Unlocking Solar Thermochemical Potential: Leveraging CSP Experience for Solar Thermochemistry – DLR Perspective

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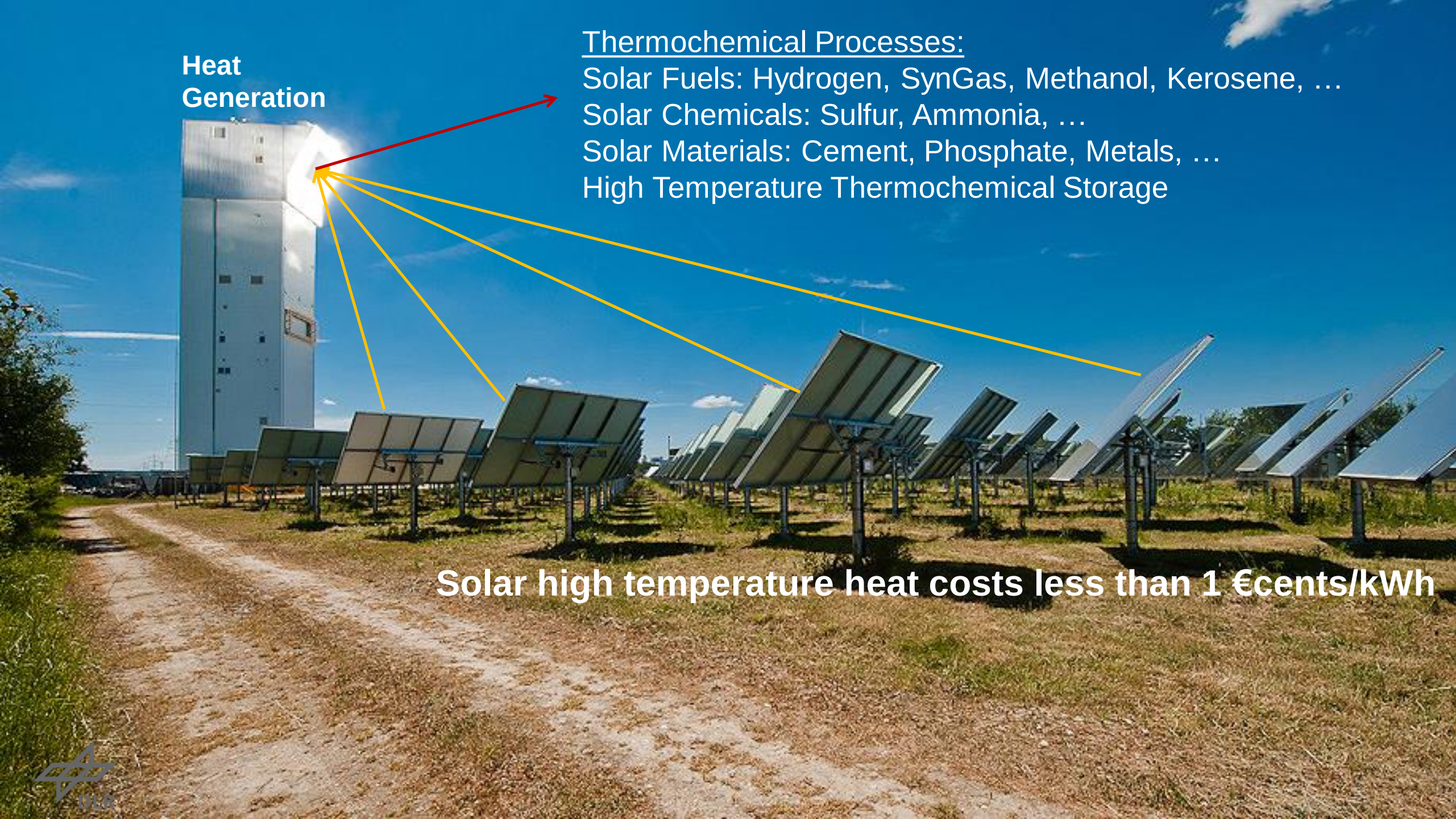
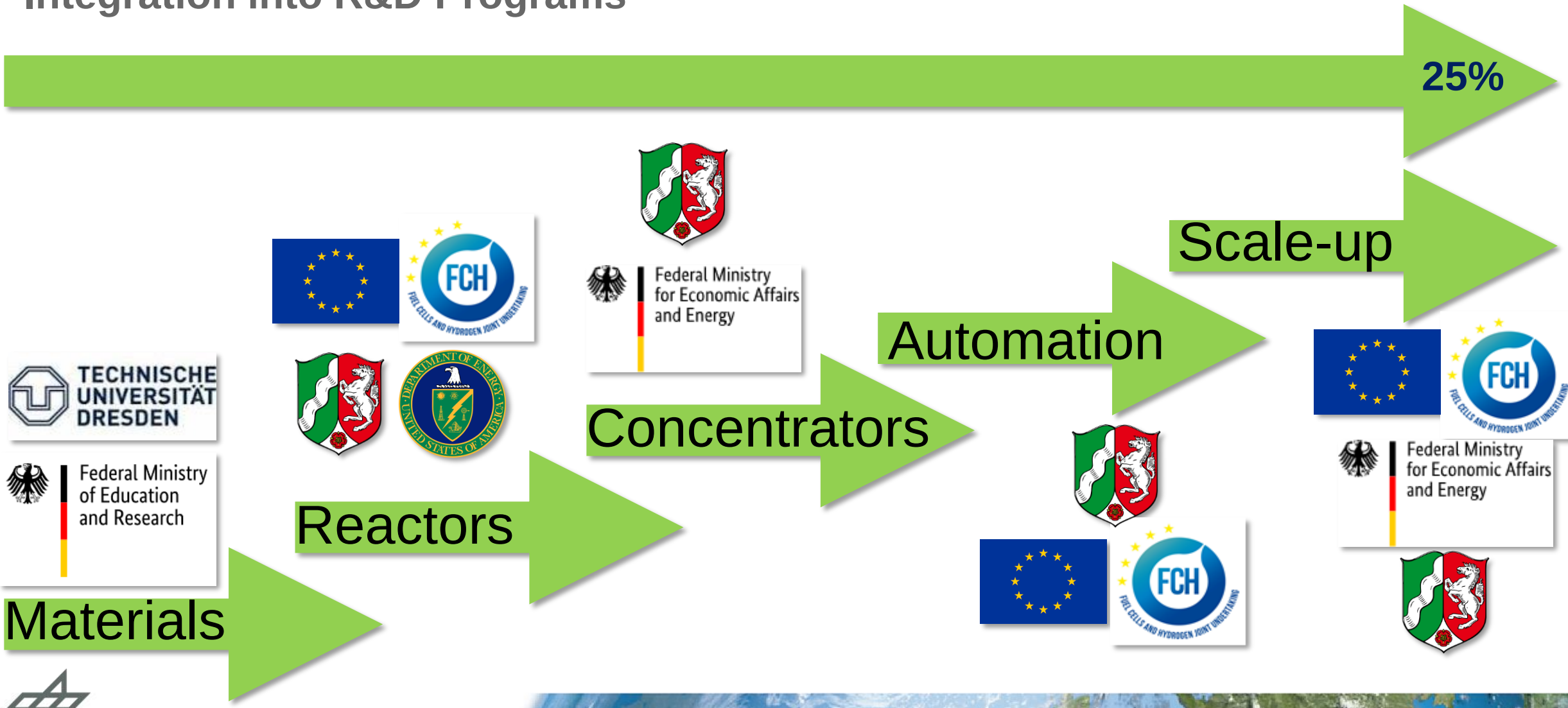

