The economic efficiency of solar process heat

Contributions to the heat transition

Berlin Energy Transition Days
Side Event: High-temperature solutions for solar process heat and district heating to 400 °C

Dr.-Ing. Gregor Bern

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www.ise.fraunhofer.de

Study on the economic potential of SHIP

Case study: Process Heat Demand of 5MW$_{th}$ 24/7

3 different temperature requirements:

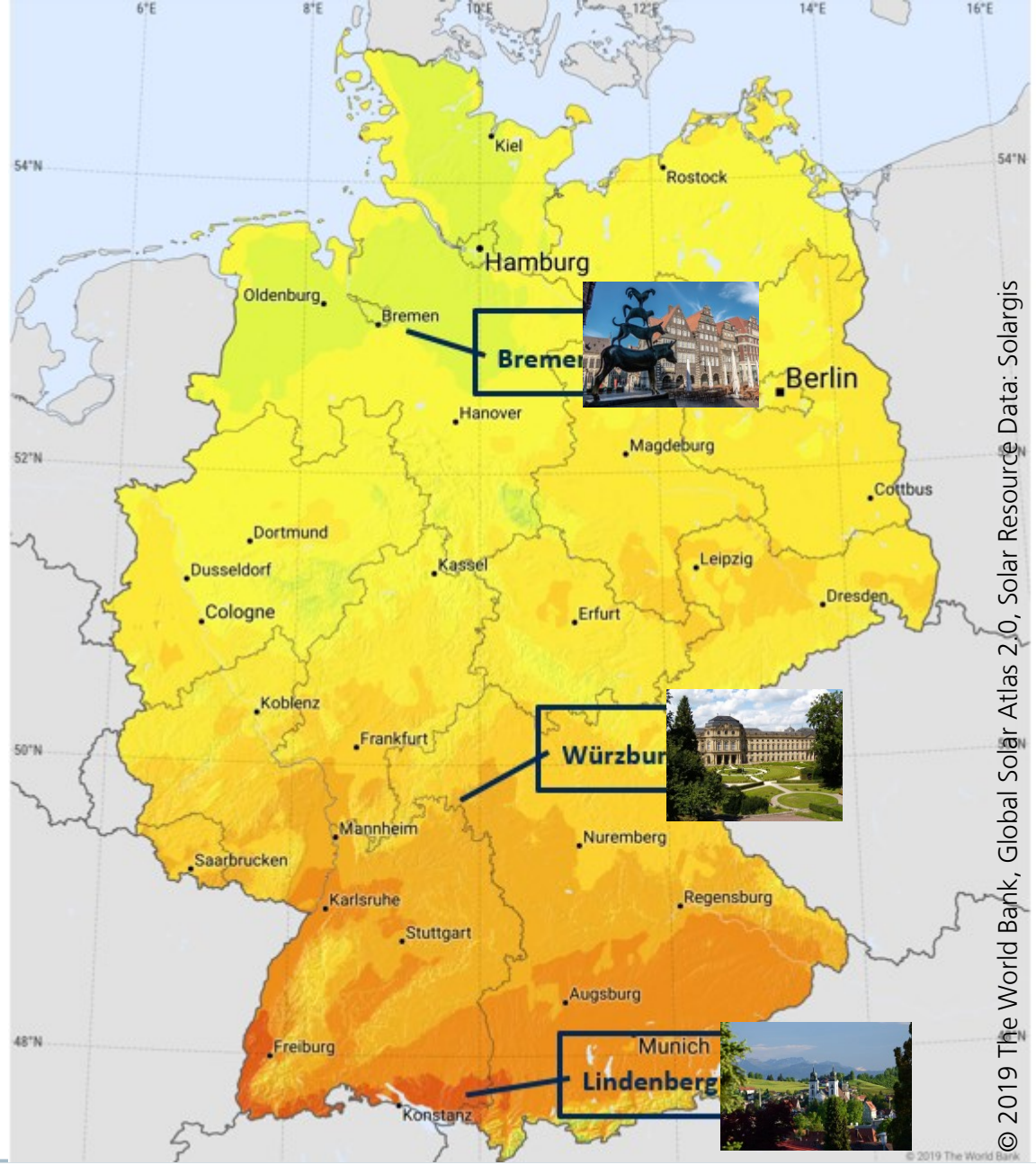
- 80°C, such as pasteurization of milk
- 120°C, general industrial processes and steam networks
- 300°C, chemical processes or high-temperature steam networks

3 representative locations in Germany:

- Bremen: low annual irradiation
- Würzburg: medium annual irradiation
- Lindenberg/Allgäu: high annual irradiation

3 solar thermal technologies:

- Flat plate collectors
- Vacuum tube collectors
- Parabolic trough collectors



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System Definition

Solar thermal heat as fuel saver

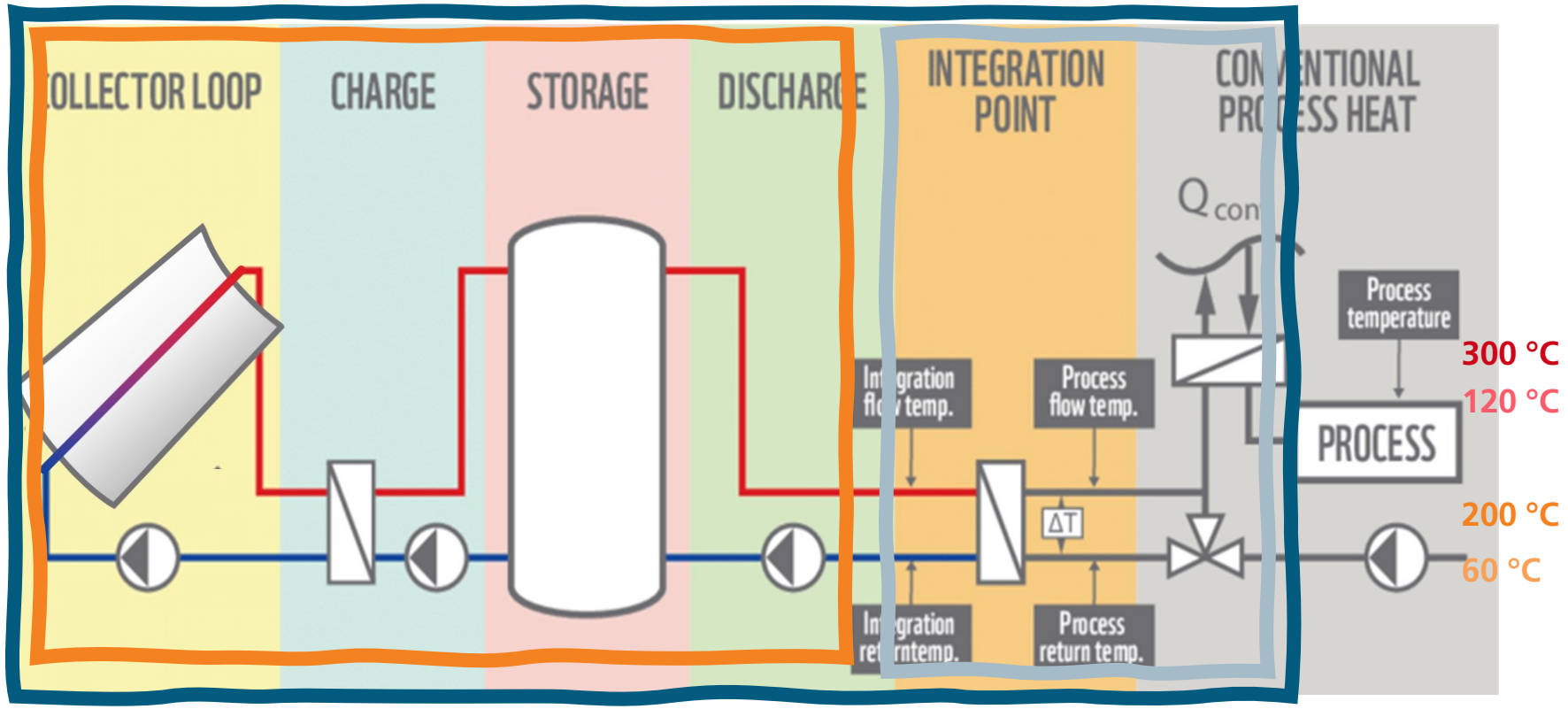
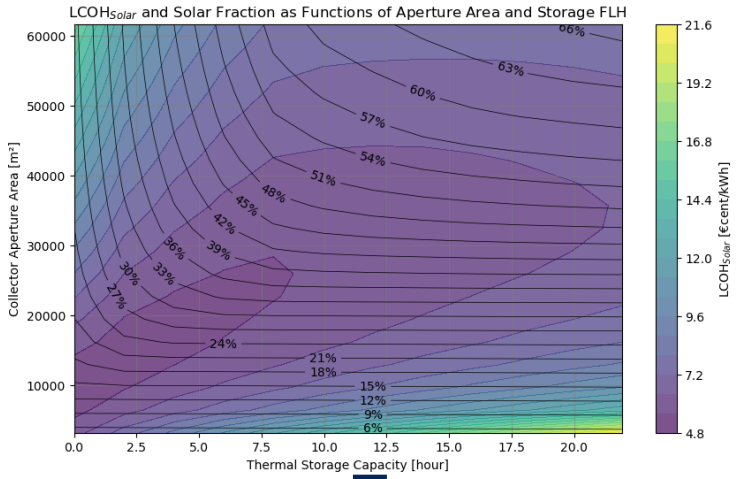
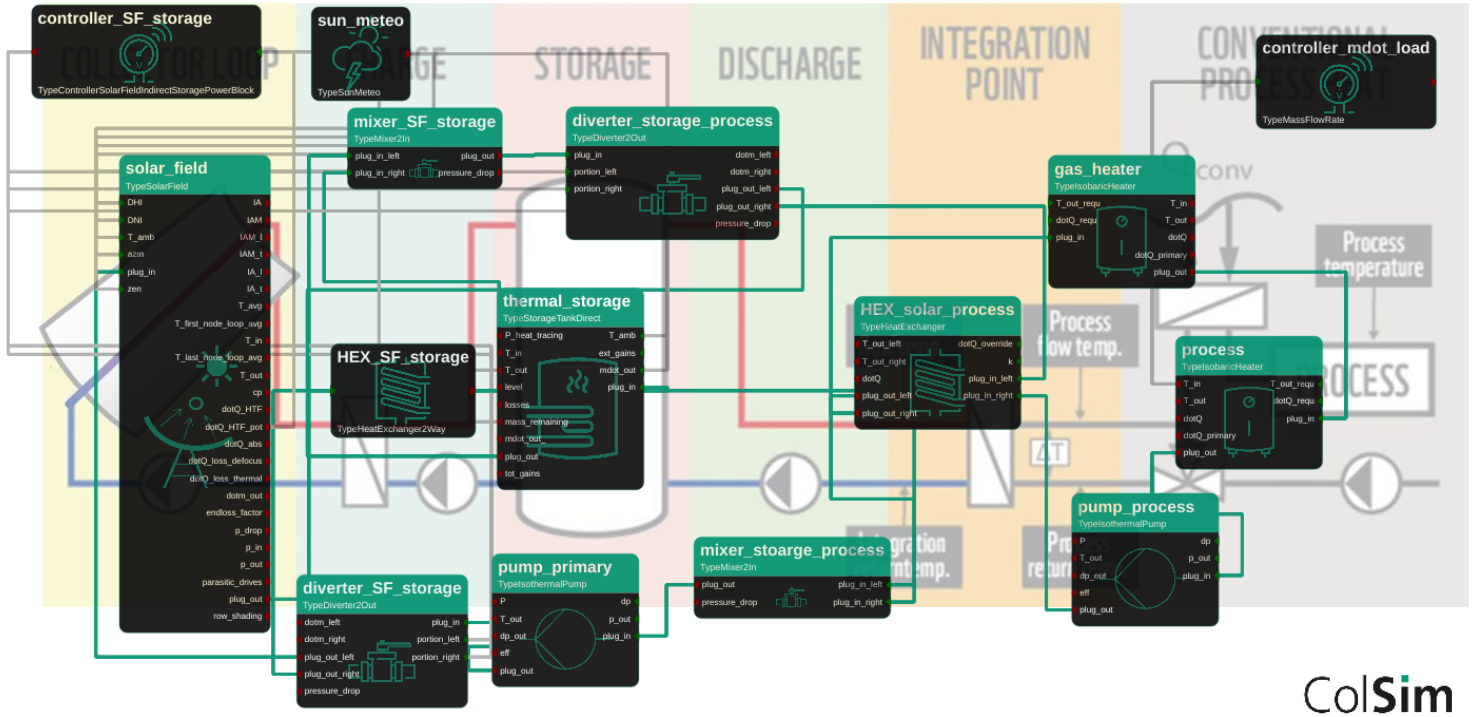


Image: Janse van Vuuren, Pieter & Basson, Lauren & Buckley, Angelo & Terblanche, Ulrich. (2017). Industrial Scale Solar Heat in South Africa: opportunities in agri-processing and textiles. 10.13140/RG.2.2.23782.32324.

