University of Stuttgart
Chair for Building Physics
Dept. Life Cycle Engineering

*Michael Baumann
Michael.baumann@lbp.uni-stuttgart.de
Chair for Building Physics, Dept. Life Cycle Engineering
Wankelstraße 5, D-70563 Stuttgart, Germany

Manuel Lorenz
Nathanael Ko
Eva Knüpffer
Michael Baumann*

LCA of Solar Thermal Tower Power Plants (CSP)

Background

- 40 % increase of greenhouse gas concentrations since the beginning of the industrial era, mainly due to combustion of fossil fuels.
- Exit from fossil electricity generation necessary to reach goals from Paris agreement.
- Concentrating solar power (CSP) plants as a promising renewable energy technology.
- Heat storage enables electricity generation according to grid demand.
- LCA methodology to assess the environmental impact from cradle-to-grave in different categories.

Life Cycle Assessment (LCA)

- Functional unit: 1 kWh electricity supplied to the grid.
- Auxiliary power consumption and degree of efficiency deducted in advance.
- System boundary visualized in Figure 1.

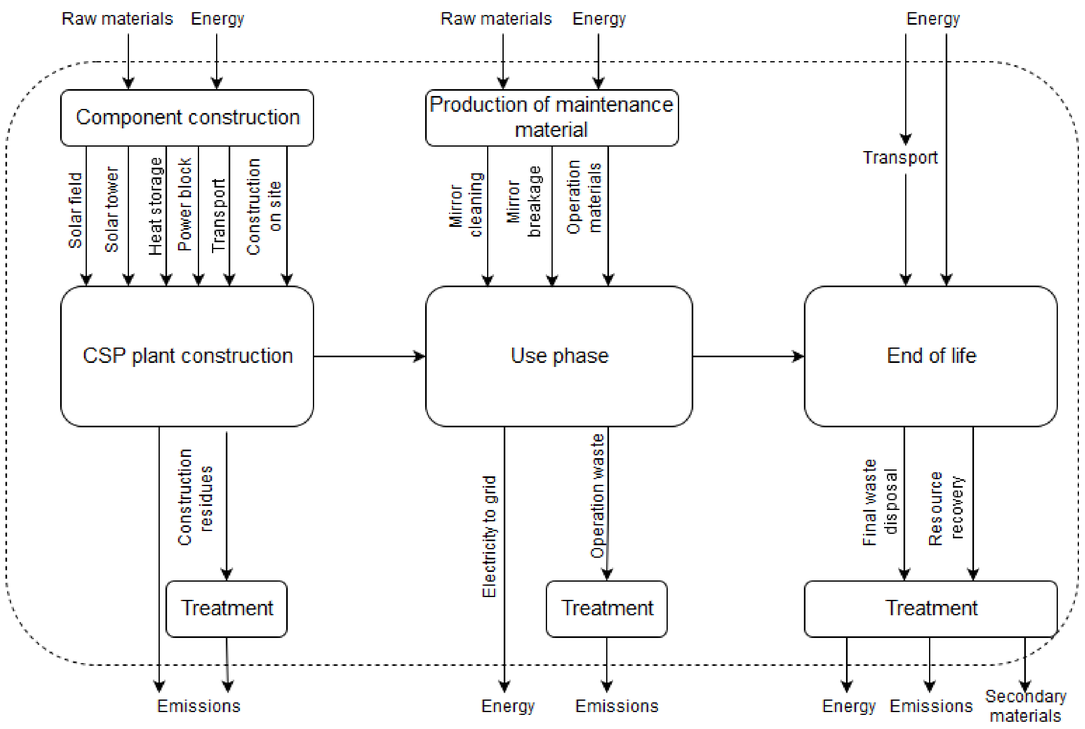

Figure 1: System boundary of the assessed CSP tower plant.

Assumptions

- Component manufacturing in Europe, USA and Chile
- Heliostat concrete foundation produced in country of plant site
- Transport by heavy load diesel truck and container ship
- Plant parameters derived from System Advisor Model (SAM) software
- No supplementary firing included
- No use of electricity from the grid
- End of life:
  - Complete dismantling of the power plant
  - Steel recycling rate: 80 %
  - Copper and aluminium recycling rate: 90 %
  - Further use of molten salt as high grade fertilizer
  - Landfilling of other materials

References

- DIN EN ISO 14040, revised: 02.12.2016.
- Hirsch, Tobias (2015/2016): Solarthermische Kraftwerke. Universität Stuttgart. DLR Stuttgart. Stuttgart, 2015/2016.
- Koffler, C. (2014): Best Practive LCA: End-of-Life Modelling. PE International, 28.10.2014, revised: 03.03.2017.
- National Renewable Energy Laboratory (2016): System Advisor Model (SAM). Version 2016.3.14.
- Stocker, Thomas F. et al. (2013): Climate Change 2013 - The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Published by: Cambridge University Press, WMO, UNEP. Intergovernmental Panel on Climate Change, revised: 01.12.2016.
- Telsnig, Thomas (2015): Standortabhängige Analyse und Bewertung solarthermischer Kraftwerke am Beispiel Südafrikas. Dissertation. Universität Stuttgart, Stuttgart. IER, revised: 02.02.2017.
- Thinkstep AG: GaBi ts. Version 7: Thinkstep AG.