Heat
Generation
Thermochemical Processes:
Solar Fuels: Hydrogen, SynGas, Methanol, Kerosene, …
Solar Chemicals: Sulfur, Ammonia, …
Solar Materials: Cement, Phosphate, Metals, …
High Temperature Thermochemical Storage
Solar high temperature heat costs less than 1 €cents/kWh

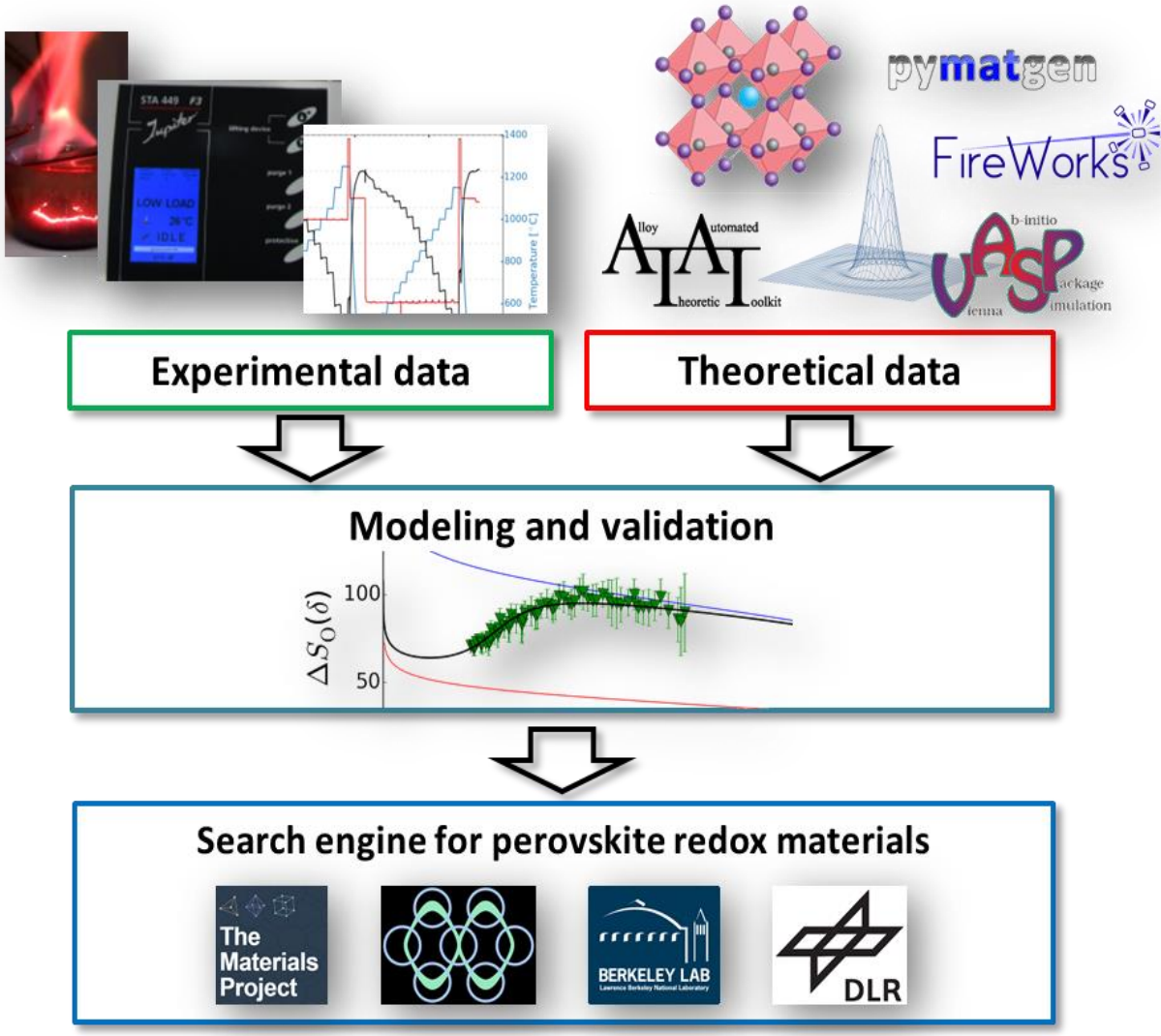
Strategy to improve the efficiency of Solar Thermochemical Processes
Integration into R&D Programs



