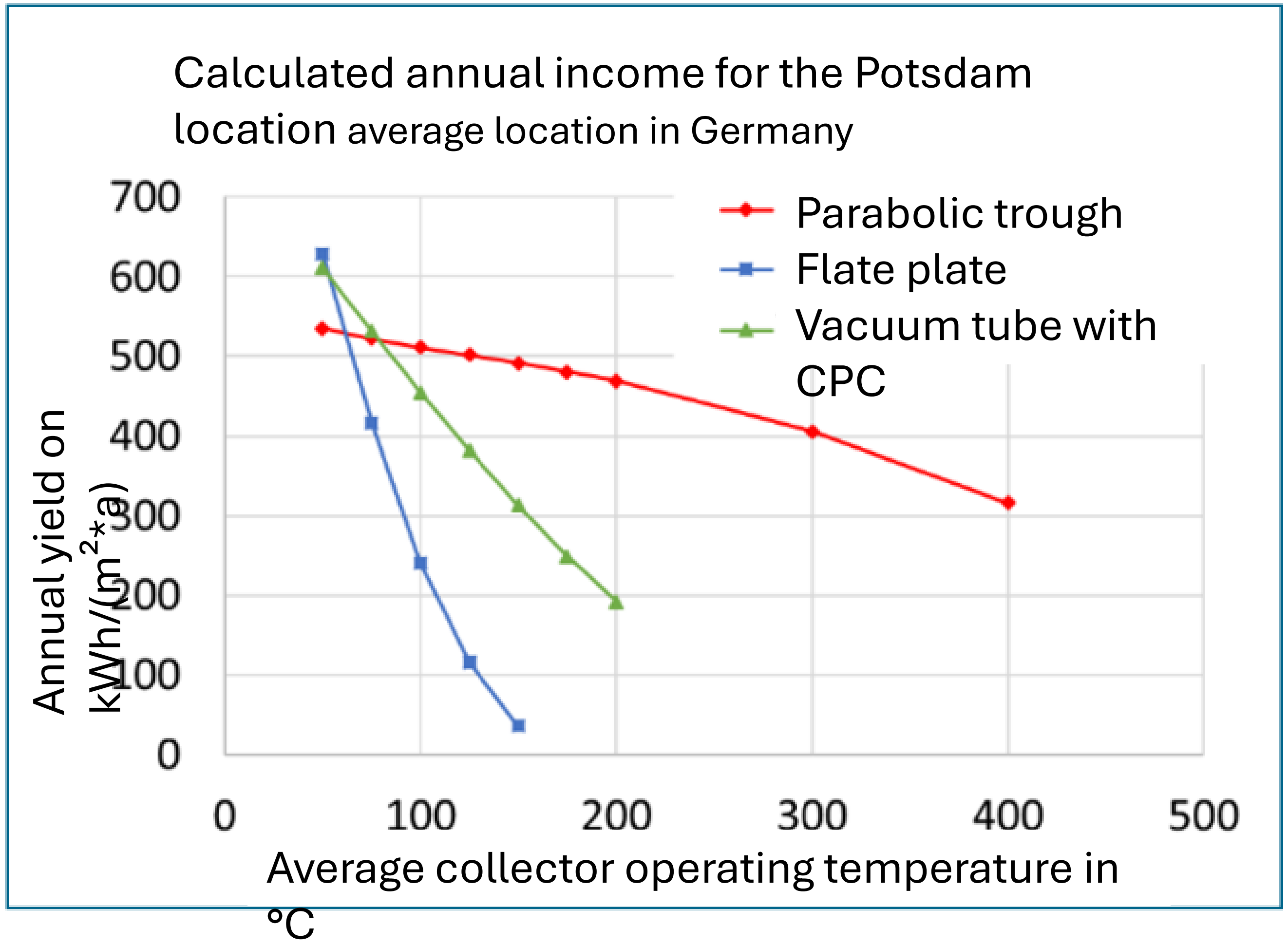
Decarbonization of heat

High-temperature heat with solar thermal energy: implementation examples and tools

