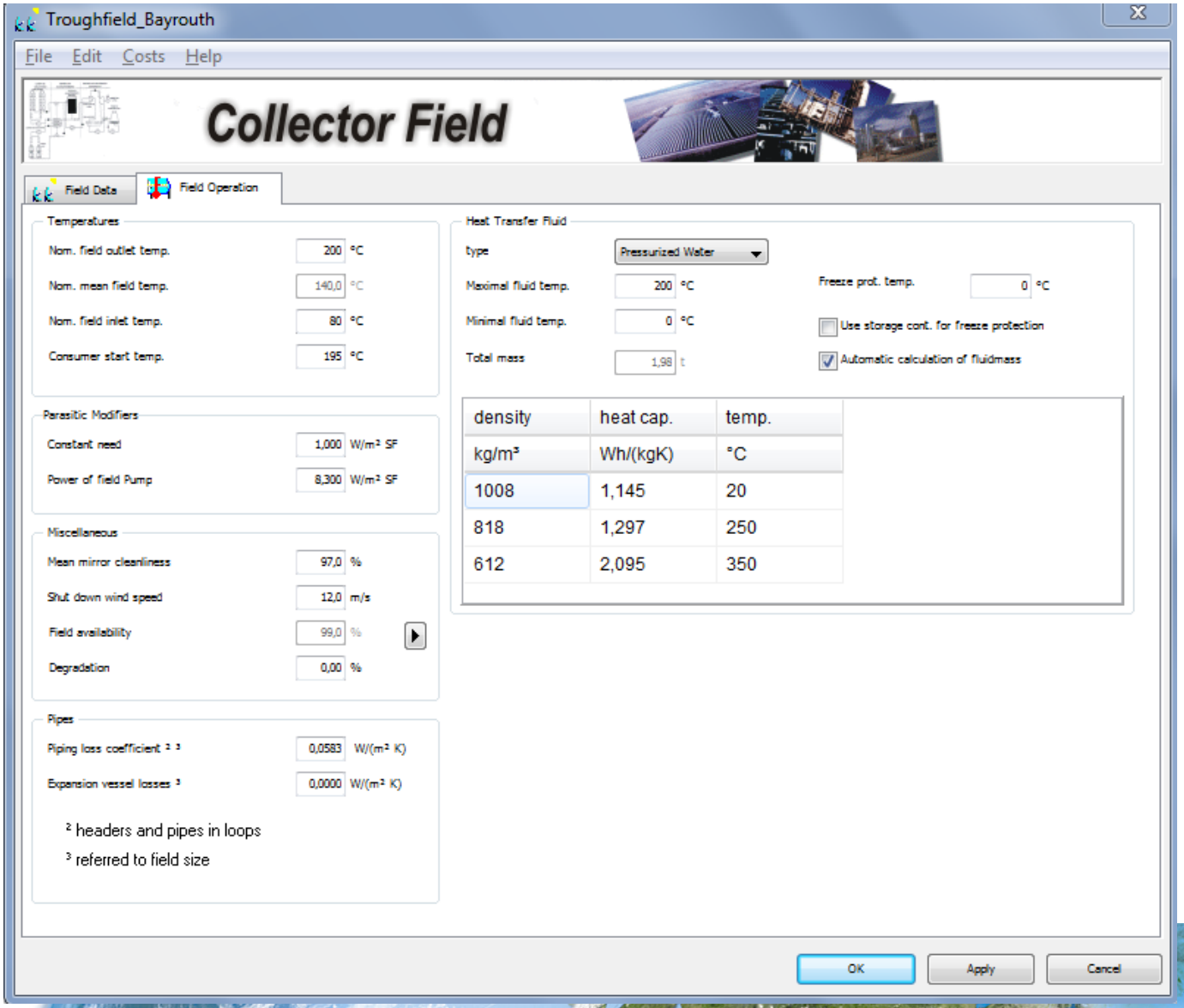
Selected outputs:

Solar thermal power
Auxiliary power
Cash flow
Summarised results
All data available in excel in hourly resolution

