

SOLAR GENERATED HEAT FOR INDUSTRIAL PROCESSES

HELMHOLTZ Energy conference 2023, Koblenz, Germany

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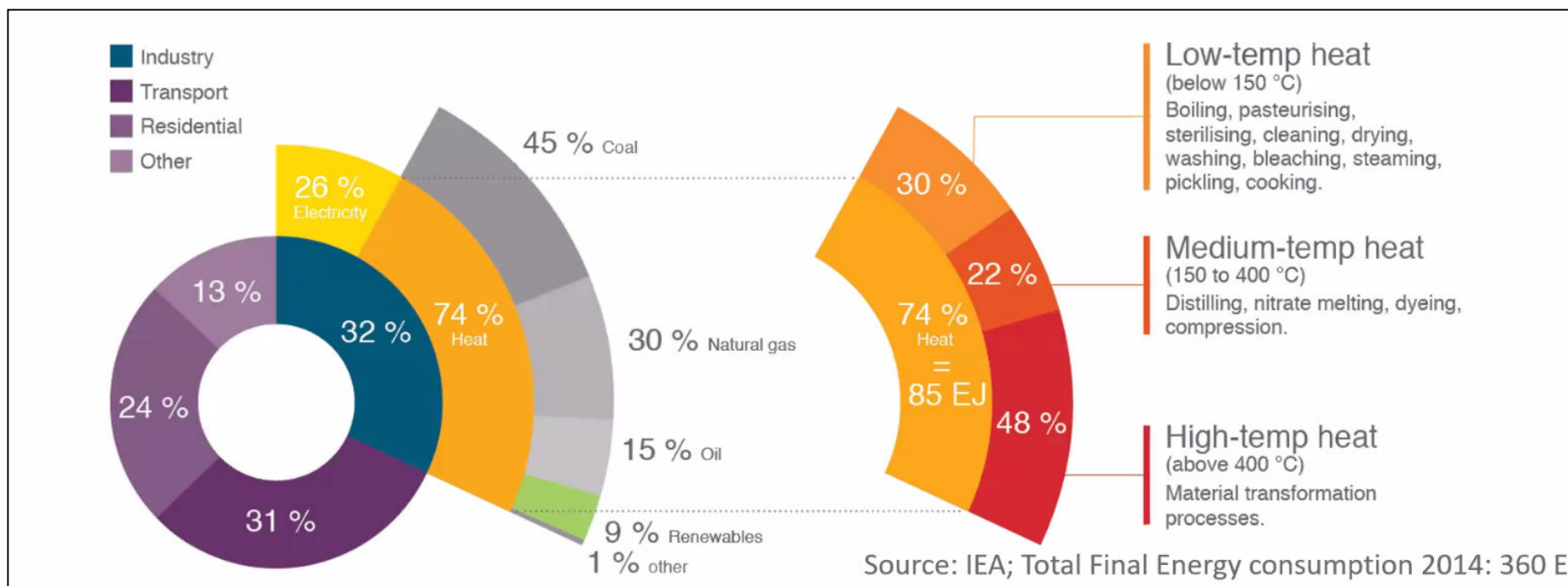


Outline



- Motivation: Heat demand in industry
- Overview on direct solar thermal heat generation technologies
- Molten salt systems up to 550 ... 600 °C (line and point focusing)
- Particle based systems
- Hybrid configurations for reliable and cheap heat supply
- Concentrating solar thermal in comparison to other heat supply options





Heat demand in industry



Significant share of heat demand is within the temperature range suited for already existing concentrating solar technologies (100 °C 550 °C) and upcoming solar technologies (>550 °C).