Navina Konz
German Aerospace Center e.V. (DLR)
BETP-Side Event

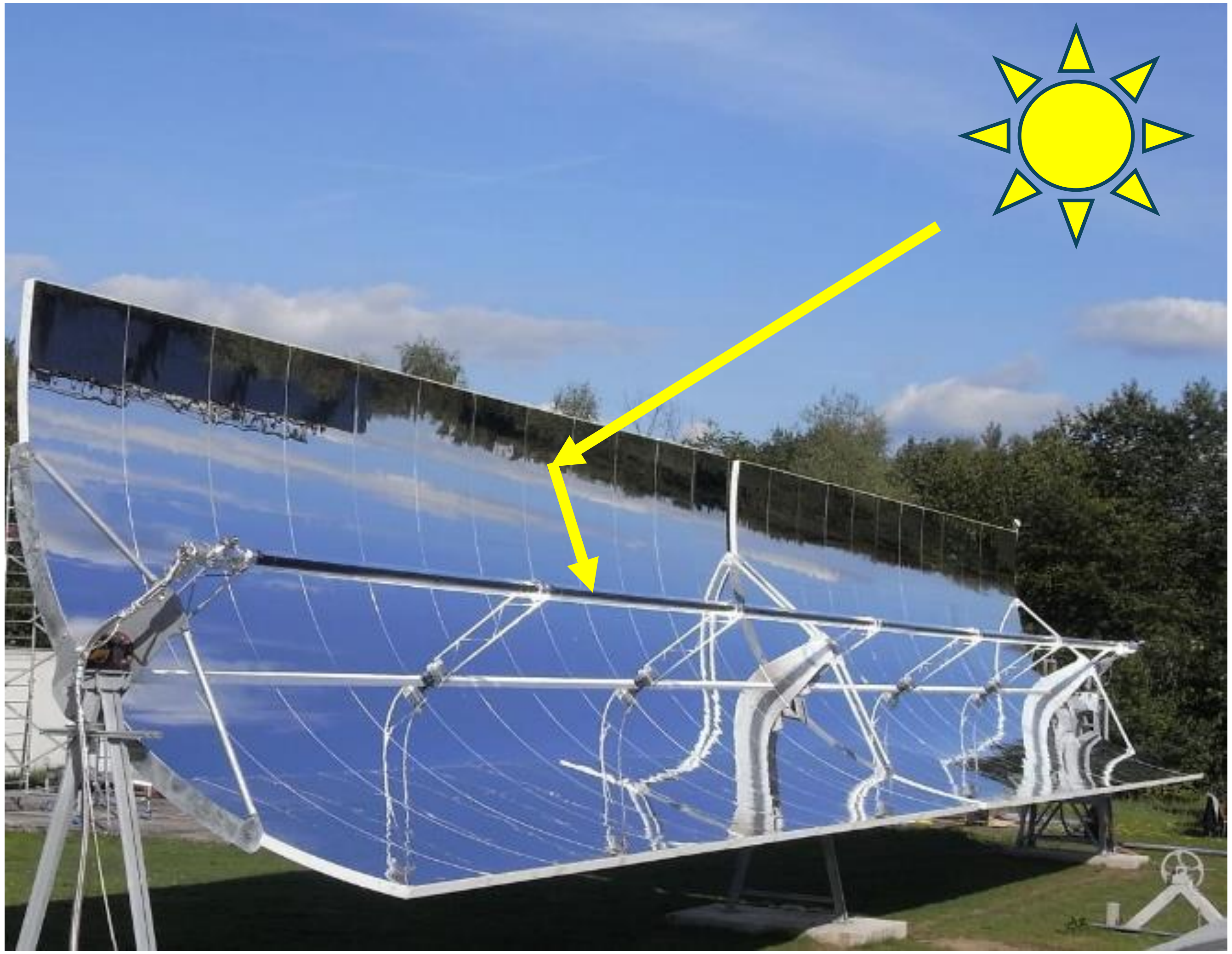
Solar heat yield in a German climate

- Historically almost exclusively flat-plate collectors and CPC tube collectors in use in Germany
- Benchmarking with established flat-plate and evacuated tube collectors:
  - ➢ Parabolic troughs achieve similar yields at approx. 80 °C in large systems
  - ➢ At comparable costs-Parabolic troughs deliver the best yields at higher temperatures (much lower heat losses)
- Solar tower (higher temperatures) and Fresnel collector further solutions