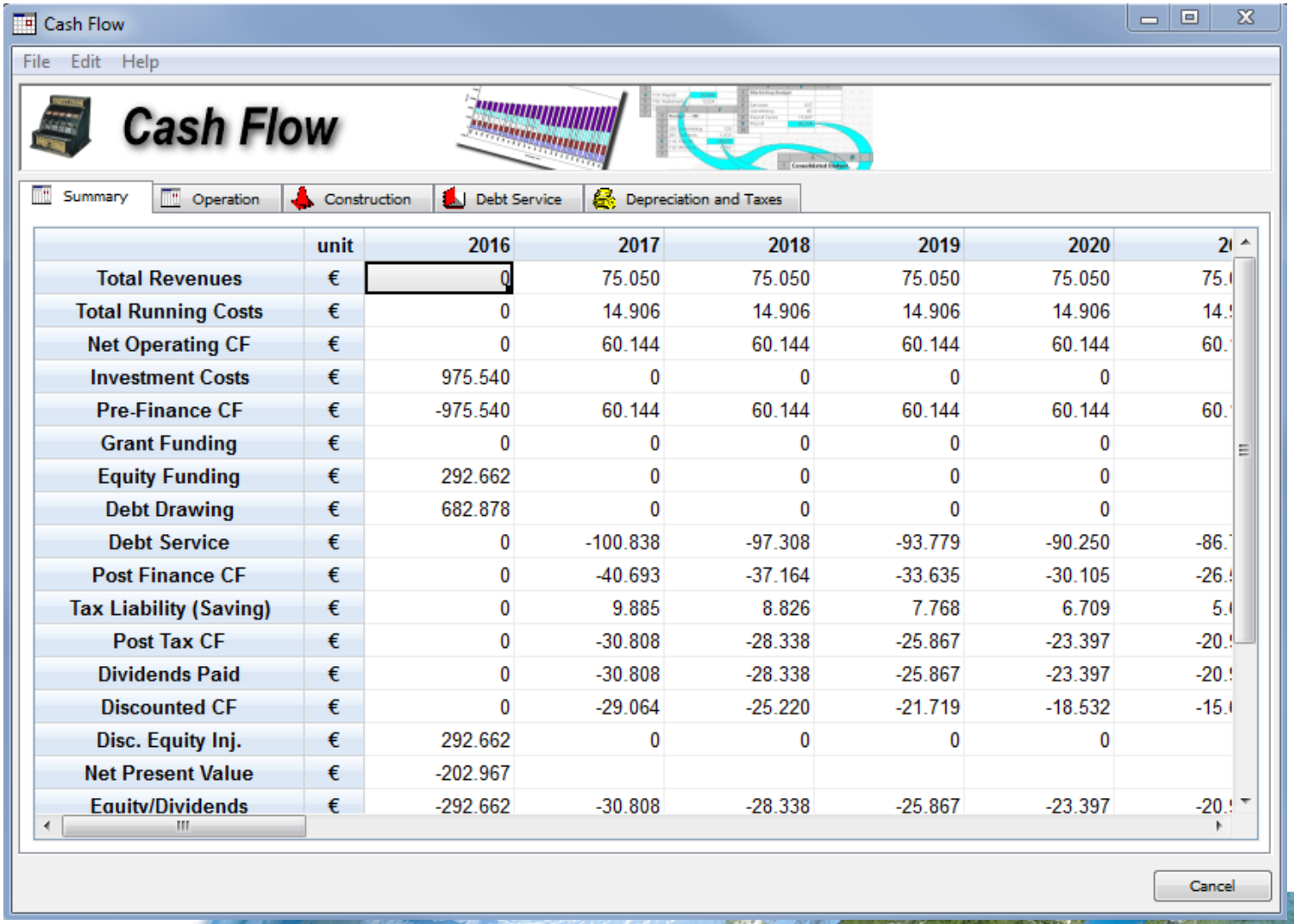


Example page greenius

Description of greenius
Example inputs collector field

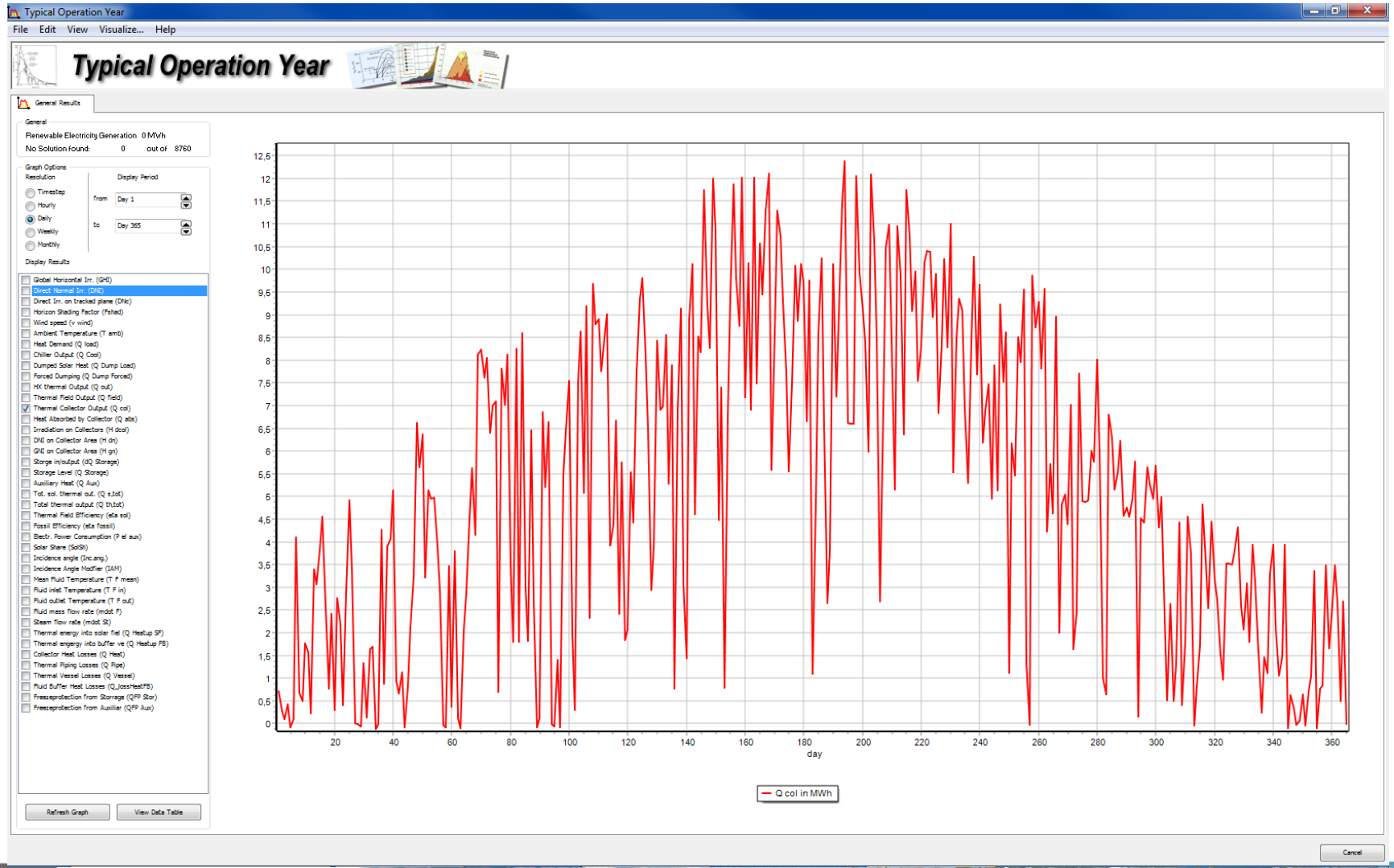


Description of greenius
Example cash flow

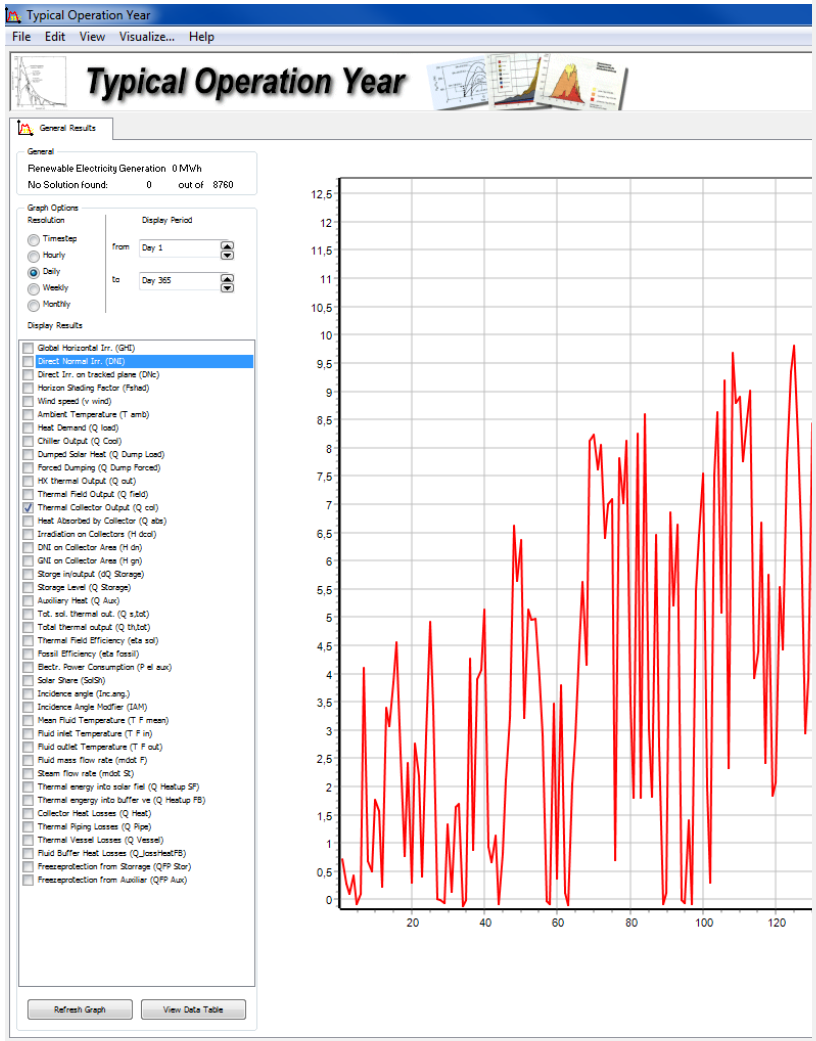


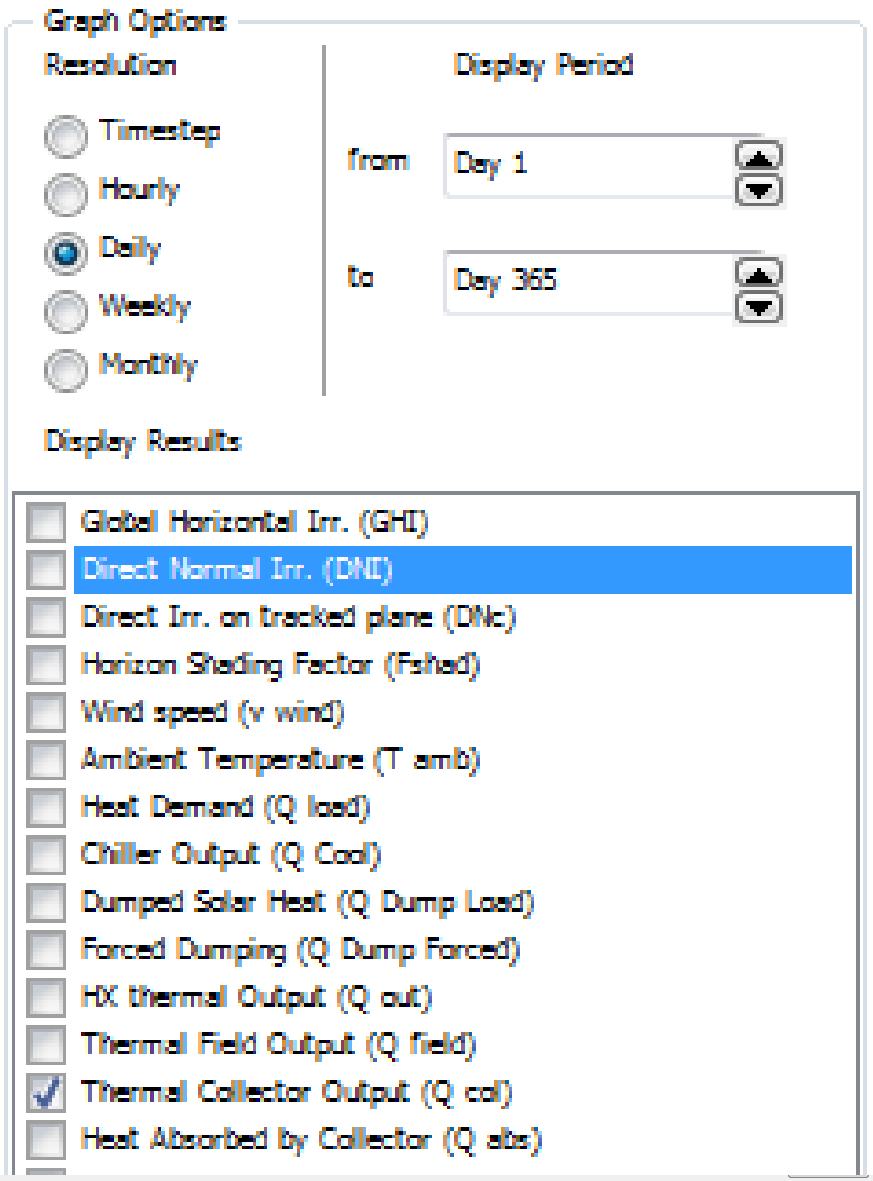
	unit	2016	2017	2018	2019	2020	2(
Total Revenues	€	0	75.050	75.050	75.050	75.050	75.(
Total Running Costs	€	0	14.906	14.906	14.906	14.906	14.!
Net Operating CF	€	0	60.144	60.144	60.144	60.144	60.1
Investment Costs	€	975.540	0	0	0	0	
Pre-Finance CF	€	-975.540	60.144	60.144	60.144	60.144	60.1
Grant Funding	€	0	0	0	0	0	
Equity Funding	€	292.662	0	0	0	0	
Debt Drawing	€	682.878	0	0	0	0	
Debt Service	€	0	-100.838	-97.308	-93.779	-90.250	-86.7
Post Finance CF	€	0	-40.693	-37.164	-33.635	-30.105	-26.!
Tax Liability (Saving)	€	0	9.885	8.826	7.768	6.709	5.(
Post Tax CF	€	0	-30.808	-28.338	-25.867	-23.397	-20.!
Dividends Paid	€	0	-30.808	-28.338	-25.867	-23.397	-20.!
Discounted CF	€	0	-29.064	-25.220	-21.719	-18.532	-15.(
Disc. Equity Inj.	€	292.662	0	0	0	0	
Net Present Value	€	-202.967					
Equity/Dividends	€	-292.662	-30.808	-28.338	-25.867	-23.397	-20.!