Reference plant

Location: Upington, South Africa	Unit	Value
Power (net output)	MW	125
Design DNI	W/m²	1,044
Total reflective area	m²	1,388,541
Type of heliostat	-	ATS-H150
Number of heliostats in solar field	-	9,330
Capacity factor	-	0.55
Lifetime	a	30
Heat transfer fluid	-	Solar salt (60% $NaNO_3$; 40% KNO_3)
Storage type	-	2 tanks, solar salt
Storage capacity	h	14
Cooling type	-	Dry, air cooled condenser

Table 1: Specifications of the reference plant.

Results – GWP 100 years

Figure 2:

- Construction phase as main contributor
- Use phase relatively small burden
- End of life avoids burden by resource recovery

Main contributing power plant components in construction:

- Solar field
- Molten salt storage
- Transport

Building type comparison:

- Solar field impact: Depending on building materials, not on heliostat size.
- Storage impact: Molten salt smaller impact than high temperature concrete or phase change material.
- Transport impact: Potential of reduction in solar tower and heliostat transport.

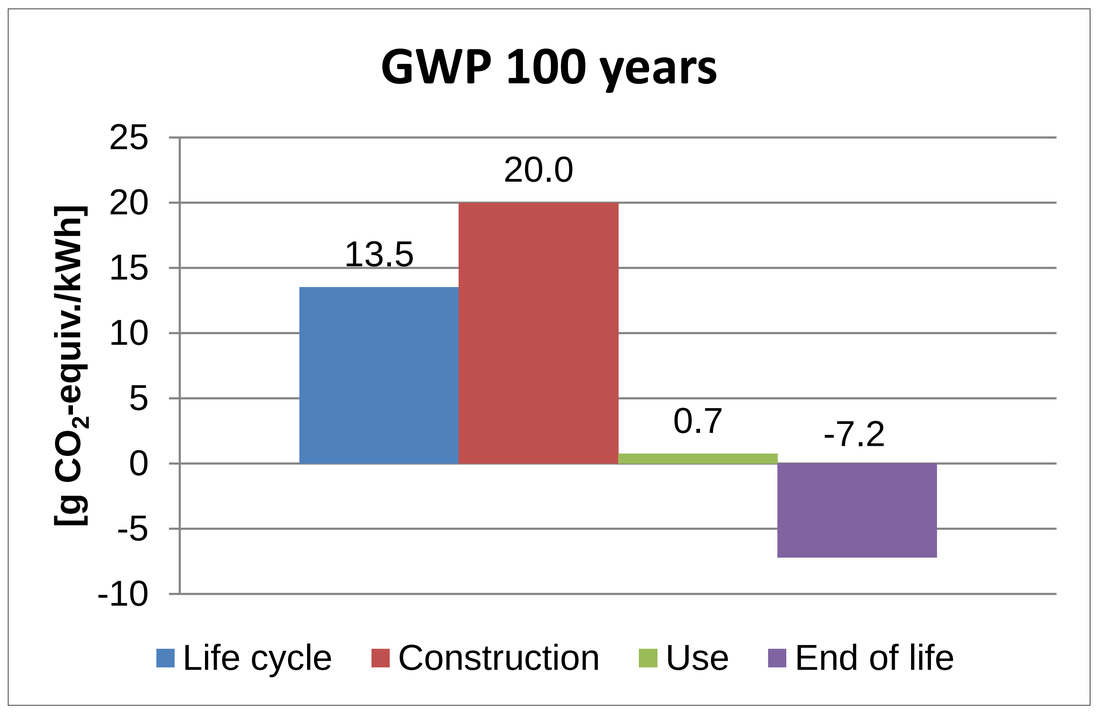

Figure 2: Global warming potential of the reference plant

Acknowledgement

This work has received funding from the European Union's Horizon 2020 research and innovation programme in the project PreFlexMS under grant agreement No 654984.

www.lbpgabi.uni-stuttgart.de

Life Cycle Engineering