Toolchain

Dynamic thermo-hydraulic system simulation with ColSim





ColSim

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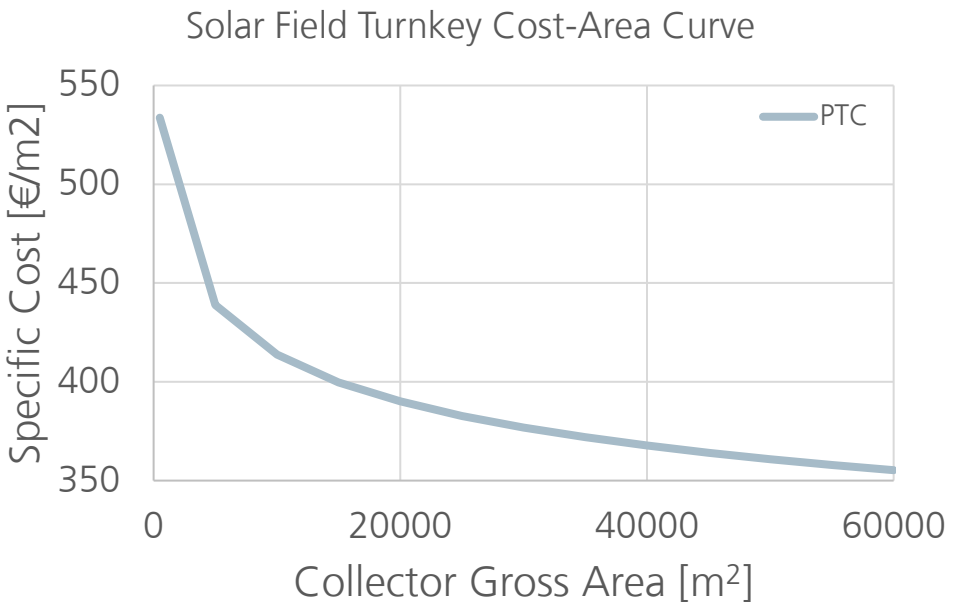
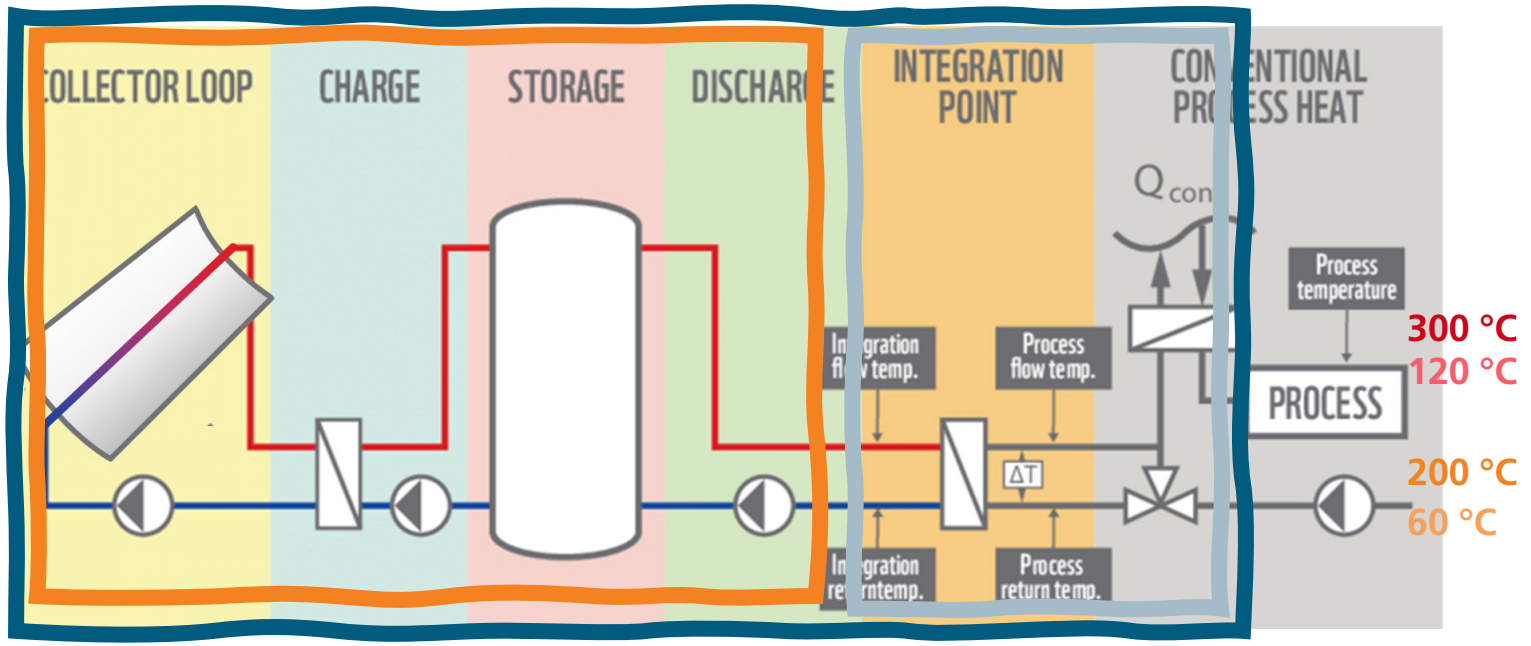
System Simulation

Solar thermal heat as fuel saver





	Prozess Temperature (°C)	HTF	Storage Density (kWh/m³)	Storage Cost (€/kWhth)
T2	120-60	Press. Water	60	48,6
T3	300-200	Thermal Oil	50	71,5

$$\begin{matrix} LCOH_{Solar} \\ LCOH_{NG} \\ LCOH_{Hybrid} \end{matrix} = \frac{\sum_{t=0}^{n} \frac{\left(I_{t,Solar} + M_{t,Solar} + I_{t,NG} + M_{t,NG} + F_t + CO_{2t}\right)}{(1+r)^t}}{\sum_{t=0}^{n} \frac{E_{t,Solar} + E_{t,NG}}{(1+r)t}}$$

Funding of 50% if invest for medium sized enterprises is optionally considered (EEW-Funding)

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Reference Case:

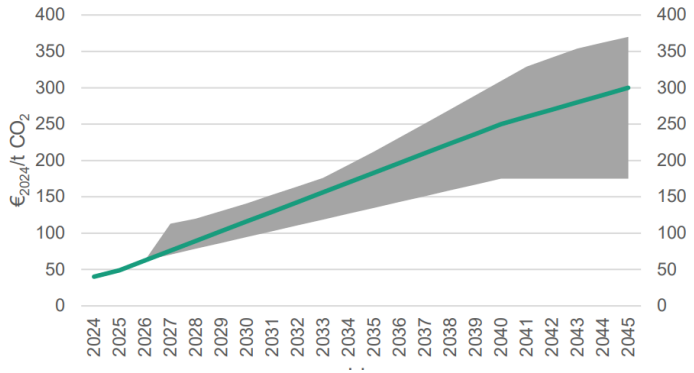
Replacing Natural Gas Fired Process Heat Systems

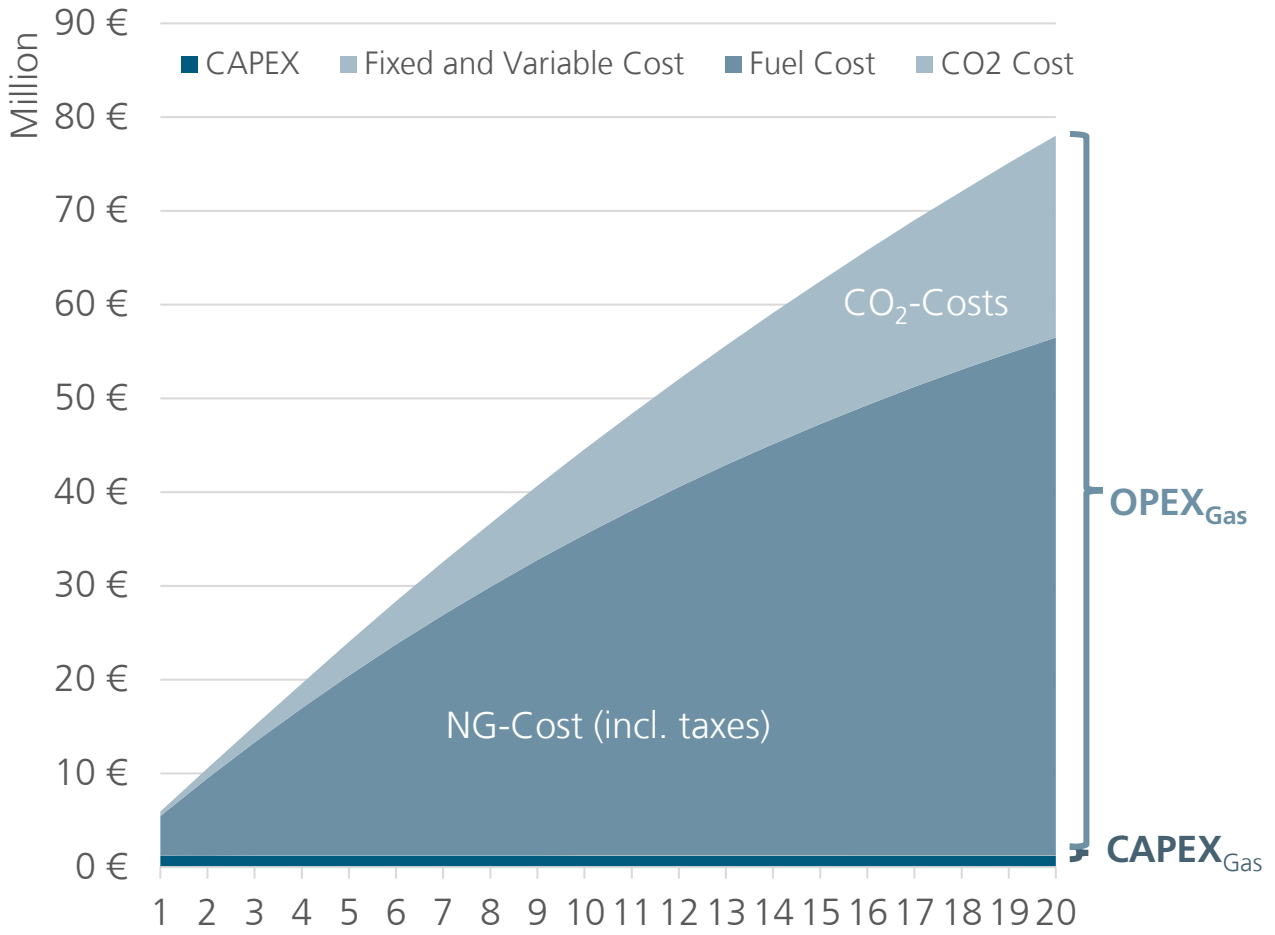
Levelized Cost of Heat $LCOH_{NG}$ from natural gas