Description of greenius
Example profiles



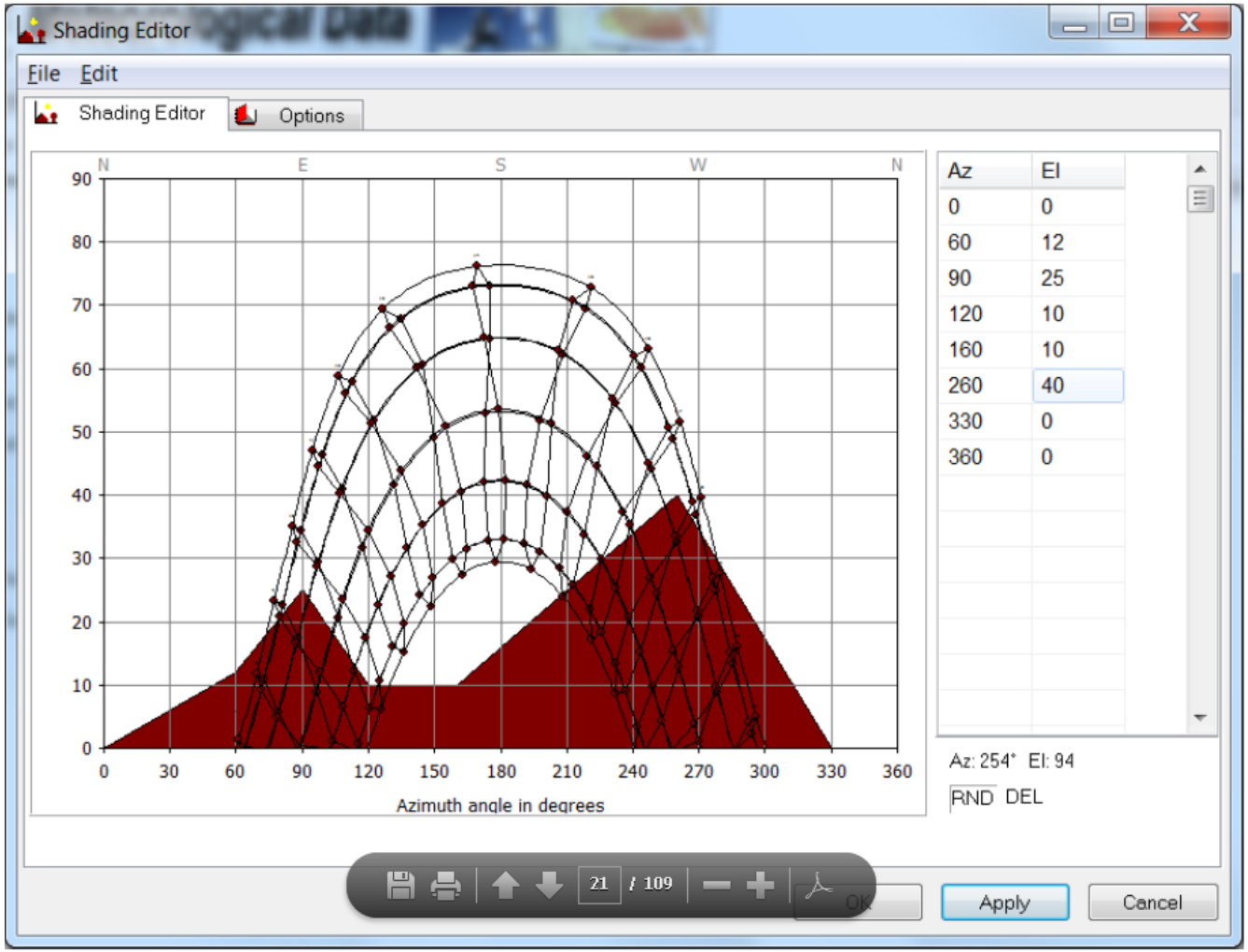
Description of greenius
Example profiles