Federal Ministry of Education and Research

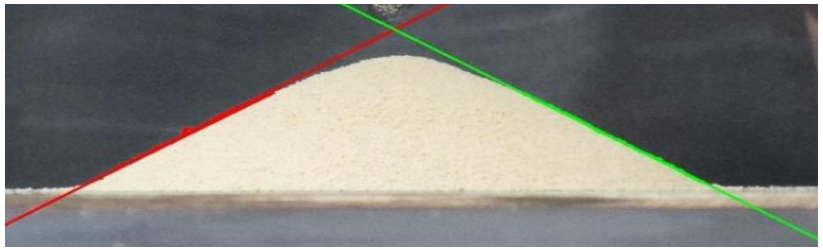
Synthesis of new redox materials - Perovskite screening

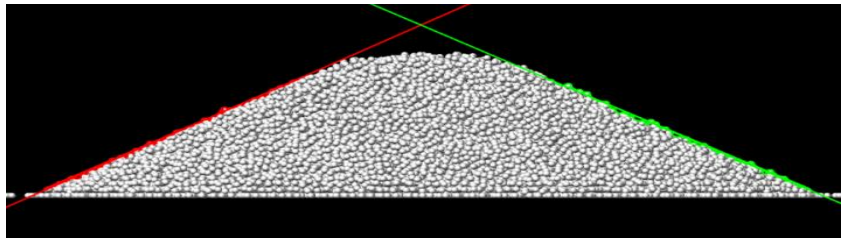
- Development of improved perovskite redox-materials
- Redox thermodynamics studied experimentally via the van‘t Hoff method
- Collaboration with Lawrence Berkeley National Laboratory, USA for modelling of experimental data and generation of additional theoretical data (DFT) available in The Materials Project
- 2019 Helmoltz PhD Student Award in the field of energy for Josua Vieten



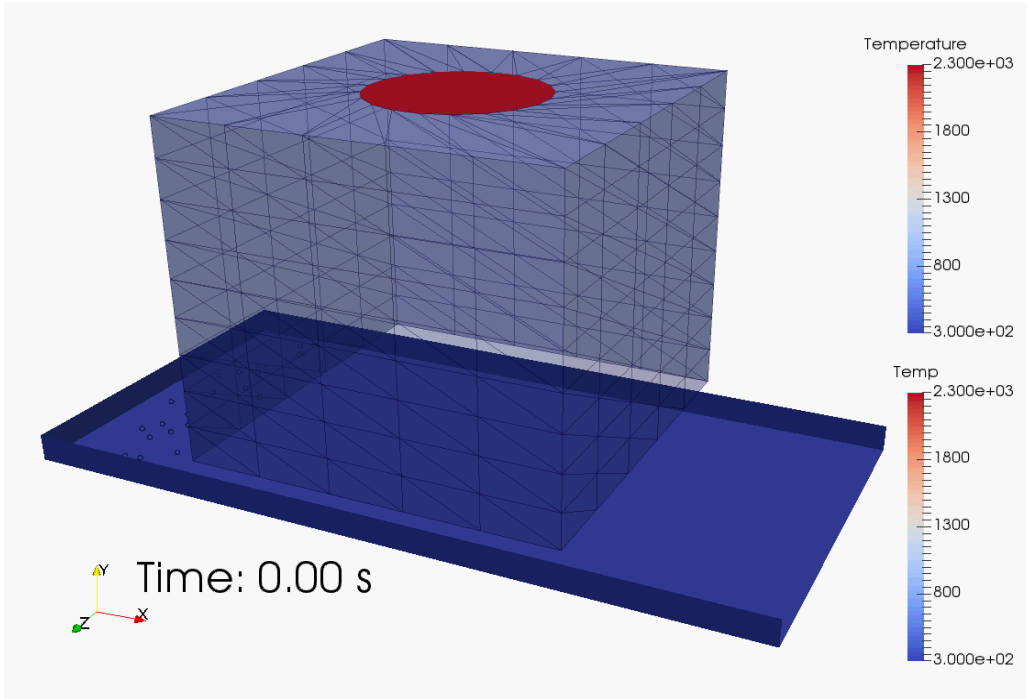
Modelling Solar Vacuum Particle-Reactors with the DEM