- 13.6 euro cents/kWh

Underlying assumptions:

- lifespan of 20 years:
- The gas price remains constant[1] at 7.8 euro cents/kWh[2] (Net: 5.6 euro cents + 2.2 euro cents taxes & charges)
- CO2 price starts at 45 €/ton in 2024





[1,3]: https://ariadneprojekt.de/publikation/analyse-heizkosten-und-treibhausgasemissionen-in-bestandswohngebauden/

[2]: Statistisches Bundesamt: www-genesis.destatis.de

Exemplary Case:

Cost Structure and Economics of Hybrid System

Levelized Cost of Heat $LCOH_{NG}$ from natural gas

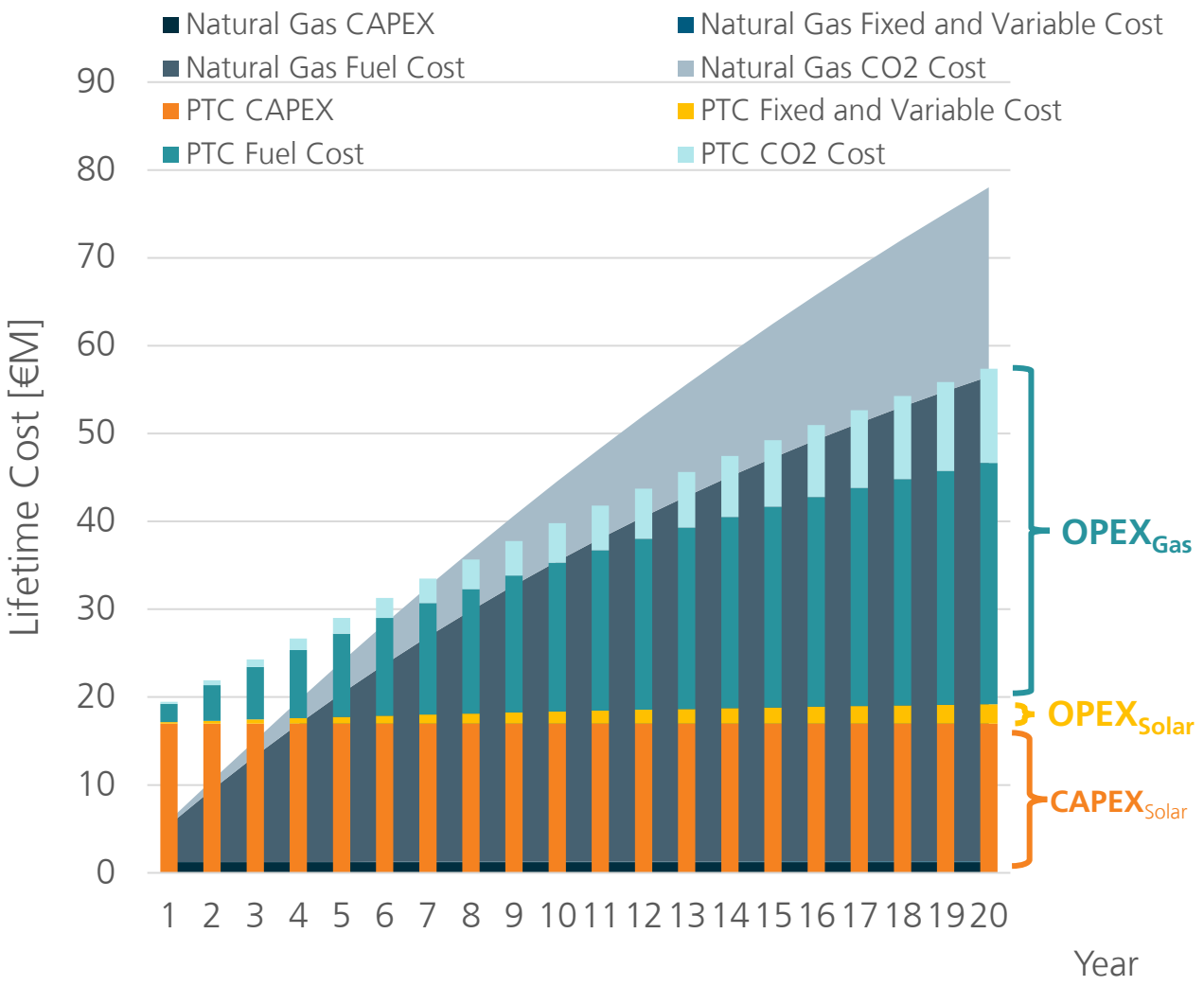
- 13.6 euro cents/kWh

Levelized Cost of Heat $LCOH_{Hybrid}$ with 50% Solar Fraction

- $LCOH_{Solar}$ 6.3 euro cents/kWh
- $LCOH_{Hybrid}$ 10.1 euro cents/kWh

For

- T3: Process Temperature 300°C
- Location: Würzburg (moderate DNI)