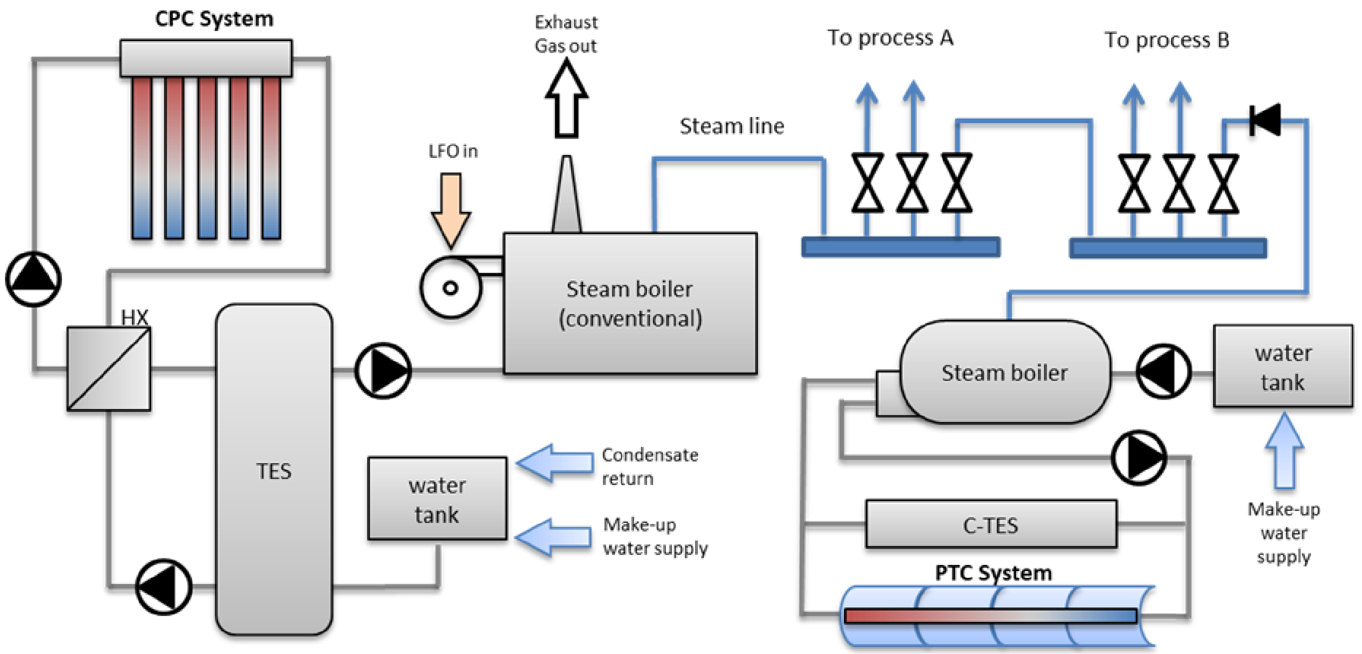
Reference: Dirk Krüger, Stephan Fischer, Peter Nitz, Javier Iñigo Labairu, Opportunities for the use of concentrating collectors in Central Europe, Solar Thermal Symposium 2021

Parabolic trough collectors – how they work



- Curved mirrors reflect the direct radiation of the sun onto an absorber tube
- The collector tracks the sun on one axis
- The heat transfer medium is heated to the desired target temperature in a controlled manner (max. ~430°C for thermal oil)
- Defocusing is possible, so that the heat supply can be stopped
- Constructions vary greatly and can be adapted to different requirements

Integration of solar heat into a steam network in the beverage industry in Cyprus



Steam network with solar collectors

Parabolic trough collector from Protarget, Cologne
(Photo: Protarget)

