Train the Trainer 2
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Economic feasibility of solar thermal plants

ENTRAIN | Solites| Patrick Geiger

ECONOMIC FEASIBILITY OF SOLAR THERMAL PLANTS

Calculation of the economic feasibility

Overview of cost types and key figures

Example calculation and influencing factors

CALCULATION OF THE ECONOMIC FEASIBILITY

- For large-scale solar thermal plants, the economic feasibility is usually assessed on the basis of the heat production costs

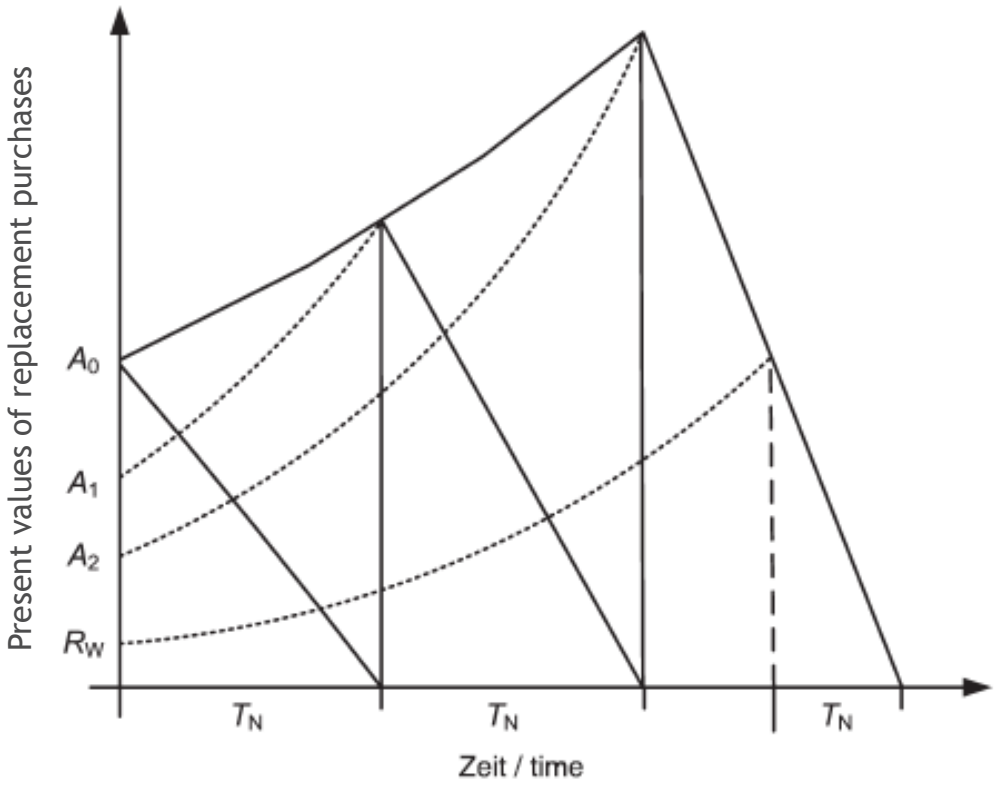
- Heat production costs = $\frac{\text{Annual total costs}}{\text{Annual amount of (solar) heat fed into DH}}$

- Where do we currently stand?
  - For larger plants, costs of **50 €/MWh** are reached, plus subsidy costs of **30 €/MWh** are possible!

CALCULATION OF THE ECONOMIC FEASIBILITY

- Calculate the heat production costs with the annuity method according to VDI 2067
- Costs incurred are broken down into:
  - Capital costs
  - Operational costs
  - Demand-related costs
  - And other costs
- Calculation over an observation period of usually 25 years
- In addition to the capital interest rate, price increase factors (usually approx. 1 to 3 %) are also taken into account (e. g. for operating electricity, reinvestments, etc.)