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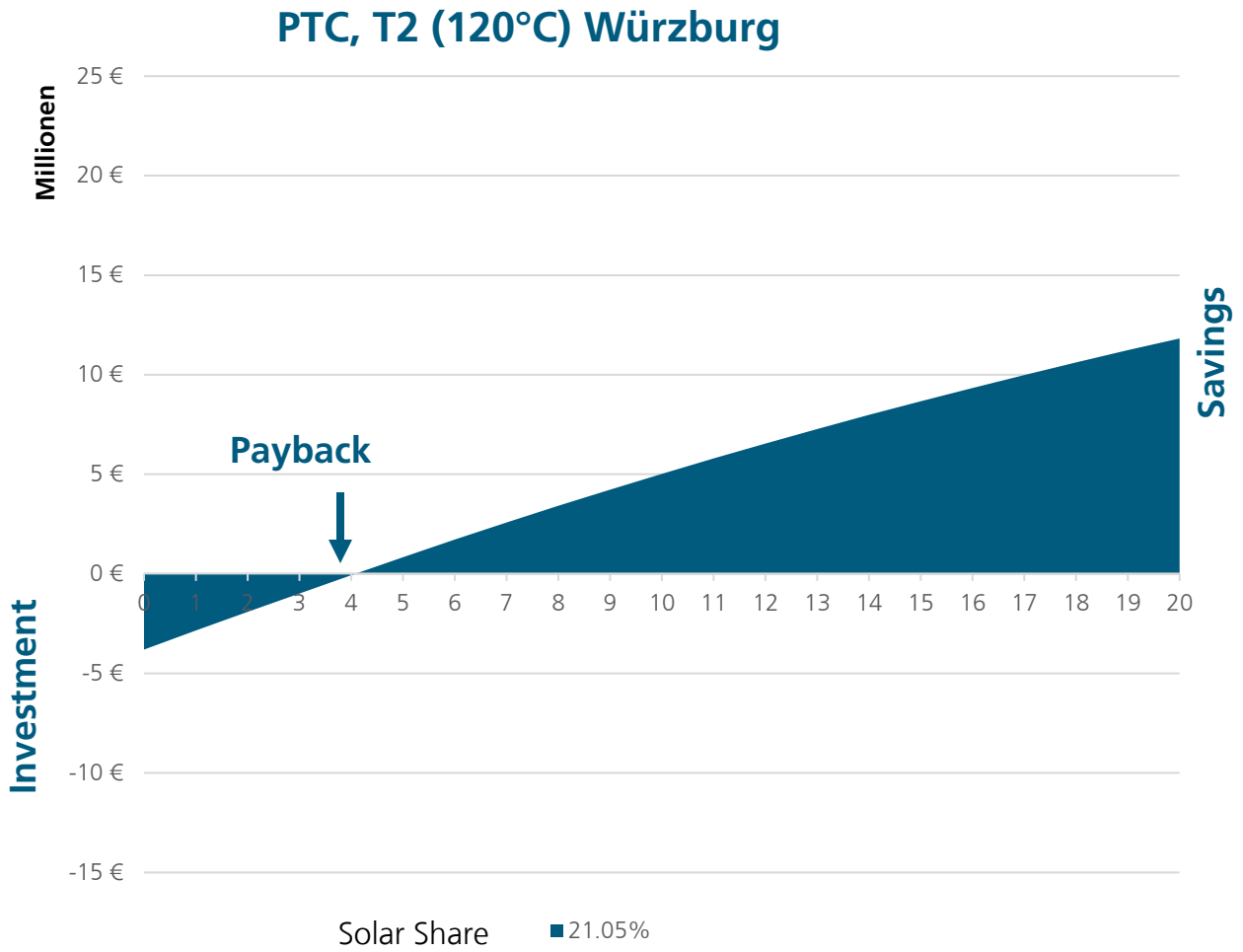
Investment and Savings

Considerations on the Solar Share

Solar share: 21.05%
Investment: €2.8 million
Payback period: 4.0 years
Return on Investment: 426%
Savings: €11.9 million



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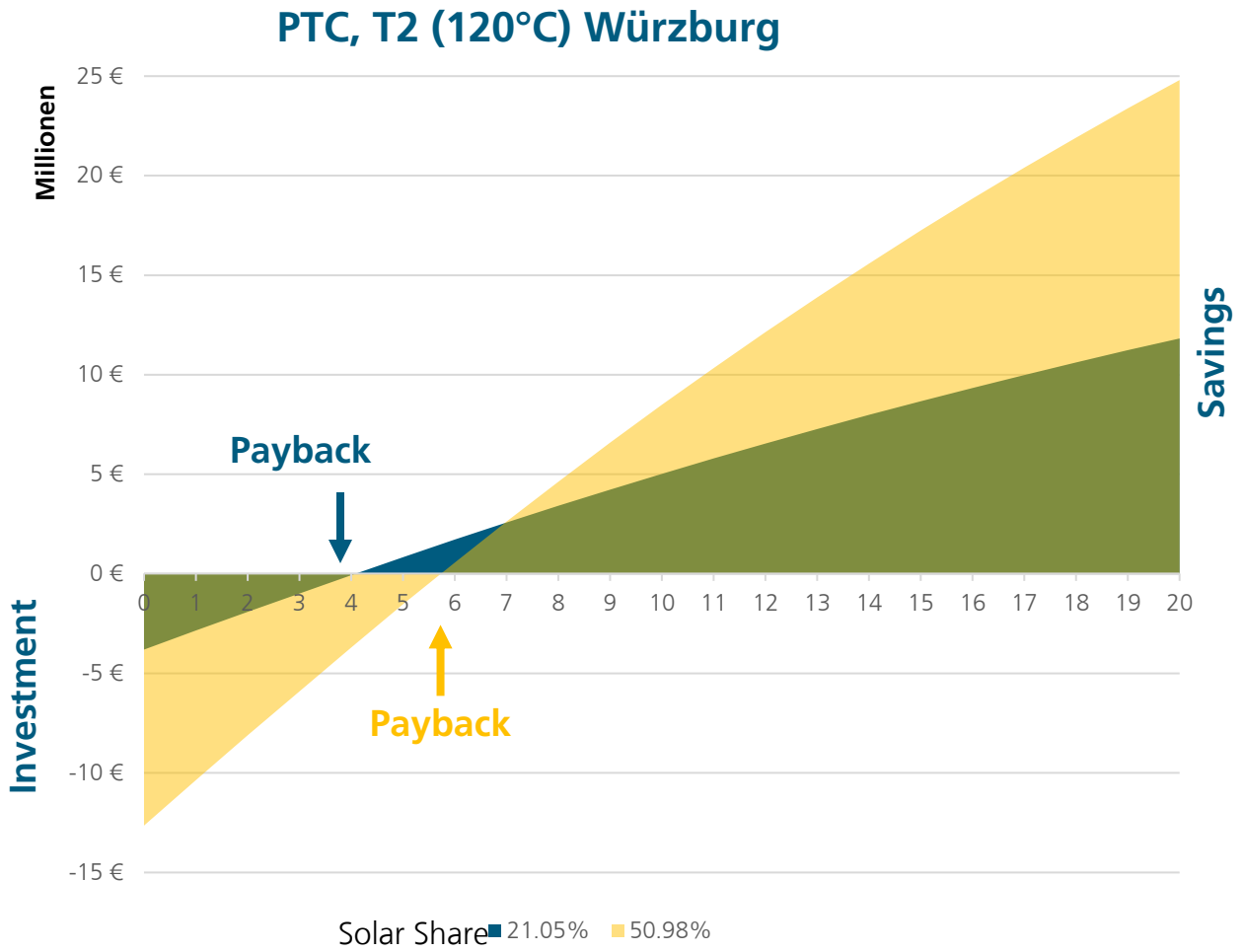
Investment and Savings

Considerations on the Solar Share

Solar share: 21.05%
Investment: €2.8 million
Payback period: 4.0 years
Return on Investment: 426%
Savings: €11.9 million

Solar share: 50.01%
Investment: €9.6 million
Payback period: 5.45 years
Return on Investment: 260%
Savings: €24.9 million