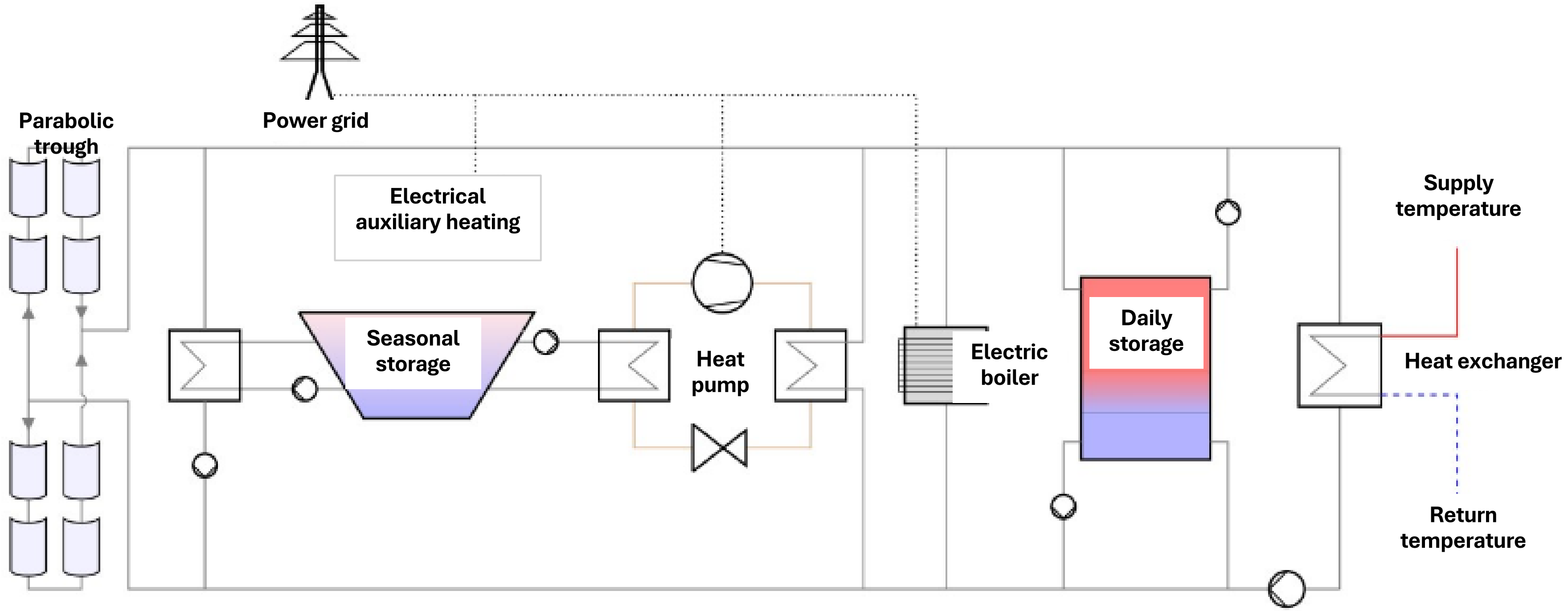
Thermal output 140 kW, concrete storage tank with max. 380°C, heat transfer medium silicone fluid, generation of saturated steam at 190°C, commissioning 2019

Solar process heat for chemical companies Turnhout, Belgium

- Parabolic trough field with 5,540 m^2 aperture area in 3 loops and a total transmission capacity of 2.5 MW
- Type: EuroTrough collectors
- 20% solar share
- Silicone oil in the solar field (280 - 380°C)
- Mineral oil (260 - 280/300 °C) on the user side
- Concrete thermal storage
- Energy-Contracting

Solar collector field from Solarlite, GermanyPower transfer station (BoP) and storage tank (Photo: Avery Dennison)

Study 100% green solution for a district heating network



Parameters:

- PTC Mirror Area
- STES Volume HP Nominal
- HP Nominal Hot Side Heat Output
- EH Nominal Electric Input
- DTES Nominal Energy Capacity

- Approach
  - Life time of 20 years und real interest rate of 4.4% to calculate TAC and LCOH
  - Generic algorithm → optimal Design with minimal LCOH by adapting parameters

Study 100% green solution for a district heating network

System specifications

- Total annual energy demand and yield is 50,000 MWh/a for 100200 m^2 mirror aperture area
- Solar share 80 %
- Grants are based on the BEW:
  - 10 €/MWh over the first 10 years
  - 40% grant on the investment except the EH
- Supply temperature: 100-105°C
- Return temperature: 60 °C
- Hot temperature: +5K to supply temp.

