
POLYGENERATION USING CONCENTRATED SOLAR THERMAL POWER



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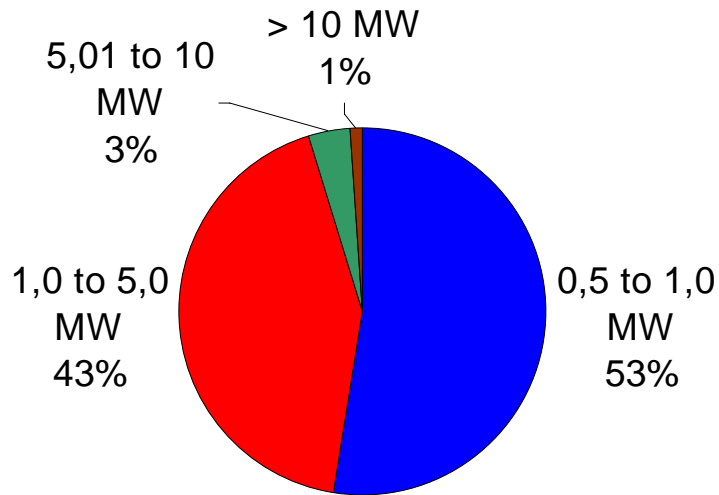
Solar Polygeneration

Content

- Motivation and Market Potentials
- What is Solar Polygeneration
- Does Solar Polygeneration pay off?
- Conclusion
- Outlook



Diesel Generator Orders Worldwide



Source: Diesel & Gasturbine Worldwide 10/2008

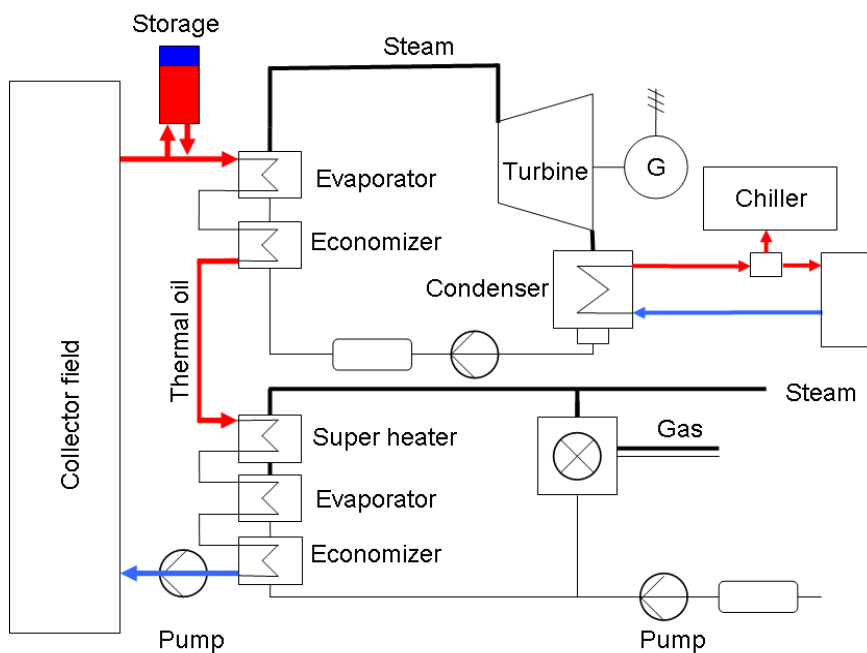
➔ 96 % (9500 units/year) below 5 MW



10/20/2009

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Combined Production of Electricity, Heat and Cold



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Technical Assumptions

- Large turbines:
about 85 %

- Dry Cooling

Parameter	Unit	Value
Fresnel Collector		
Optical Efficiency	[-]	67%
Heat Engine		
Isentropic Efficiency	[-]	70 %
Electrical Efficiency	[-]	19% (variable depending on T_{in} , load and T_{cond})

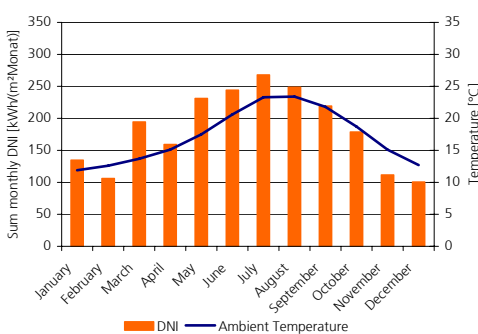
Investment Assumptions

Component	Unit	Specific Investment
Collector	[€/m ²]	300
Power Block	[€/kW]	1500
Storage	[€/m ³]	1000
Steam Generator Process Heat	[€/kW]	25
Absorption Chiller	[€/kW]	280