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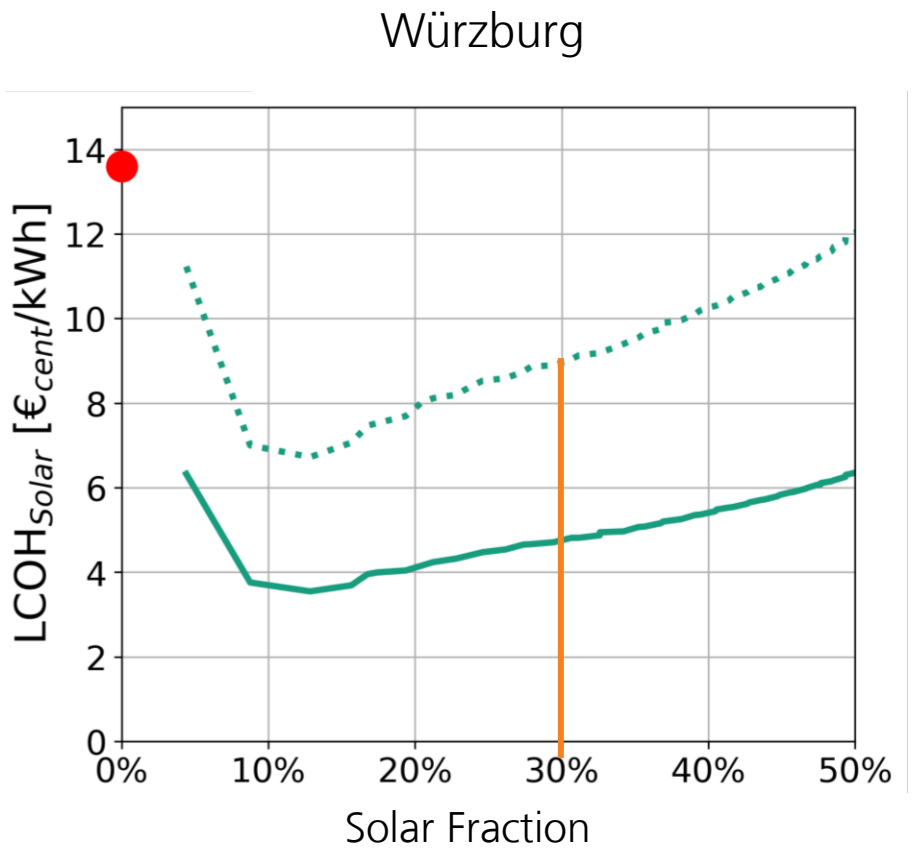
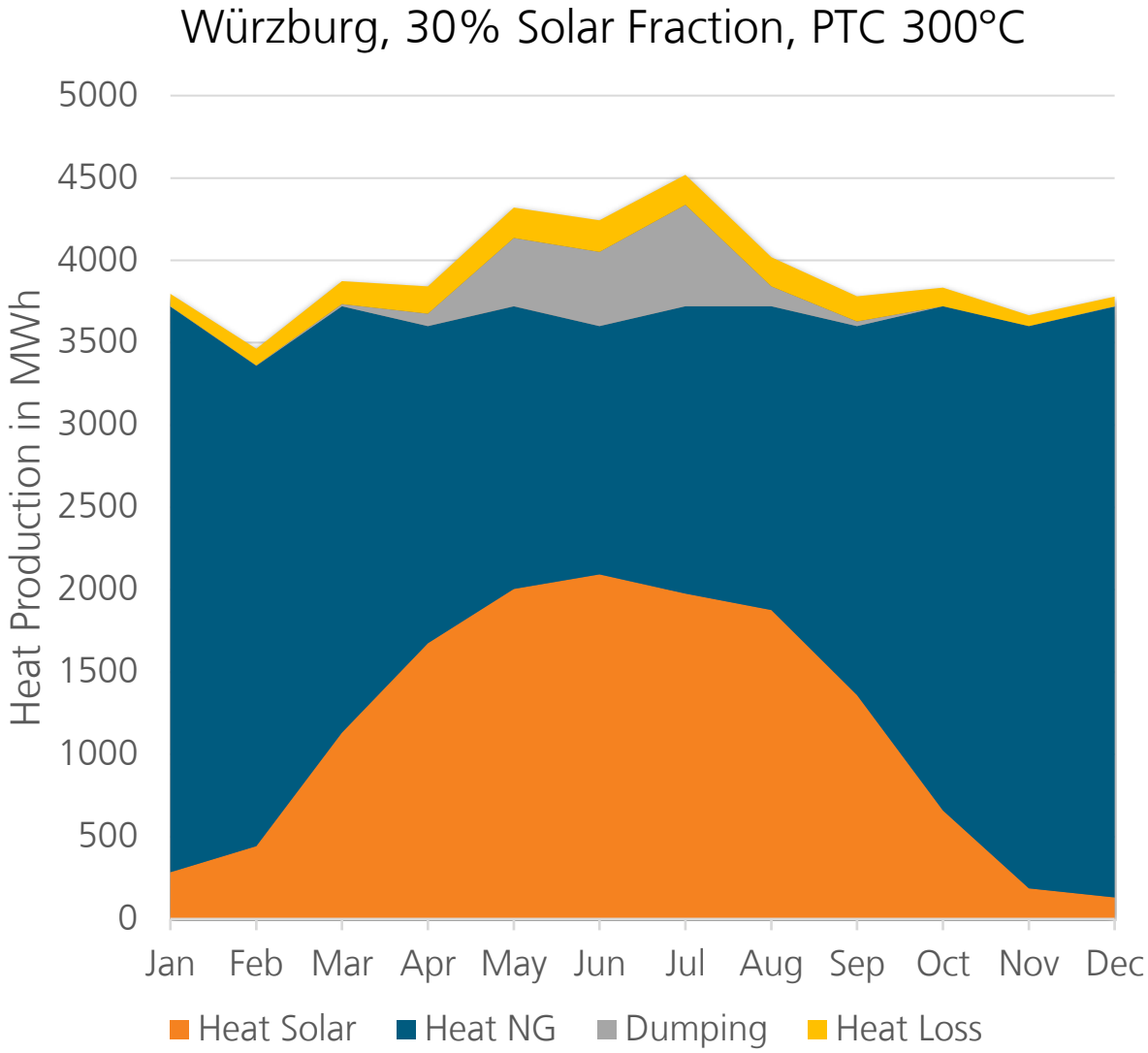
Techno-Economic Analysis

Solar yield and solar heat cost





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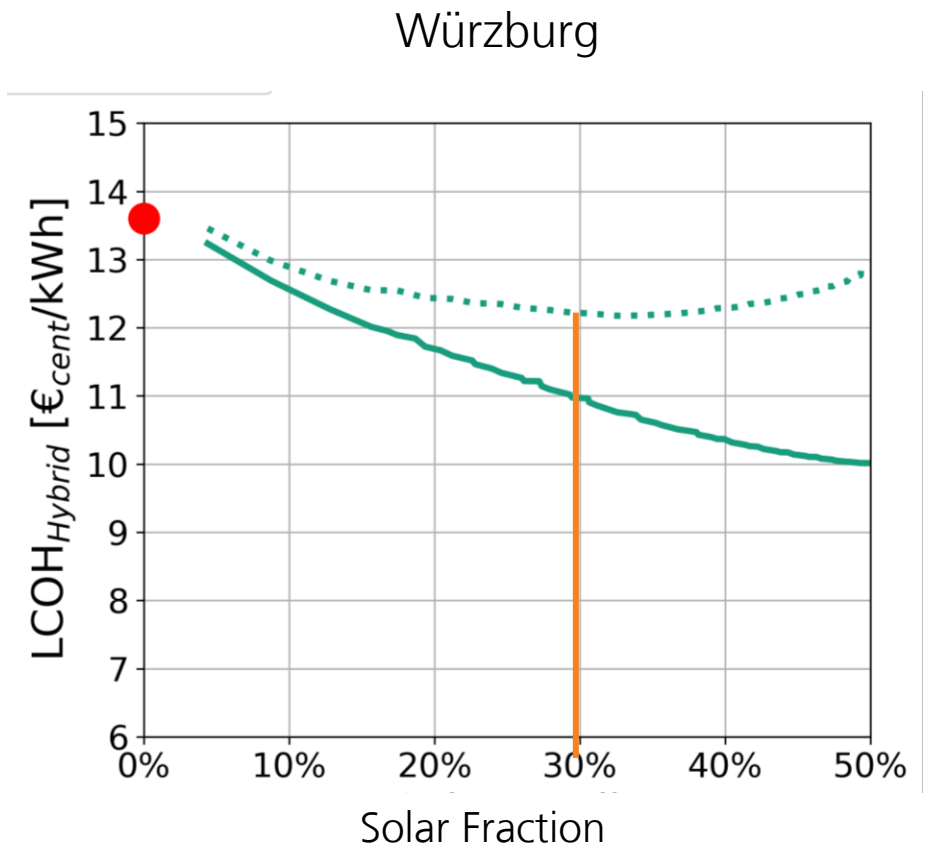