Portfolio of direct solar thermal solutions



up to 120 °C	100 °C to 500 °C	300 °C ... 800 °C	> 800 °C
No/low concentrating systems like flat plate or CPC	Line focusing systems like parabolic troughs or Linear Fresnel	Point focusing systems heating steam, air, particles	Advanced receiver concepts
State of the art	Collector technology state of the art in power plants. Several heat plants already operational.	Receiver technology used in about 20 power plants. Use for heat supply in demonstration.	Research
Use in all climates.	Up to 300/400 °C usable in central European climate. Higher temperatures in sunny regions in southern Europe.	Preferably in sunny regions.	Preferably in sunny region.
 Source: Aalborg CSP	 Source: TSK Flagsol	 Source: SENER	 Source: DLR

Experimental facilities for molten salt



Experimental facilities for molten salt



Évora Molten Salt Platform (EMSP), Portugal

Jointly operated by DLR Institute of Solar Research and University of Évora

**Solar demonstration
started in October 2021**

- Operation at temperatures up to 500 °C with Yara MOST salt mixture
- Salt degradation analysis: chemical and thermo-physical properties
- Demonstration of solar preheating and operation with Solar Salt
- >5000 hours operational experience in handling key process steps



Please find more info here:

Demonstration of 3.5 MWth Parabolic Trough With Termanry Molten Salt at the Évora Molten Salt Platform, Dicke et al., SolarPACES 2022

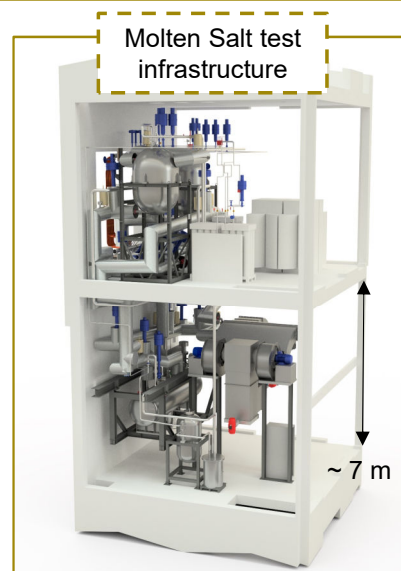
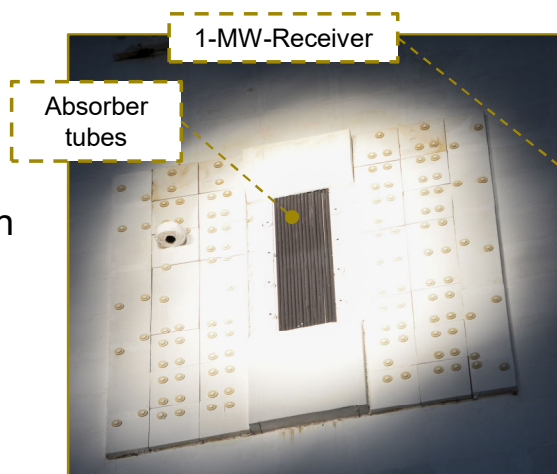
DLR's molten salt test facility in Julich (Germany)



Objectives

- Development, manufacturing and operation of a molten salt test receiver
- Solar Salt (60% NaNO_3 , 40% KNO_3)
- 600 °C design temperature in a controlled atmosphere configuration
- Scaled-down version of a commercial 700 MW_{th} tubular receiver
- Demonstrate all relevant operation scenarios
- Demonstrate manufacturability
- Demonstrate the expected receiver efficiency