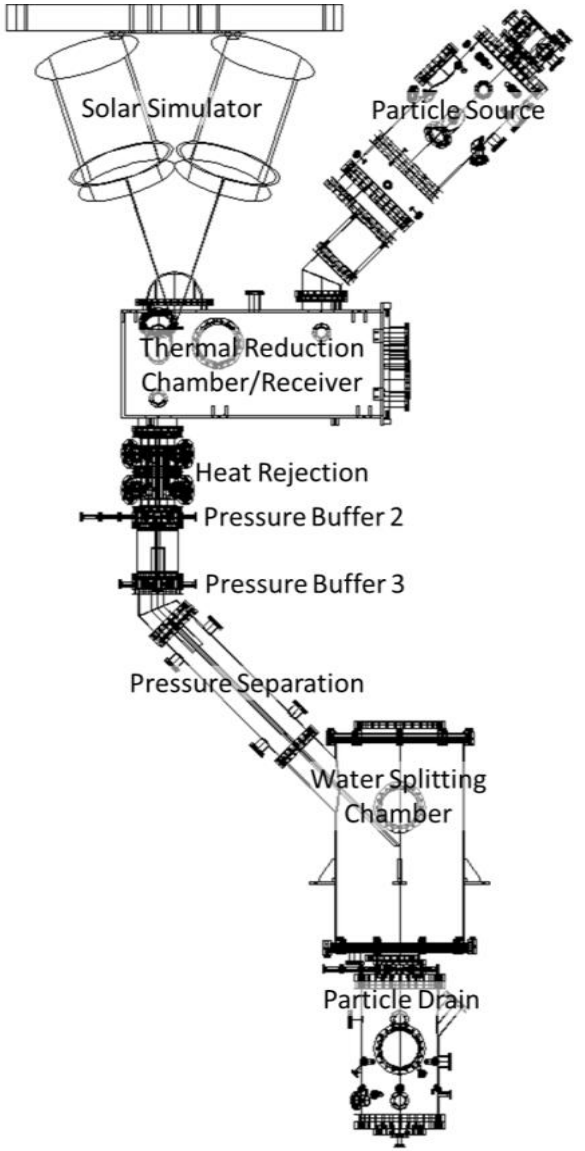
- Calibration of DEM input parameters for bauxite and ceria particles





- Heat transfer models for DEM
  - Chemical reaction
  - Inter-particle model
  - Radiation with MCRT
  - Use for the design of advanced reactors