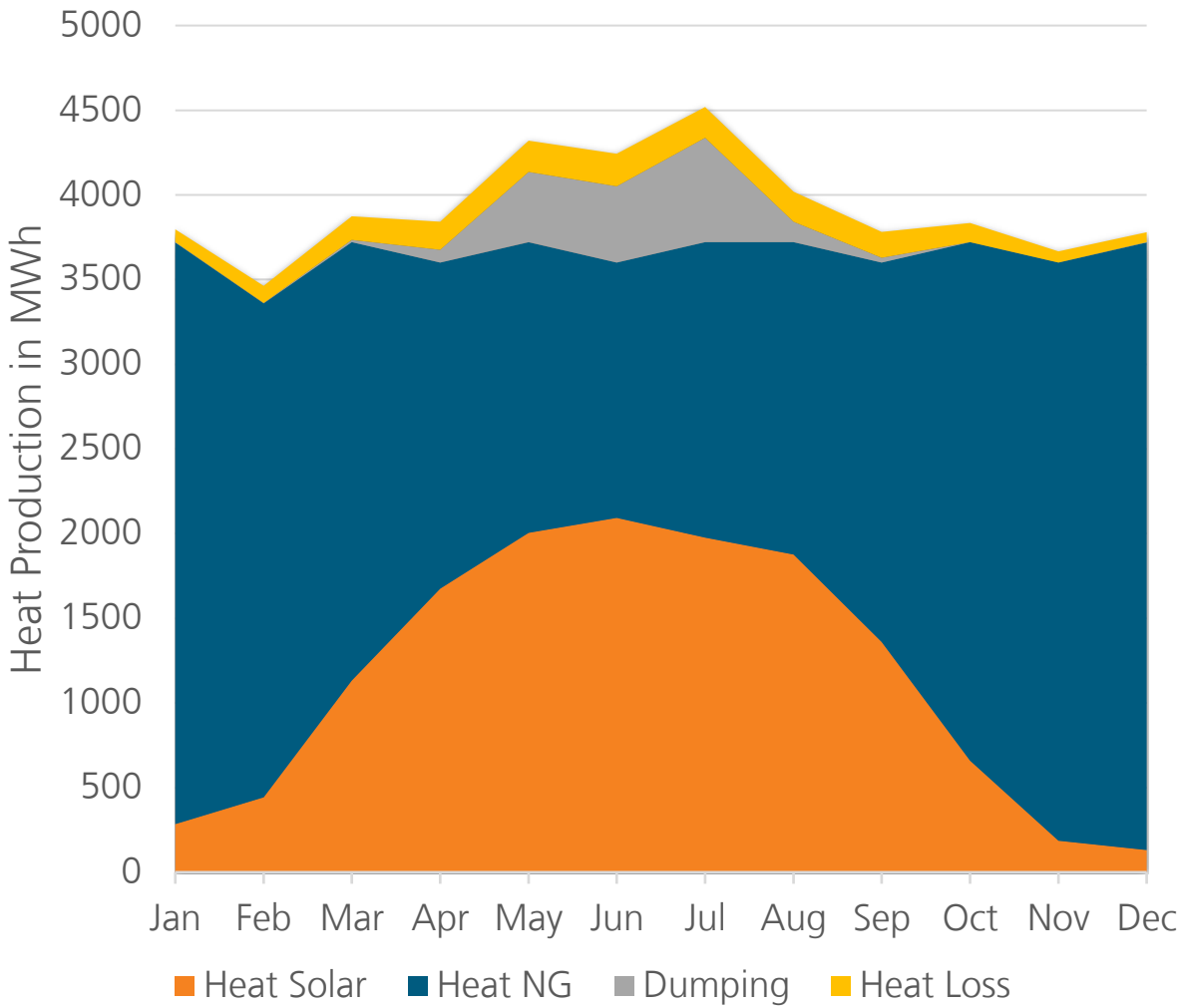

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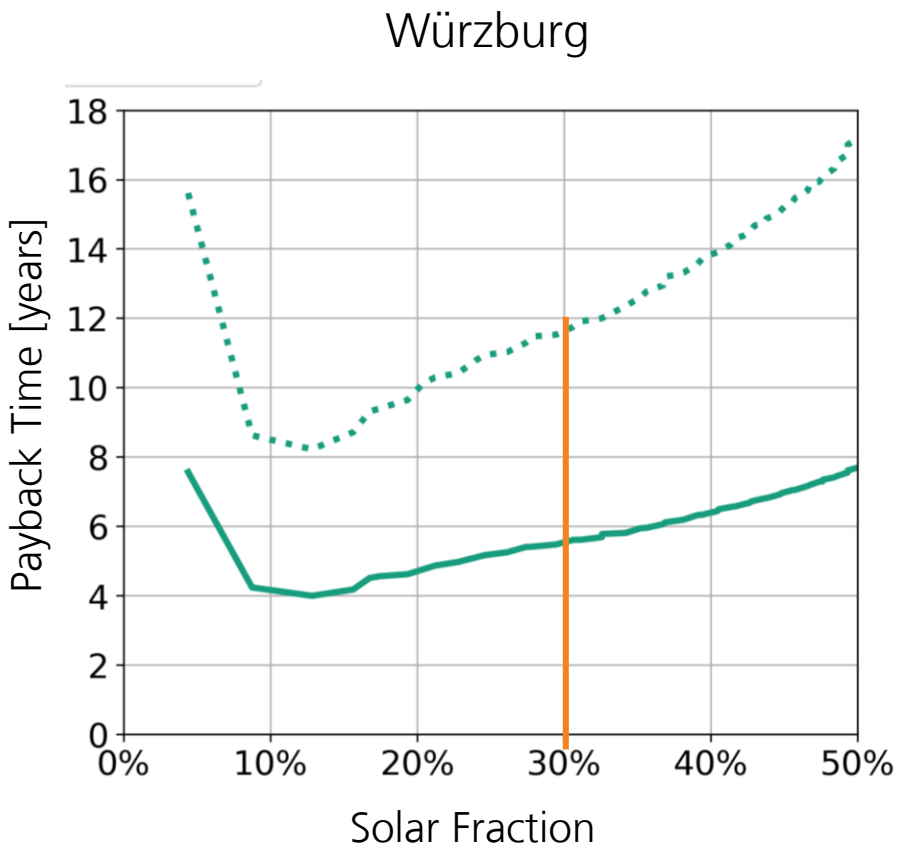