**Commissioning finished in 2022,
solar test campaign in summer 2023**

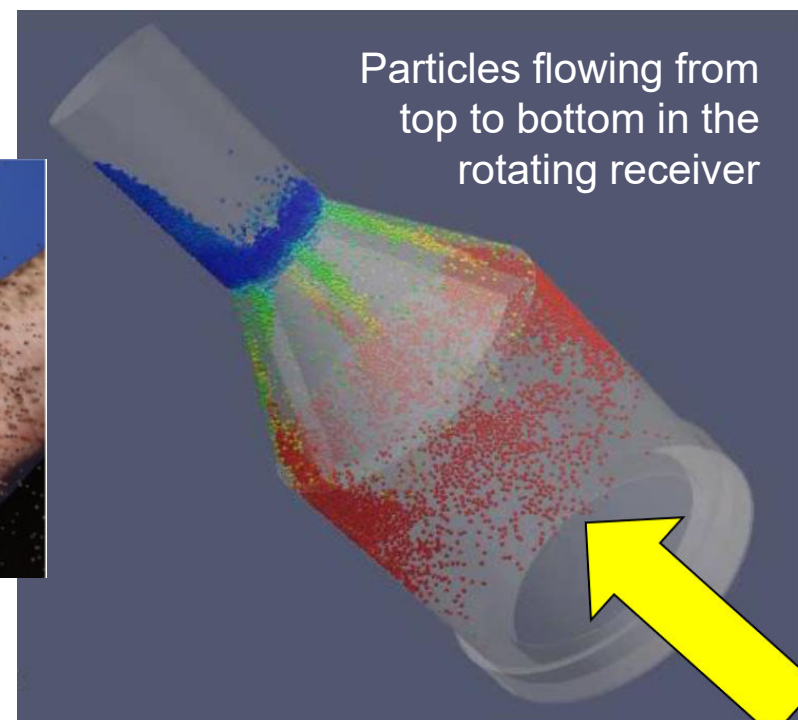
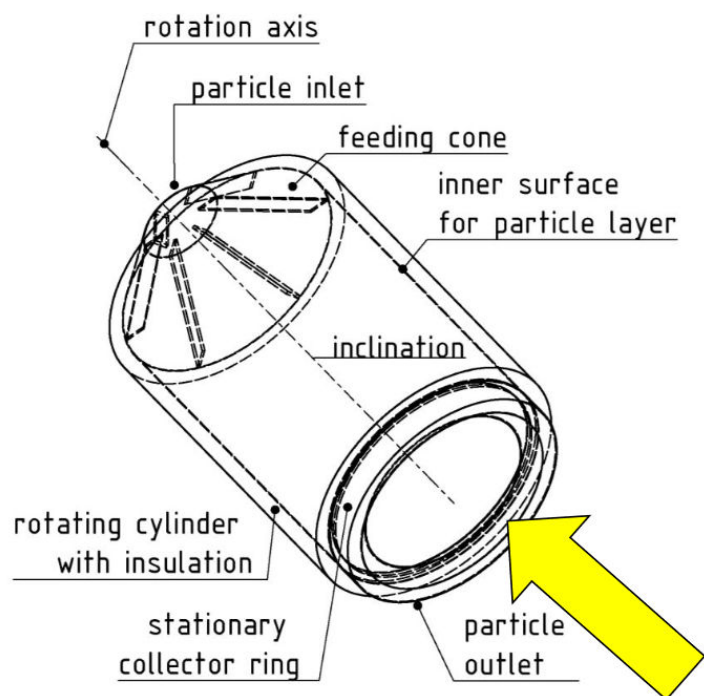


Please find more info here:

Commissioning of a Solar
Salt Test Setup for Central
Receiver Operation
at 600 °C
Frantz et al.,
SolarPACES 2022