CALCULATION OF THE ECONOMIC FEASIBILITY



Initial value A_0
Present value A_1
Present value A_2
Residual value R_W
Period of use T_N

Source: VDI 2067 Blatt 1, Sept. 2012

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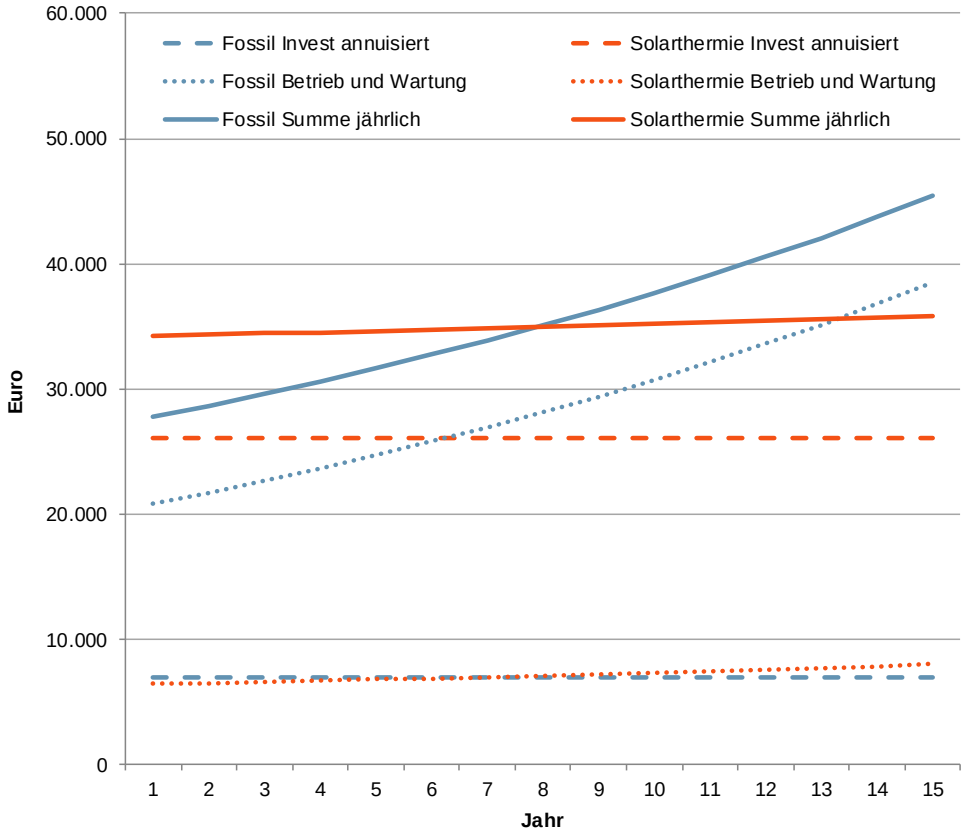
CAPITAL COSTS

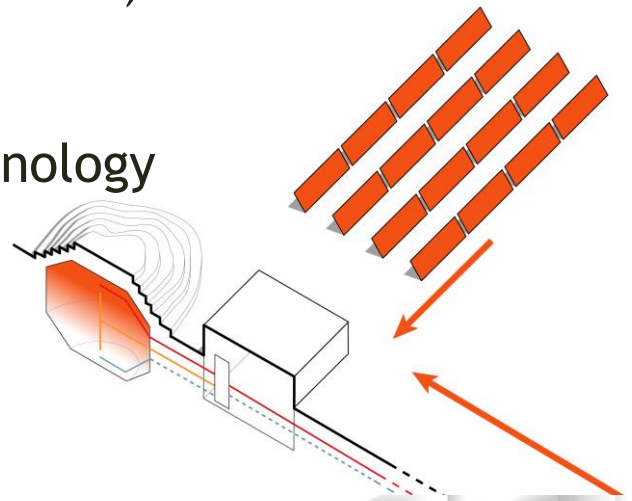
- Investments in solar thermal systems are capital-intensive projects



Info:
Comparison of a economic feasibility calculation of solar thermal energy and fossil boiler

CAPITAL COSTS

- Heat generation costs of a large-scale solar thermal plant are primarily determined by **investment costs**
- And split up into following components:
  - Collectors (flate-plate or vacuum tube collector)
  - Heat storage (if required)
  - Plant engineering (e. g. transfer station to DH)
  - Building (e. g. heating system)
  - Measurment, control and regulation technology
  - Ground
  - Planning and approval