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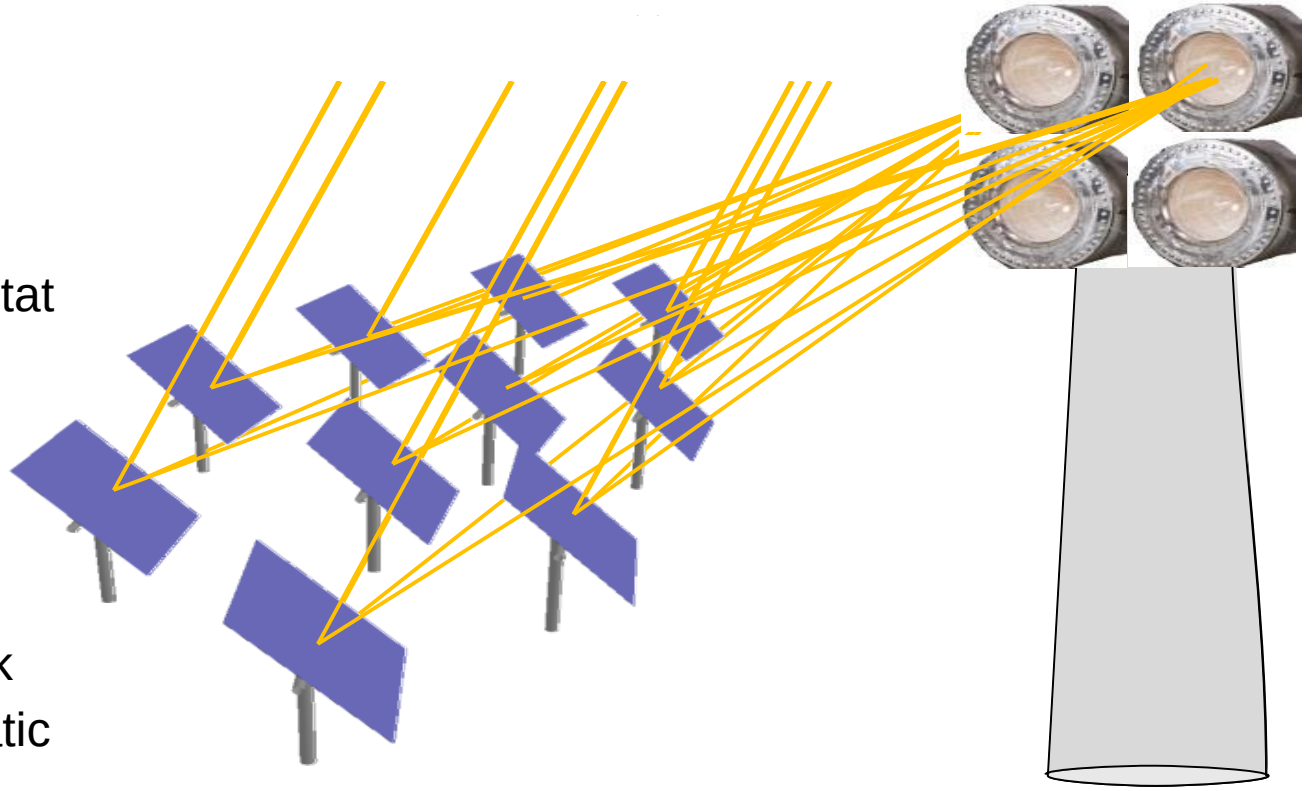
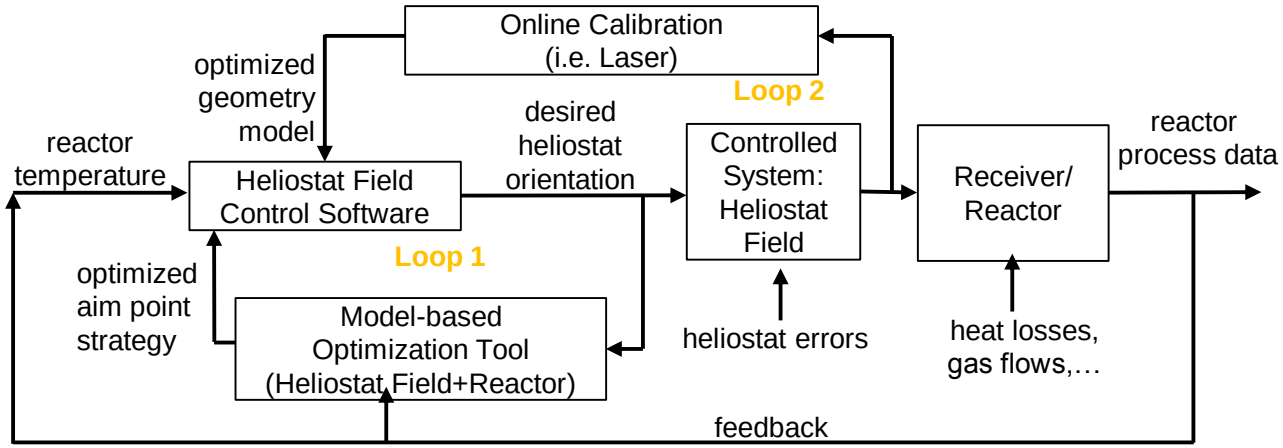
Automatic Heliostat Field Control For Chemical Applications

- Automatic control of the process temperature in a solar chemical multi-chamber reactor via the heliostat field
- Model-based aim point optimization tool for multi-chamber receiver-reactors
- Integration of an online heliostat field calibration procedure
- Development of a real-time communication network
- Modification of the heliostats, integration of automatic canting