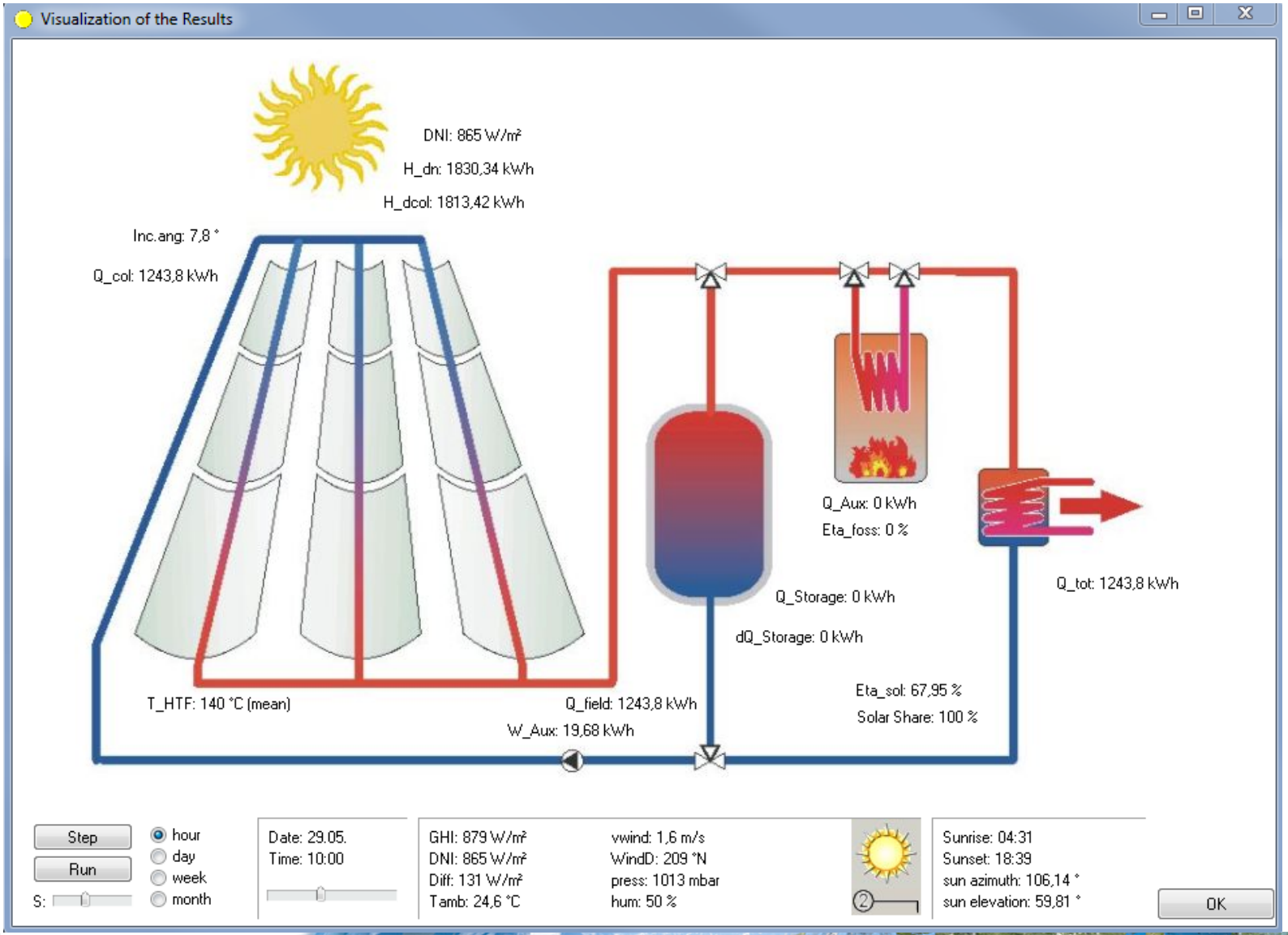


Description of greenius

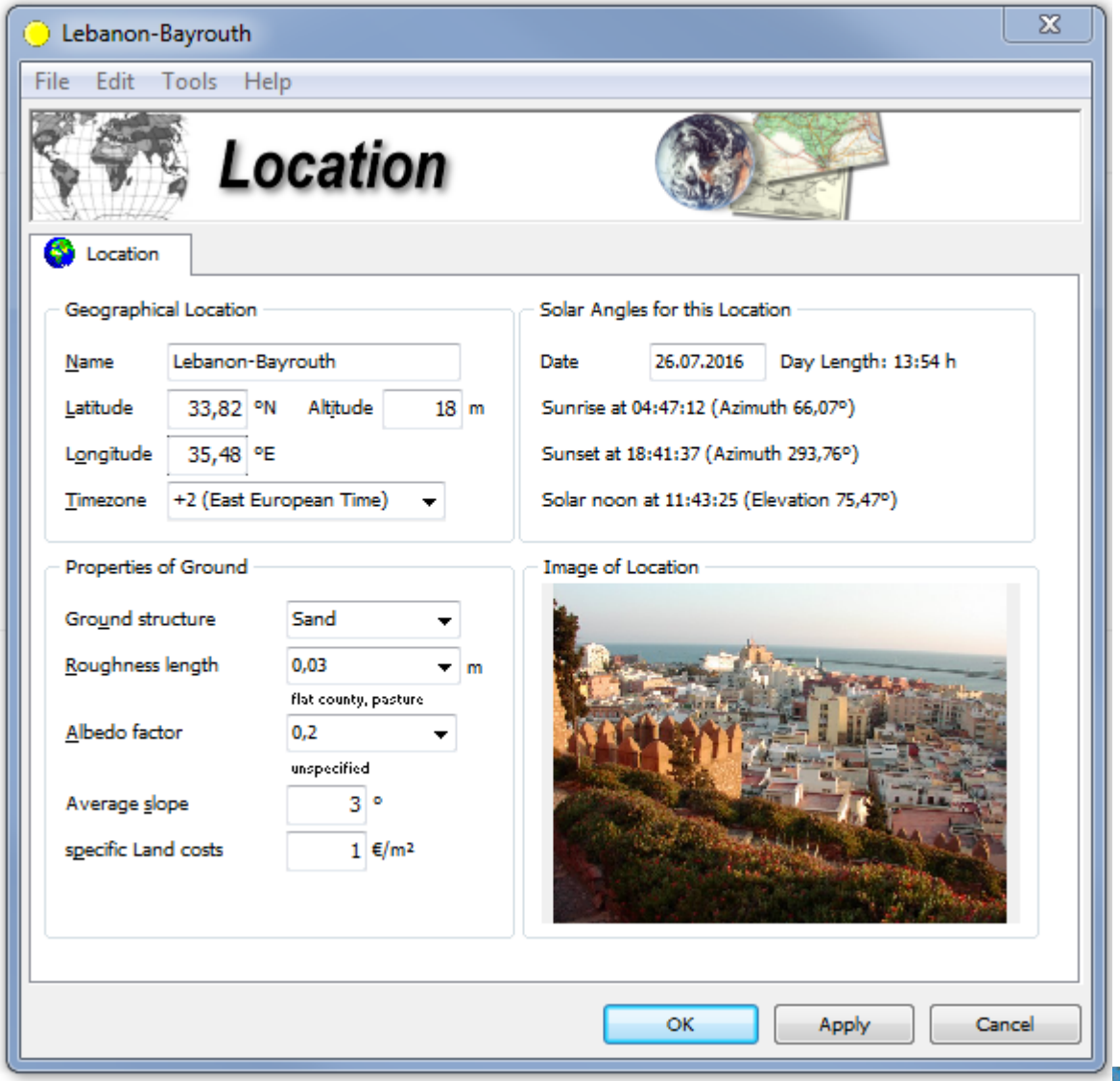
Shading editor



Description of greenius



Lebanon example calculation



Lebanon example calculation

Collector technology: Parabolic Trough (alternativ Fresnel)

Collector field size: 2116 m²

Assumption all solar energy consumed

Temperature from solar field: 200°C

Maintenance 1 € /(m²*a)

Replacement costs 0.2%/a

Insurance costs 0.8%/a

Assumed costs per m² of collector surface: 300 €/m² installed