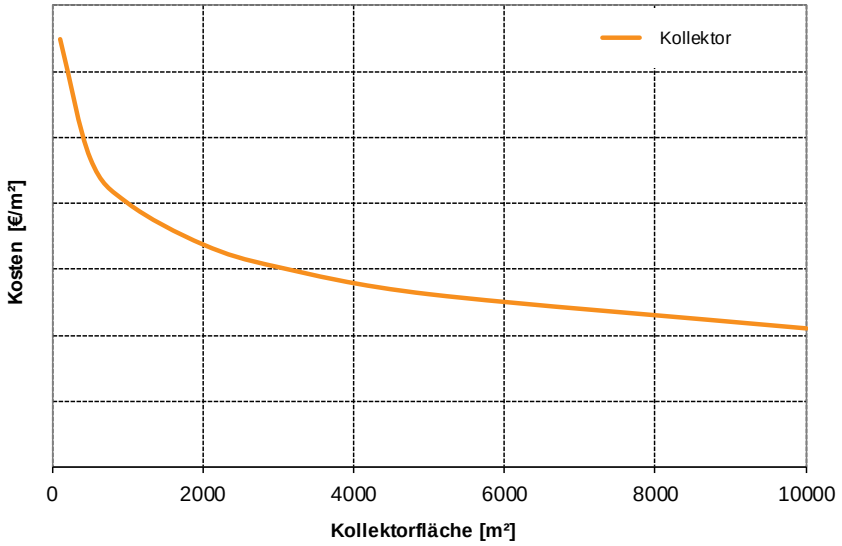


CAPITAL COSTS

- Significant **economies of scale** in the costs of the main components

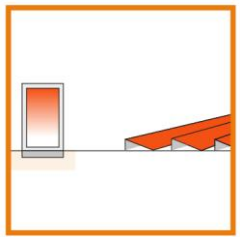
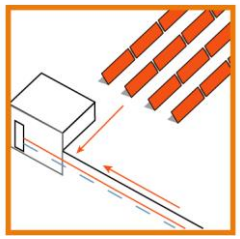
Collector area in m² ↑ specific costs in €/m² collector area ↓

Heat storage tank in m³ ↑ specific costs in €/m³ storage volume ↓



CAPITAL COSTS

- **Estimate** of the capital costs:
  - Collector determination via cost curve or price query
  - Heat storage tank determination cia cost curve or price query
  - Plant technology approx. 7 % surcharge on main components
  - Building approx. surcharge on main components
  - Measurement and control technology surcharge on main components
  - Planning approx. 5 % or 10 % surcharge on the total costs for decentralized or centralized integration

CAPITAL AND OPERATION COSTS

- Further important boundary conditions are the useful lifes of the various components and the costs of repair and maintenance

	Useful lifes (in years)	Annual repair and maintenance costs (in % of investment costs)
Collectors	25[1]	0,50 %[1]
Heat storage	40[2]	1,00 %[2]
Solar grid	40[3]	1,00 %[3]
Plant engineering	15[3]	2,00 %[1]
Building	50[3]	2,00 %[3]
Measurement and control technology	20[3]	2,00 %[1]

[1] *www.solar-district-heating.eu/ServicesTools/Plantdatabase.aspx,* [2] *BINE-Infopaket: Solare Nahwärme - Ein Leitfaden für die Praxis,* [3] *Richtlinie VDI 2067 Blatt 1*

DEMAND-RELATED COSTS

- In plant operation the running costs relatively low, as no fuels are required
- Only the **operating current** is needed (approx. 1 to 2 % of the solar thermal useful heat yield)
- This means that the heat production costs are **stable** and are known from the first day of operation for the next 25 years!