- **Joint work with DLR Solar Power Plant Technology**
- **Partner:**





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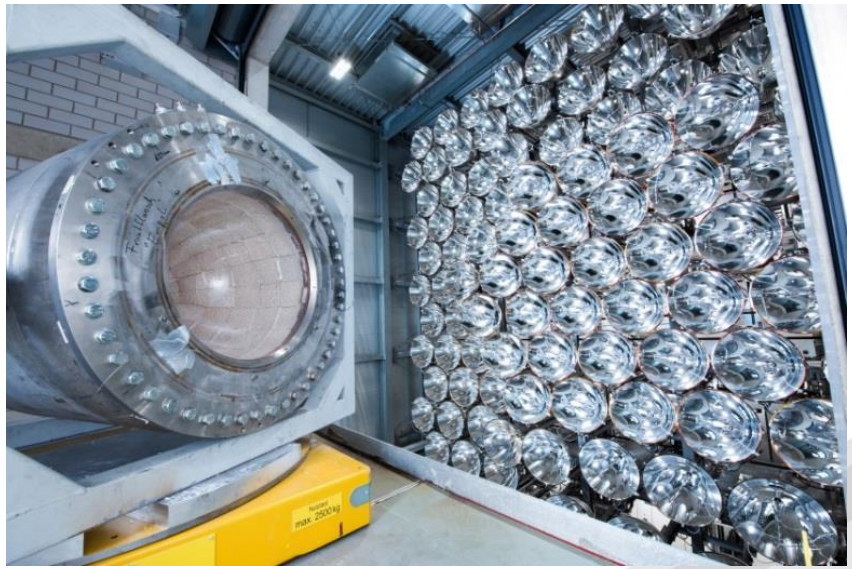
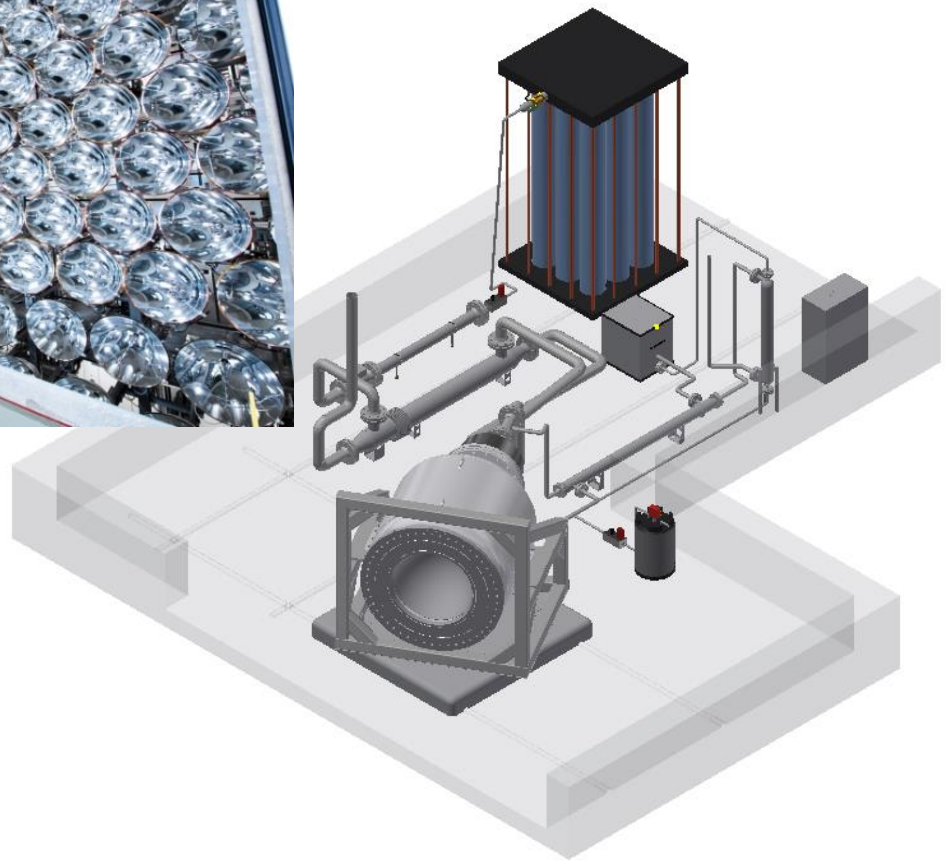
Automation of a Receiver-Reactor Plant for Thermochemical Cycles

Objective

- Set-up and operation of an automatically controlled 200 kW demo plant for solar-thermochemical hydrogen production
- Presently installed in Synlight
- Detailed presentation on our tour





Goal

- Improve the efficiency of the plant
- Reduce the H_2 production cost

Partners

Rheinische Fachhochschule Köln
University of Applied Sciences

AWS-TECHNIK

SV

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Development needs to be faster!
HYDROSOL Scale-up – 20 years development

HYDROSOL-beyond

- Improvement of heat recovery
- 5% efficiency of the 750 kW plant
- > 1000 cycles