plus land costs, civil works, foundations, fence and freight, project development, supervision (*Specific costs lower with greater size!)*

Estimated total investment costs 975,540 €

Financial Input Parameters:

Heat Tariff	0,0400	€/kWh_th
Grant Proportion (Renewable)	0,00	%
Debt-Equity-Ratio	70,00	%
Average Interest Rate	5,64	%

High uncertainty about conditions in Lebanon

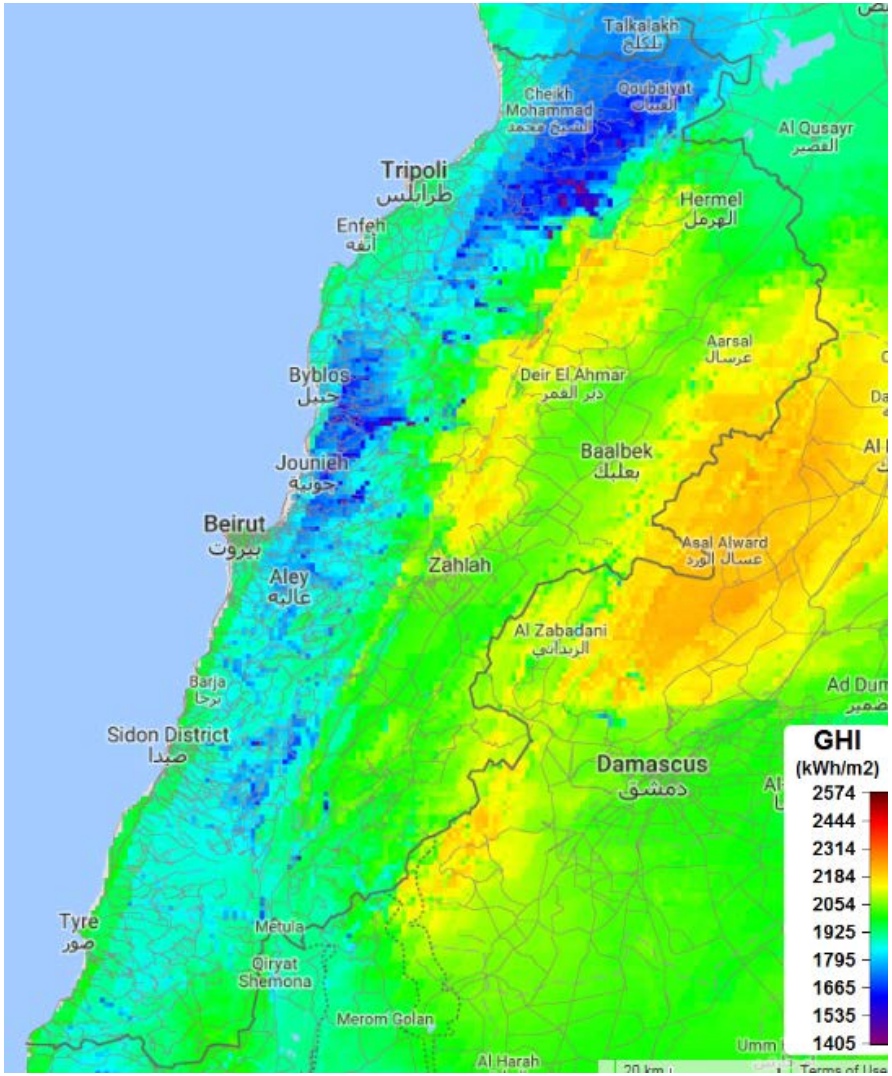
Weather data Beirut used for calculation

Data from MeteoNorm in hourly resolution:

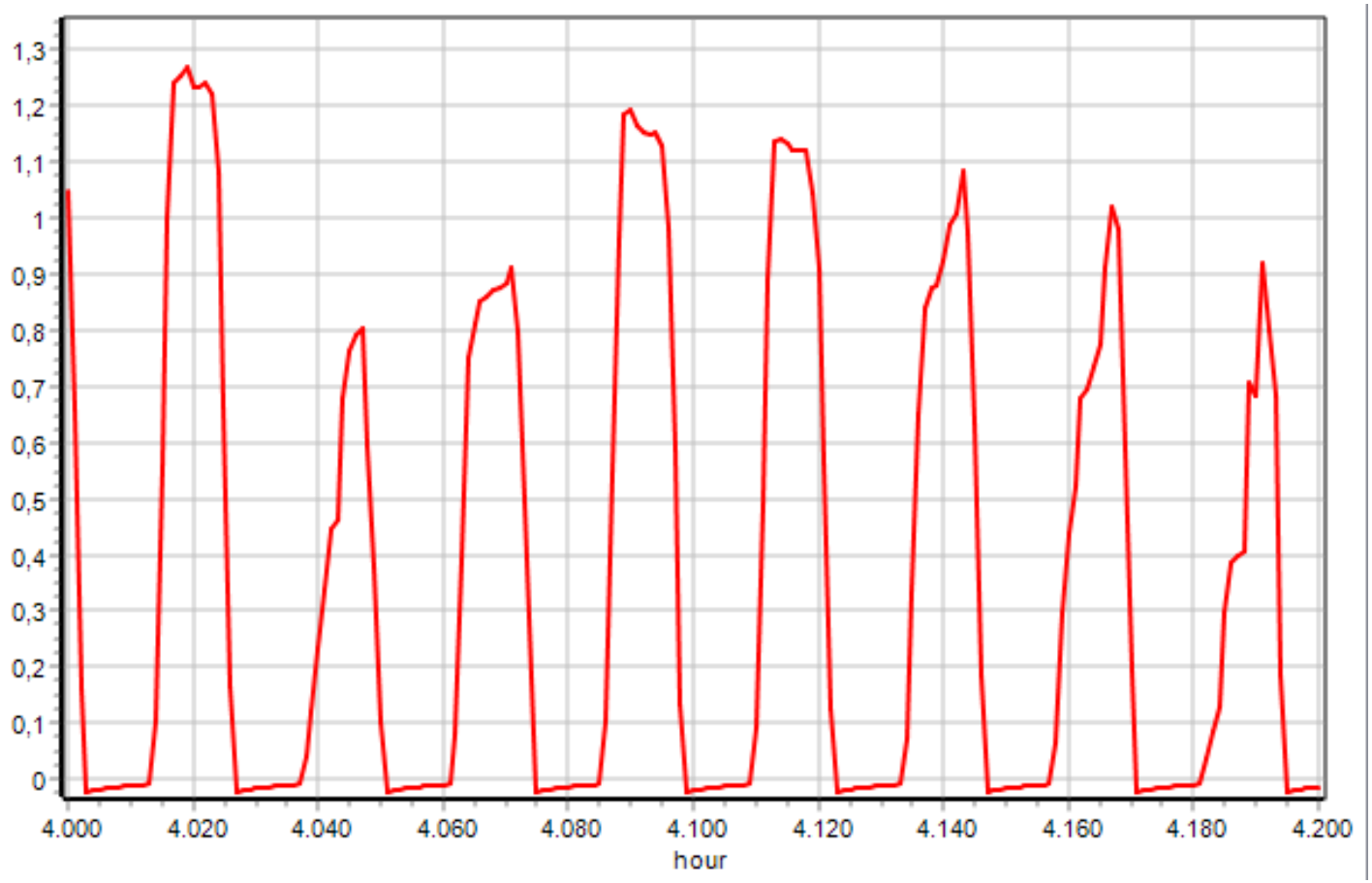
DNI (Direct Normal Radiation)

Ambient temperature

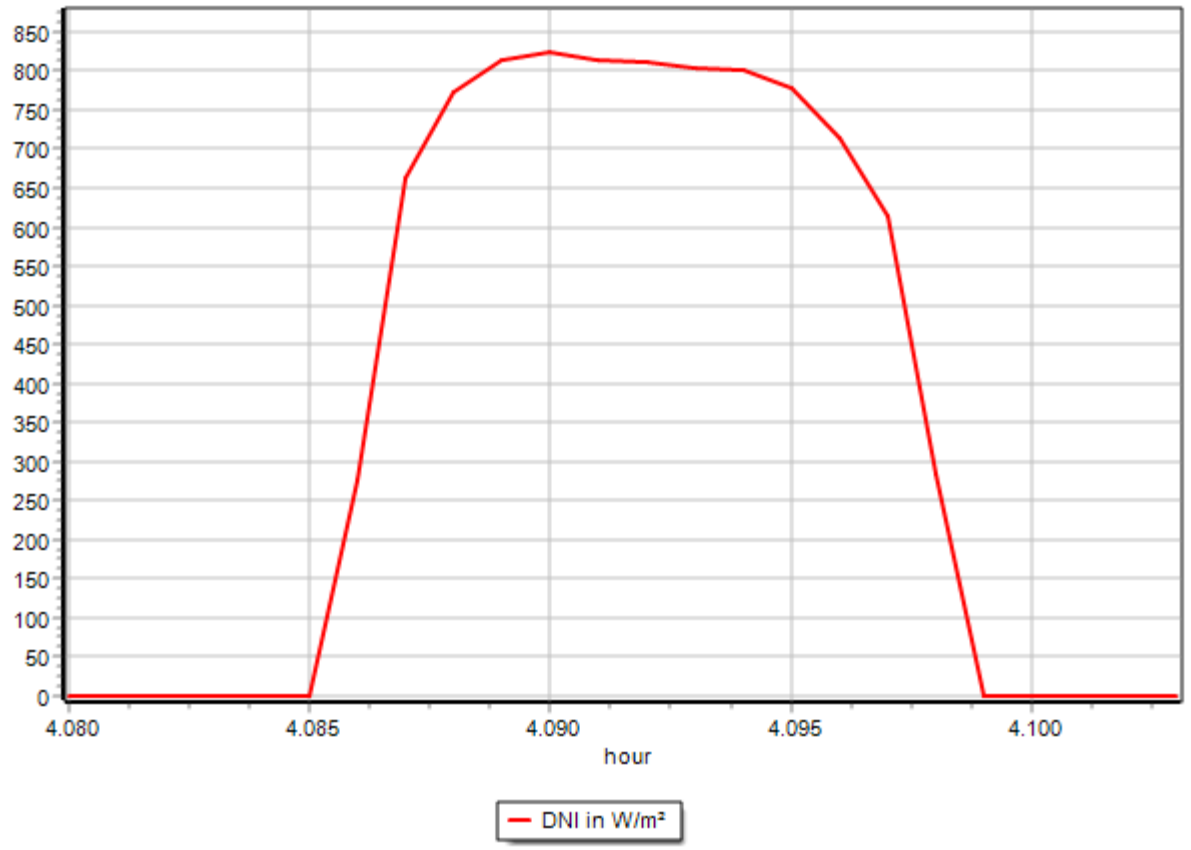
(Annual DNI in Beirut: 1864 kWh/m²)