- **Component specifications**

- Daily storage (DTES): stratified water storage
  - V = 320 m^3
- Seasonal storage (STES): pit storage in a form of a truncated cone
  - V = 284,100 m^3
- Heat Pump (14 MW): water to water
  - Max. outlet temperature 150°C
  - Max. COP of 6.5 & efficiency of 55% of the Carnot COP
- Electric heater: efficiency of 95 %

➢ All costs included, except land investment € 58 million

➢ Heat production costs after subsidy approx. 110 €/MWh after

Standards and software

<u>Standards for planning</u>

VDI Guideline 3988 Process heat

VDI Guideline 4190 Solar thermal systems *in progress*

<u>Software in the Pro-Sol network project:</u>

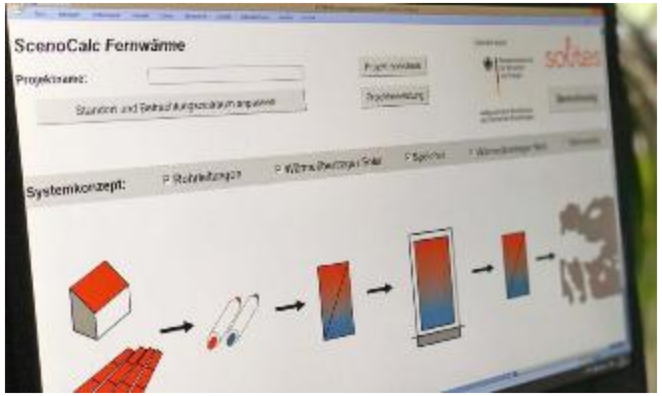
Greenius: Electricity and heat generation with renewable technologies (freely available, www.dlr.de/sf)

ScenoCalc District heating: Solar thermal energy with buffer storage still without parabolic trough collectors (freely available, www.scfw.de)

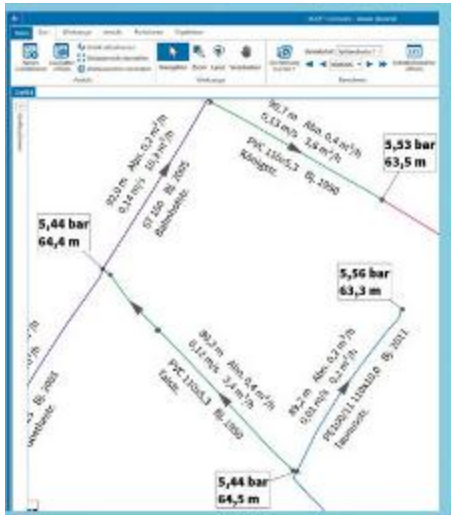
ROKA: Calculation of pipe network (www.roka3.de)

ColSim-CSP: Simulation of concentrating solar thermal systems (contact: stefan.mehnert@ise.fraunhofer.de)

Simple tool under development in the Pro-Sol network project



ScenoCalc Fernwärme



ROKA

Summary

- ✓ Plot requirement approx. 0.25 kW/m^2 floor area
- ✓ Planning services not readily available → contact ProSolNetz consortium
- ✓ Provides heat from the storage tank even when the sun is not shining
- ✓ Heating to target temperature, easily controllable, suitable for heating networks
- ✓ Defocusing of the collectors and thus switching off the heat supply possible
- ✓ A year-round 100% supply possible in conjunction with storage tank and heat pump

Contact

Deutsches Zentrum für Luft- und Raumfahrt

Dirk Krüger

Project leader ProSolNetz

ProSolNetz | Bundesverband Solarwirtschaft

DLR – German Aerospace Center e.V.

Linder Höhe

51147 Köln

Phone 02203 601 2661

dirk.krueger@dlr.de

www.dlr.de/sf