Solar particle receivers to elevate temperatures

Principle of CentRec technology

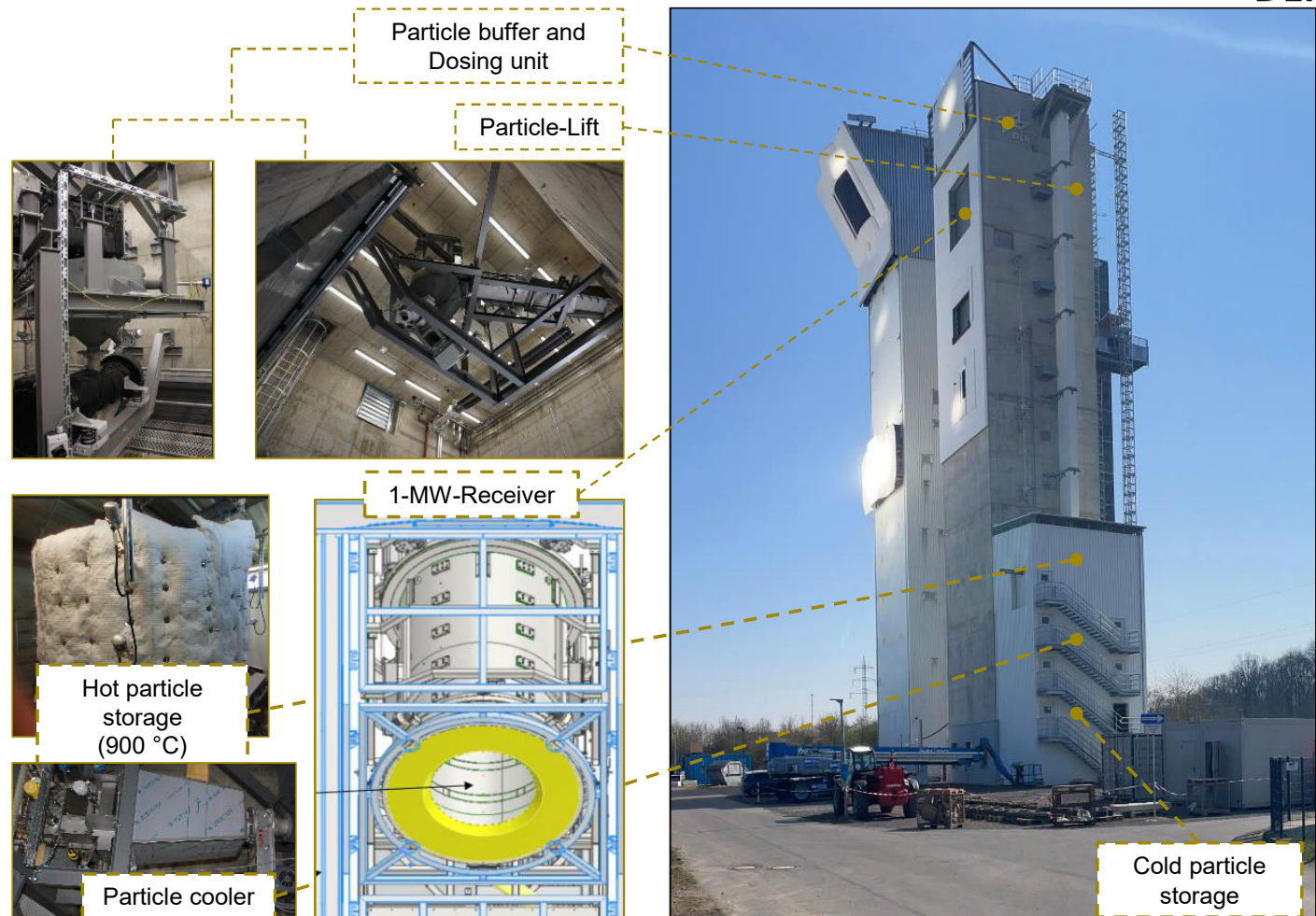


DLR's HEHTRES particle test facility in Julich (Germany)



A milestone for R&D and commercialization

- 1 MW scale technology demonstration
- Test platform for R&D on:
 - Receiver control
 - Particle film optimization
 - Receiver scaling
 - Validation of simulation models
- Testing and optimization of the receiver under real conditions
- Hands- on experience for industrial clients



Hybrid configurations for reliable and cheap heat supply

Heat generation



Backup:
Biomass, synth fuels,
(fossil) fuels

Electric heater/
heat pump



Heat buffer /
heat storage

Heat distribution

Heat consumption

Industrial process

Industrial process

Solar thermal in comparison to other heat supply options



▪ Electrification (grid or onsite PV)


- Available technology for air as heat transfer medium up to $\sim 900\text{ }^{\circ}\text{C}$
- From the company perspective easy to integrate.
- Generation costs PV 5-10 €/kWh_{el}, Wind onshore 4-8 €/kWh_{el} + grid transport
- Availability depends on expansion of renewable generation capacities

▪ Renewable fuels like hydrogen or its derivatives

- Expected hydrogen cost in Germany in 2030 around 4 €/kg \rightarrow 10 €/kWh_{th} (only fuel)
- Availability limited

▪ Direct solar thermal

- Stable and fixed generation costs of 4-6 €/kWh_{th} directly on site
- About double heat output than PV from the same land area (2x efficiency)
- Adaptation to load profile by integrated thermal storage
- Hybridization with other renewables/renewable fuels is easy
- Benefits becoming more relevant in the future:
 - Very high recycling rates (mainly metal, glass)
 - Very low dependency on critical raw materials (see the EU critical materials act)
 - Life time of plants usually much longer than depreciation period (40 instead of 20 years)



Use concentrating solar
wherever the local
conditions allow it!