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SIMPLIFIED EXAMPLE CALCULATION

Basic data

- Collector field (gross): 10,000 m^2
  - High-temperature flat-plate collectors
  - Integrated centrally into DH
- Heat storage: 700 m^3
- Solar useful heat yield: 3,300 MWh/a
  - Location — Frankfurt
  - Collector field orientation — 0° (South)
  - Collector inclination — 35°
  - DH temperature — Summer 80/60 °C, winter 100/50 °C
  - DH heating requirement — 60 GWh/a
- Connection to the DH and property costs are not taken into account

SIMPLIFIED EXAMPLE CALCULATION

Components	Calculation method investment costs	Costs	Unit
Collector field	Determination via cost curve	2.214.000	€
Heat storage	Determination via cost curve	232.000	€
Plant engineering	0,07 * (2.214.000 + 232.000) €	171.000	€
Building	0,05 * (2.214.000 + 232.000) €	122.000	€
Measurement and control technology	0,03 * (2.214.000 + 232.000) €	73.500	€
Planning	0,05 * total costs	140.500	€
Investment costs without subsidies		**2.953.000**	**€**

Subsidy KfW-Programme 'Renewable Energies Premium'			
Subsidy Solar thermal plant *(Simplified reference: all costs, except heat storage)*	- For large enterprises 45 % - For medium-sized enterprises 55 % - For small enterprises 65 %	1.224.500 1.496.500 1.768.500	€ € €
Subsidy heat storage	0,30 * 232.000 €	69.500	€
Investment cost with subsidies (large enterprises)		**1.659.000**	**€**

SIMPLIFIED EXAMPLE CALCULATION

Components	Calculation method annual costs		Costs	Unit
Investment costs without subsidies			2.953.000	€
Investment cost with subsidies (large enterprises)			1.659.000	€
Annual costs of capital (Annuitized, interest rate 3 %, observation period 25 years)	Calculation taking into account useful lifes, price increase factors, reinvestments and residual values		97.000	€/a
Electrical auxiliary power	0,01 * 0,15 €/kWh (Electricity costs) * 3.300 MWh/a (solar thermal yield)		5.500	€/a
Maintenance and operation (Annuitized, interest rate 3 %, observation period 25 years)	Collectors:	0,005 * 2.214.000 €	26.000	€/a
	Heat storage:	0,01 * 232.000 €		
	plant engineering:	0,02 * 171.000 €		
		0,02 * 122.000 €		
	Building:			
	Measurement and control technology:	0,02 * 73.500 €		
Total annual costs (without subsidies)			**210.500**	**€/a**
Total annual costs (with subsidies, large enterprises)			**128.500**	**€/a**

SIMPLIFIED EXAMPLE CALCULATION

	Calculation method	Costs	Unit
Total annual costs			
without subsidies		210.500	€/a
with subsidies		128.500	€/a
Heat production costs			
without subsidies	210.500 €/a (Total annual costs) / 3.300 MWh/a (Solar useful heat yield)	**64**	**€/MWh**
with subsidies	128.500 €/a (Total annual costs) / 3.300 MWh/a (Solar useful heat yield)	**39**	**€/MWh**

VARIOUS FACTORS INFLUENCE THE HEAT PRODUCTION COSTS

- Interest rate has a great influence on the annual capital costs and thus on the heat production costs. It is dependent on:
  - **Internal interest rate applied** (depending on the company)
  - **Interest rate available on the capital market** (financing through borrowed capital)
- **Land acquisition costs** and the realisation of **distributed or roof-integrated collector areas** increase costs
- **Higher solar fraction** usually requires a more complex system/storage technology, at the same time lower specific system yields
- **Duration of calculation**: 3, 10 or 25 years?
  - The basis for the calculated cost allocation is „normal useful life of the asset“…25 years for large solar thermal systems[1]

[1] *According to VDI 6002 min. 20 Years; www.solar-district-heating.eu/ServicesTools/Plantdatabase.aspx*

LARGE-SCALE SOLAR THERMAL SYSTEMS – AN ECONOMICAL ALTERNATIVE!

- Essential prerequisites for favourable heat production costs:
  - Sufficient plant size (> 1 MW_{th})
  - Simple plant technology (e. g. open land installation)
  - Suitable heating network temperatures

- For larger systems, heat production costs of **50 €/MWh** are achieved
- With subsidies costs of around **30 €/MWh** are possible

Further Informations: https://www.solar-district-heating.eu/

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