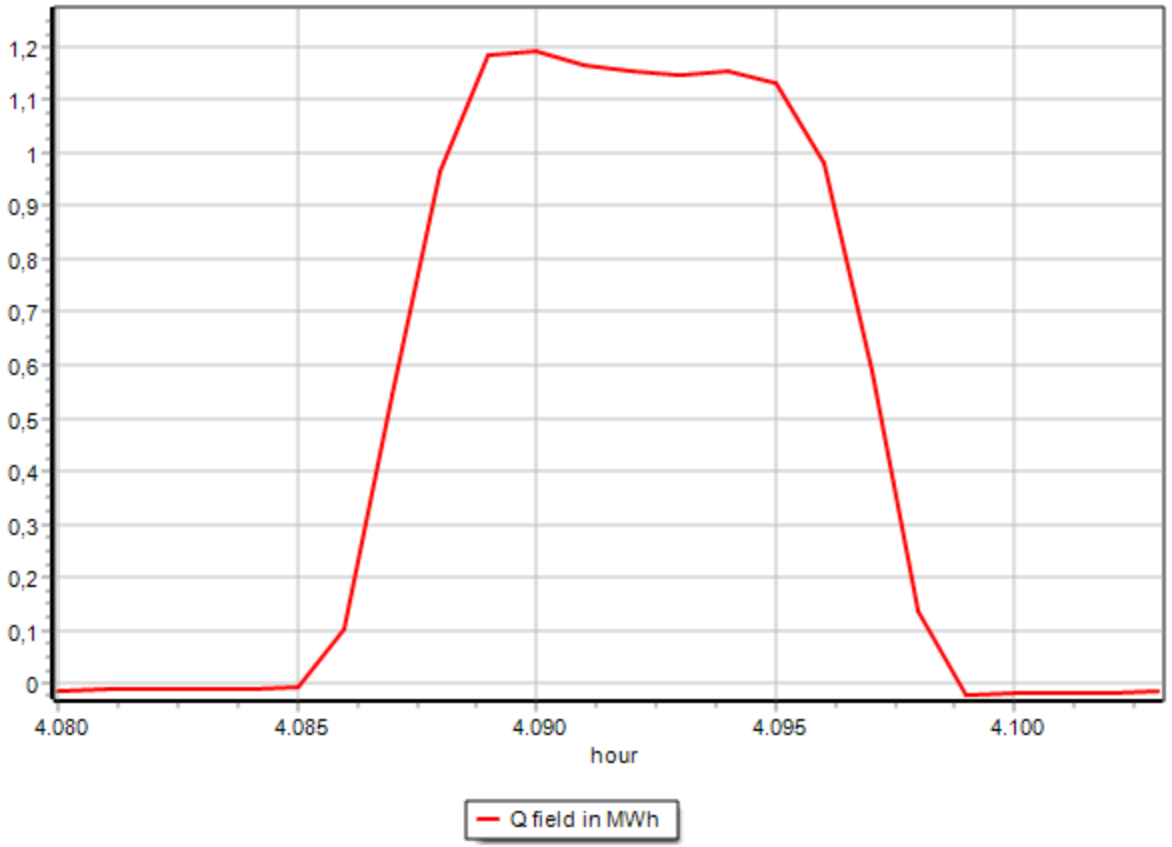
Solar field thermal production during several days in June



Solar field thermal production one day in June



Solar field thermal production during several days in June



Technical Key Results

Direct normal irradiance (DNI)	1864	kWh/(m²·a)
Annual solar heat generation	1,876	MWhth
Specific thermal field output	886,69	kWh_th/m²
Mean annual field efficiency	47.57	%
Solar share	100.00	%
Annual electricity consumption	29	MWhel

Economical Key Results

Simulation Results:		
Internal Rate of Return (IRR) on Equity	1,96	%
Net Present Value	-202.967	€
Payback Period	21	yrs.
Levelized Heat Costs (LHC)	0,0463	€/kWh_th
Annuity of Investment Costs	0,08	
NPV of Running Costs (OC)	135.248	€
Environmental Aspects:		
Annual CO2 Reduction	562,88	t CO2

Other data given as annual values e.g. revenues, debt service etc.

The required heat price is 0.079 €/kWh to match the minimum required IRR of 12%

Check financial parameters – no inflation included

Improving chances for solar process heat projects

Cost reduction via local production
Create awareness and know-how about the technology
Create motivation in industry through local production
Funding through e.g. EU projects
Creating awareness that solar energy provides price stability
National programme including subsidies
Drive costs down by experiences from installations

Summary

No examples for such installations in Lebanon - so still high uncertainty

National heat demand structure investigated?

Local share unknown – who can assist in building and maintenance of installations?

Good radiation potential in Lebanon

Demonstration projects necessary to gain experiences