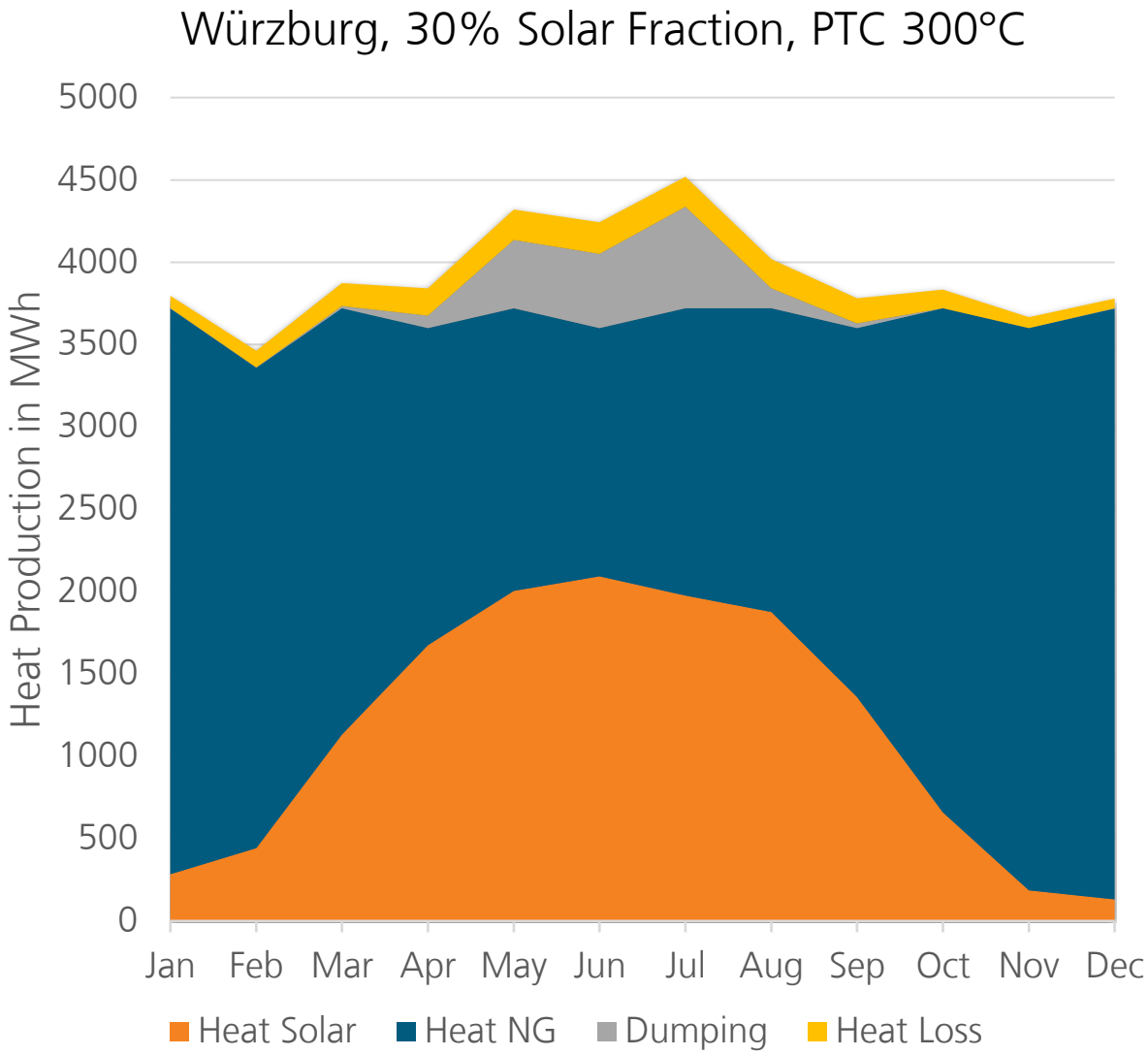

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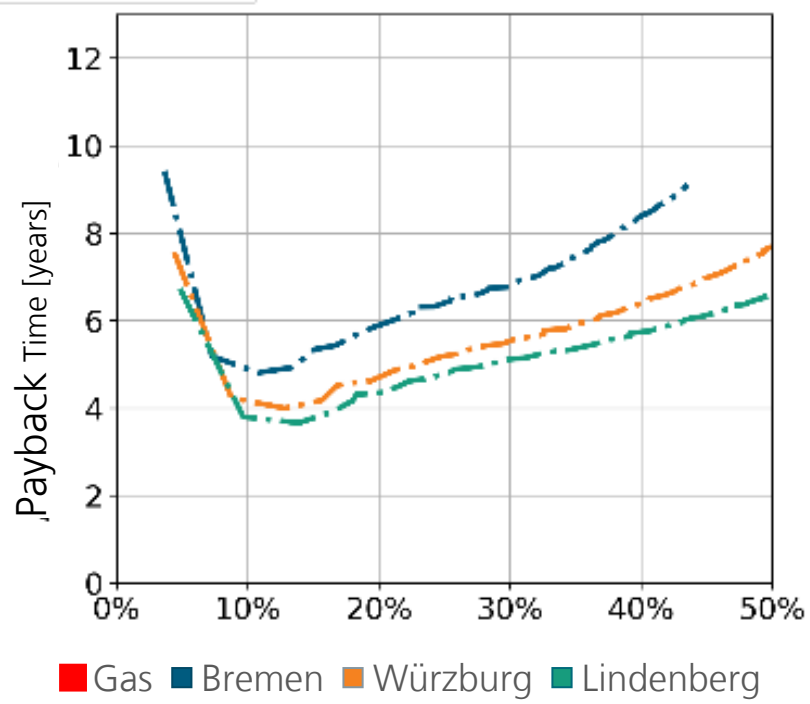
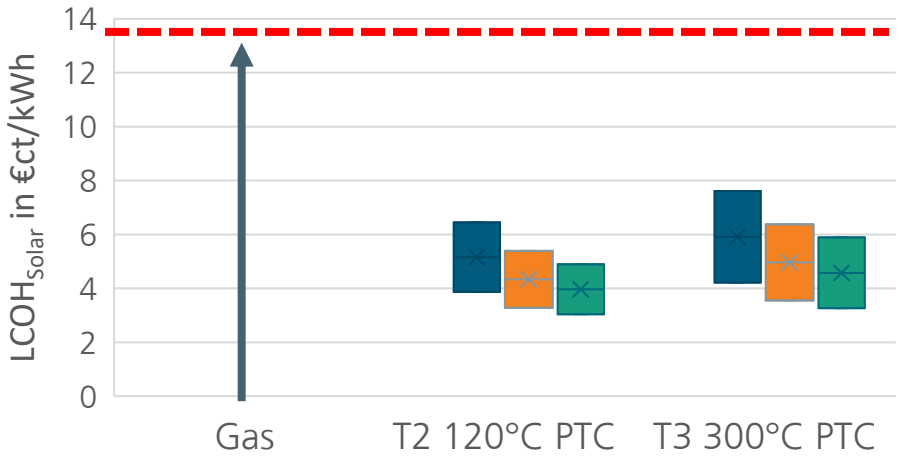
Conclusions

High Temperature Solar Thermal Heat is Competitive in Germany

- Smaller Solar Fractions allow Payback Periods below 4 years
  - Bremen 11% Solar Fraction: 4.4-4.8 years
  - Würzburg 13% Solar Fraction: 3.7-3.9 years
  - Lindenberg 14% Solar Fraction: 3.4-3.7 years
- Larger Solar Fractions Maximize Life Time Savings
- Larger Solar Fractions Minimize Levelized Cost of Heate
- Optimized return of Invest up to 390%
- Solar Heat Costs up to 78% of NG cost





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Thank you very much for your attention

Dr. Shahab Rohani, Xinyue Zhou, Dr.-Ing. Gregor Bern
Fraunhofer Institute for Solar Energy Systems ISE
Phone: +49 761 4588-5906
gregor.bern@ise.fraunhofer.de

Climate-Neutral Industry

Solar Power Plants and Integrated Photovoltaiks

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