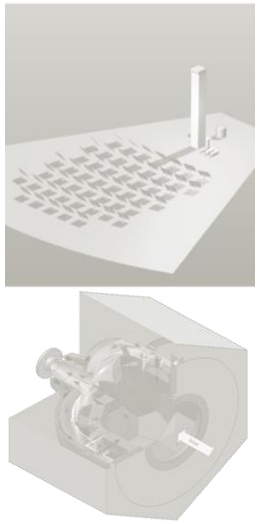
Achievments

HYDROSOL

HYDROSOL-II

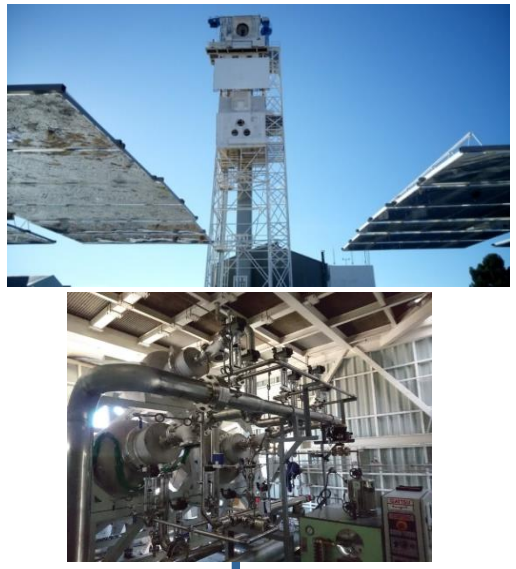
100 kW_{th} X 2, pilot plant

HYDROSOL-3D



1 MW_{th} plant design

HYDROSOL-PLANT



750 kW_{th} solar H_2 reactor

2002 2005 2008 2010 2014 2018 2022

Partner

HYDROSOL: APTL/CERTH, JM, STOBBE

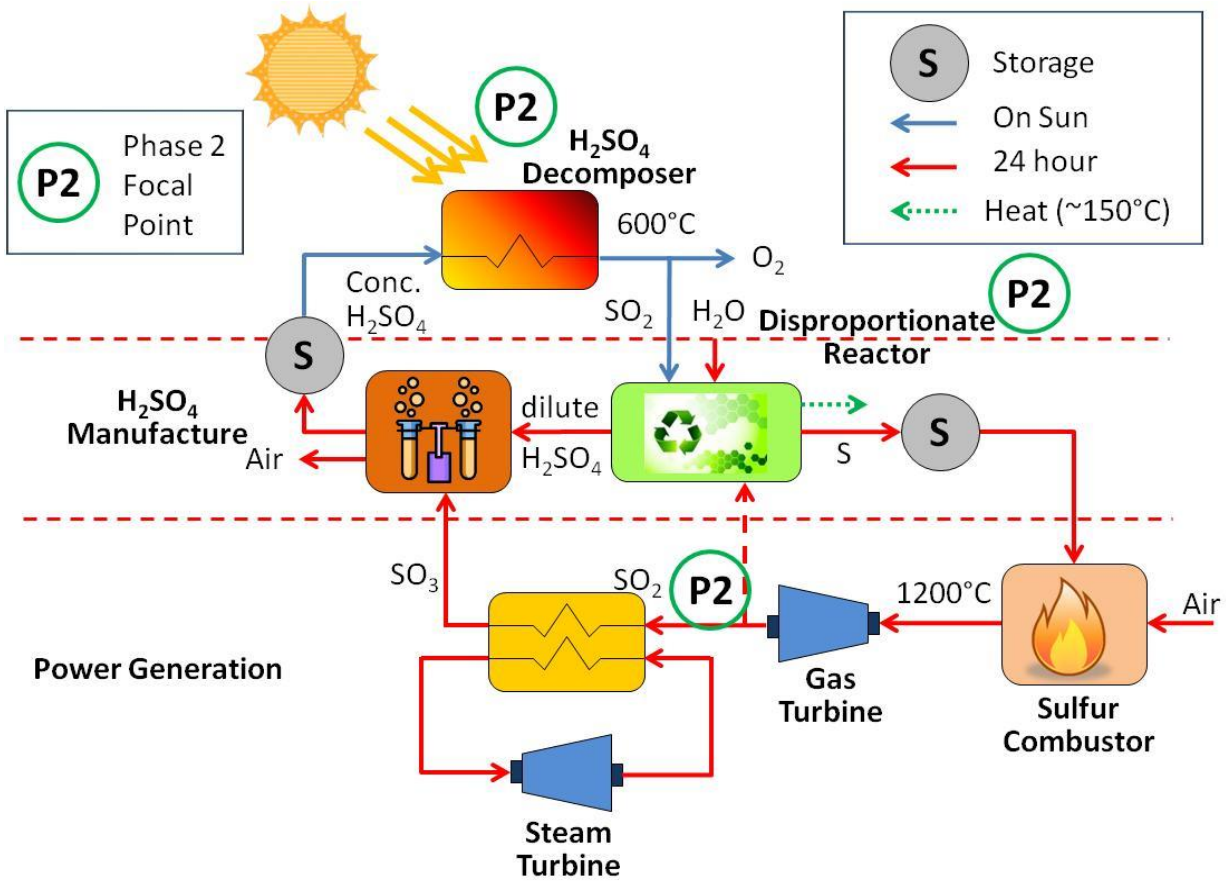
HYDROSOL-II: APTL/CERTH, CIEMAT, STOBBE

HYDROSOL-3D: APTL/CERTH, CIEMAT, HYGEAR, TOTAL

HYDROSOL-PLANT: APTL/CERTH, CIEMAT, HYGEAR, HELPE

EngiCer, SUPSI

Sulfur, Hydrogen, Heat



DLR GENERAL ATOMICS

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2020: Application of the pilot receiver developed in CentRec project

Renewable PowEr Generation by Solar PArticle Receiver Driven SUlphur Storage Cycle - In the final stretch!

In order to overcome the drawbacks of state-of-the art molten salt technology, a thermochemical storage cycle is investigated by the PEGASUS project to convert solar heat into chemical energy storing it as elemental sulphur leading to very higher storage densities.

Sulphur is one of the most important commodities of the chemical industry and can be easily, safely and cost-effectively stored, transported and combusted to produce high-temperature heat suitable for electricity generation using gas turbines.

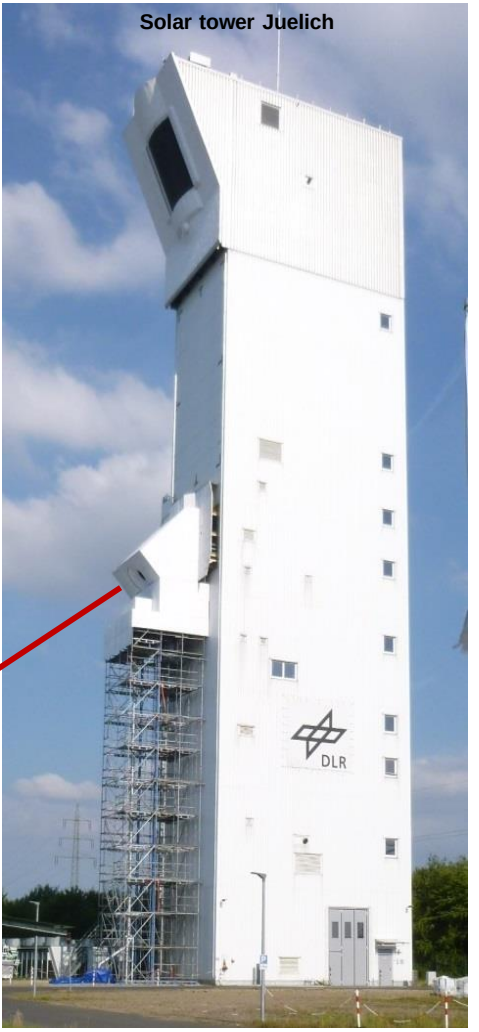
Recently, the 36 month review was successfully completed and the project in its final phase will validate the operation of three novel prototypes:

1. Solar centrifugal particle receiver
2. Particle reactor for sulphuric acid splitting
3. Pressurised sulphur burner

2.5 MW_{th} Centrifugal particle solar receiver

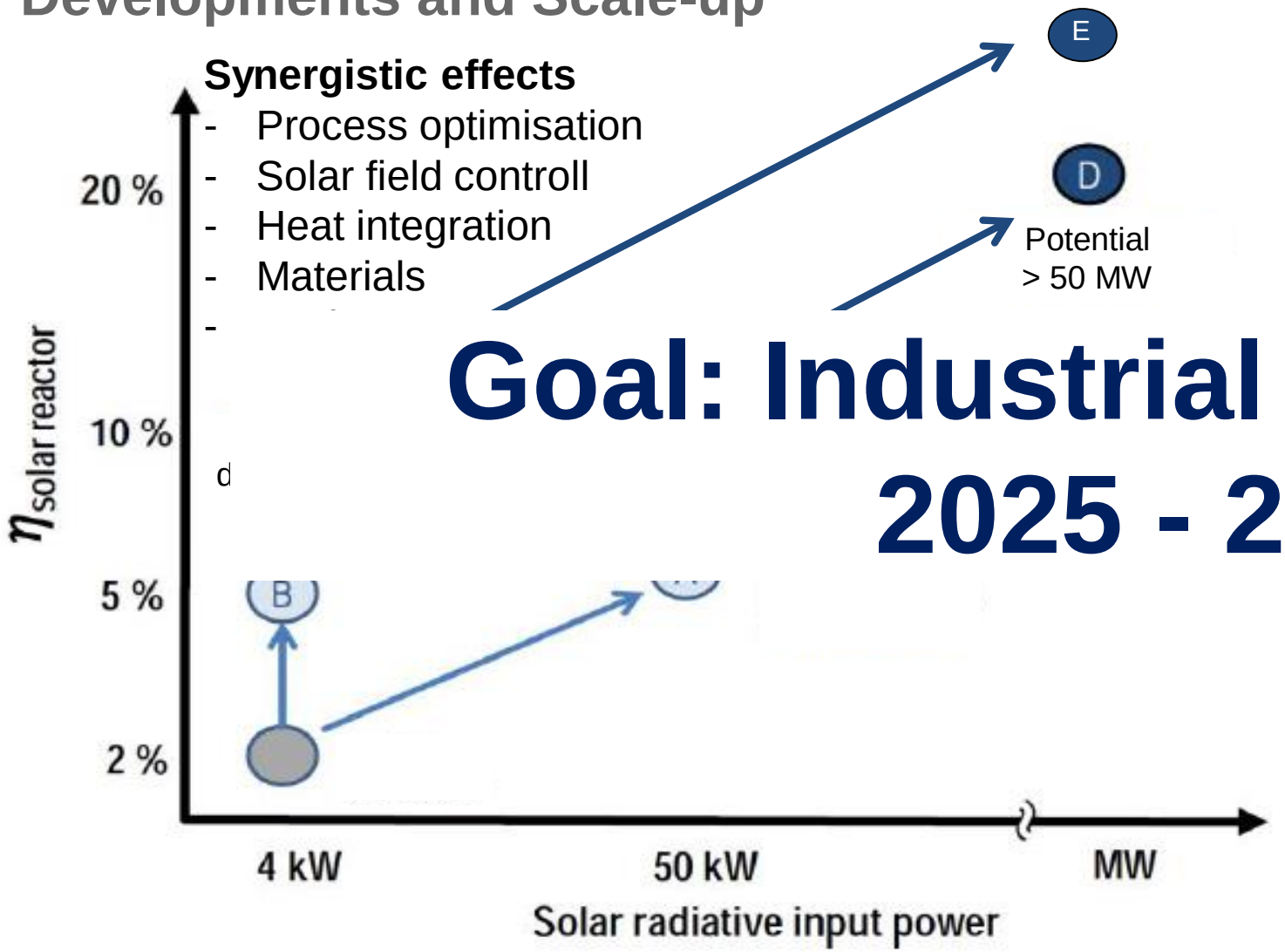
CentRec during construction

CentRec during operation



Developments and Scale-up

- Scale-up more processes in the MW scale
- Demonstration on sun e.g. in DLR's multi focus tower in Juelich, Germany



Goal: Industrial Application 2025 - 2030