Economical Assumptions

	Unit	Costs
Operation and Maintenance	[% p.a.]	2
Insurance	[% p.a.]	1
Feed-in-tariff (Portugal)	[€/kWh]	27
Electricity cost	[€/kWh]	10
Rate of electricity price increase	[% p.a.]	2,5
Oil price	[€/kWh]	0,08
Rate of oil /diesel price increase	[% p.a.]	8
Electricity generation costs diesel generator	[€/kWh]	0,31

Location



■ Faro, Portugal

■ Annual Direct Normal Irradiation (DNI):
2197 kWh/(m² a)

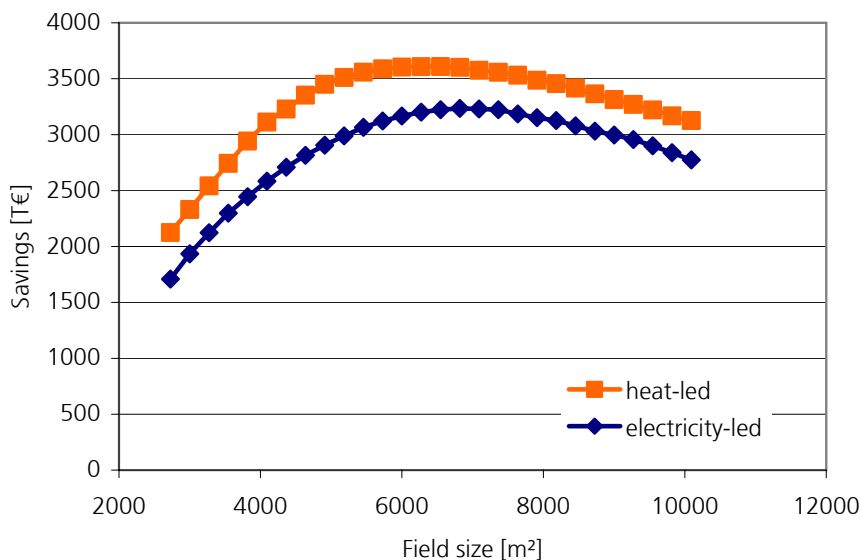
■ Fed-in tariff: 27 Cent / kWh

➡ Representative for good location in South Europe

Optimization for maximum savings

Parameters:

- Field size
- Storage size
- El. nom. power
- Nom. power heat
- Nom. power cold
- Operation strategy



➔ About 4000 Simulation runs per case



Grid Connected System

- Process Heat 800 kW
9 am till 6 pm
- Process Cold 500 kW
24 h
- Fed-in tariff:
0,27 €/kWh

Parameter	CSP electricity only	CSP Polygeneration
Pel,nom [kWel]	300	300
Pchill,nom [kWcold]	0	500
Pheat,nom [kWth]	0	800
Field Size [m²]	4000	6500
Storage Size [m³]	30	80
Financial Savings [T€]	----	3600
Investment [T€]	1600	2700
Payback Time [a]	-----	11
IRR [%]	-----	16
LEC [€/kWh]	0.35	-----



Off-Grid System

	Parameter	CSP electricity only	CSP Polygeneration
■ Process Heat 800 kW 9 am till 6 pm	Pel,nom [kWel]	170	300
■ Variable Electricity Demand Max.: 420 kW	Pchill,nom [kWcold]	0	500
	Pheat,nom [kWth]	0	800
■ Electricity Costs Diesel Generator 0,31 €/kWh	Field Size [m ²]	4600	8500
	Storage Size [m ³]	280	200
	Financial Savings [T€]	2000	9000
	Investment [T€]	2000	3400
	Payback Time [a]	15	9
→ Better economics than grid connected	IRR [%]	13	20
	LEC [€/kWh]	0.37	-----

Worst-Case-Scenario

	Parameter	CSP el. Only Grid	CSP Poly. Grid	CSP Poly. Off-grid
■ Collector field: 500 €/m ²				
■ Power block 4000 €/kW	Pel,nom [kWel]	300	170	200
	Pchill,nom [kWcold]	0	500	500
	Pheat,nom [kWth]	0	800	800
	Field Size [m ²]	3000	4600	6000
	Storage Size [m ³]	10	60	160
	Financial Savings [T€]	no savings	1500	6000
	Investment [T€]	2700	3200	4400
	Payback Time [a]	-----	18	13
	LEC [€/kWh]	0.70	-----	-----

→ Also pays off

Advantages of Small Solar Polygeneration Systems

- Lower Investment
- Small and Medium Sized Companies can take part
- Feasible for remote locations (mines ...)
- No feed-in tariff necessary

Summary

- Solar Polygeneration with concentrating collectors can save cost
- Combined generation leads to better economics
- Off-grid cases where a diesel genset is replaced have the best economics

Outlook

- Develop and test components with dynamic heat source
- Control and interaction of all components
- Demonstration projects

Thank you!