Opportunities of applying concentrating solar solutions for process heat of up to 1000°C in South Africa

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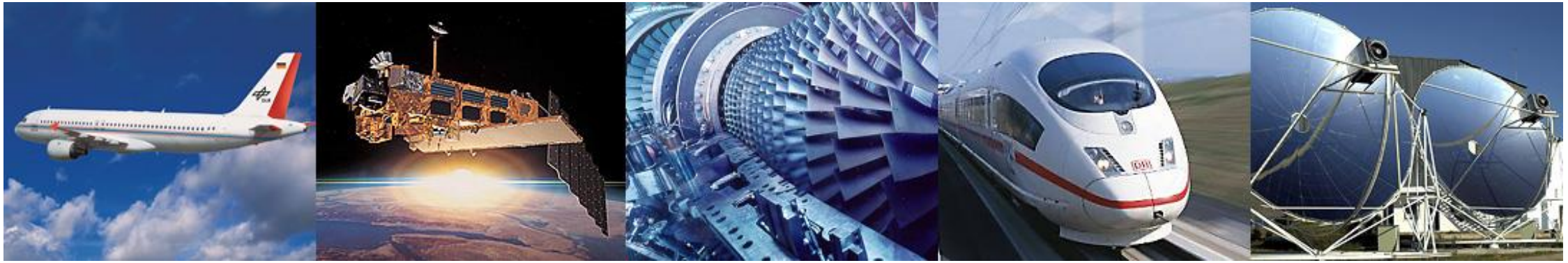
DLR, Institute of Solar Research

DLR – German Aerospace Center



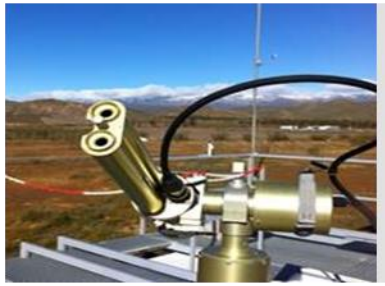
- Research Institution, Space Agency and Project Management Agency
- Research Areas:
  Aeronautics | Space Research and Technology | Transport | Energy | Defence and Security
- 8400 employees across 47 institutes and facilities at 27 sites in Germany
- 17 subsidiaries, cooperations and outposts in Germany, the Netherlands and Spain
- Offices in Brussels, Paris, Tokyo and Washington
- Total income 2018: 1035 Mio. €

DLR - Institute of Solar Research
Research & Development

Point Focus Systems
- Heliostats
- High temperature receivers
- System technology

Qualification
- Components
- Component durability
- Systems

Line Focus Systems
- Heat transfer media
- Collector development
- Industrial process heat



Solar Energy Meteorology
- Solar radiation measurement and modelling
- Radiation nowcasting
- Other meteorological influences

New Materials
- Absorber materials
- High temperature redox systems
- Photocatalysts
- Heat transfer fluids

Solar chemical engineering
- Solar fuels
- Solar materials
- Solar water treatment

- Located in Cologne, Stuttgart, Jülich and Almería (Spain)
- 135 staff members

Concentrating solar power and thermal – CSP and CST

Concentrating solar technologies for power production and provision of process heat

Why are we talking about concentrated solar?

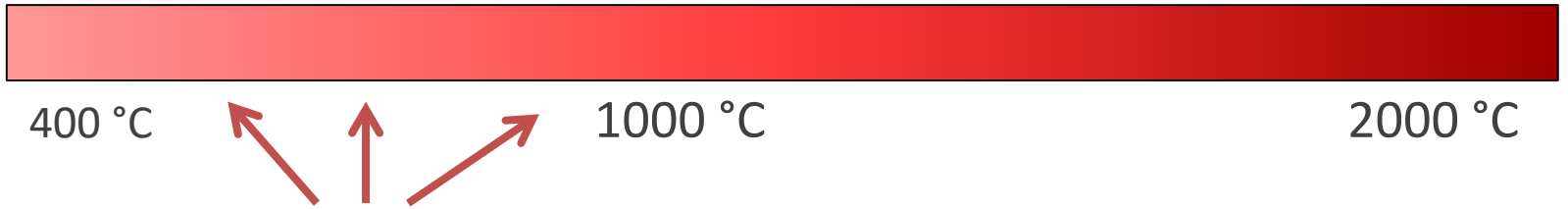
parabolic trough

solar tower

dish

line focus (2D-conc.)
concentration 10 - 200

point focus or central receiver (3D-conc.)
concentration 100 - 2000

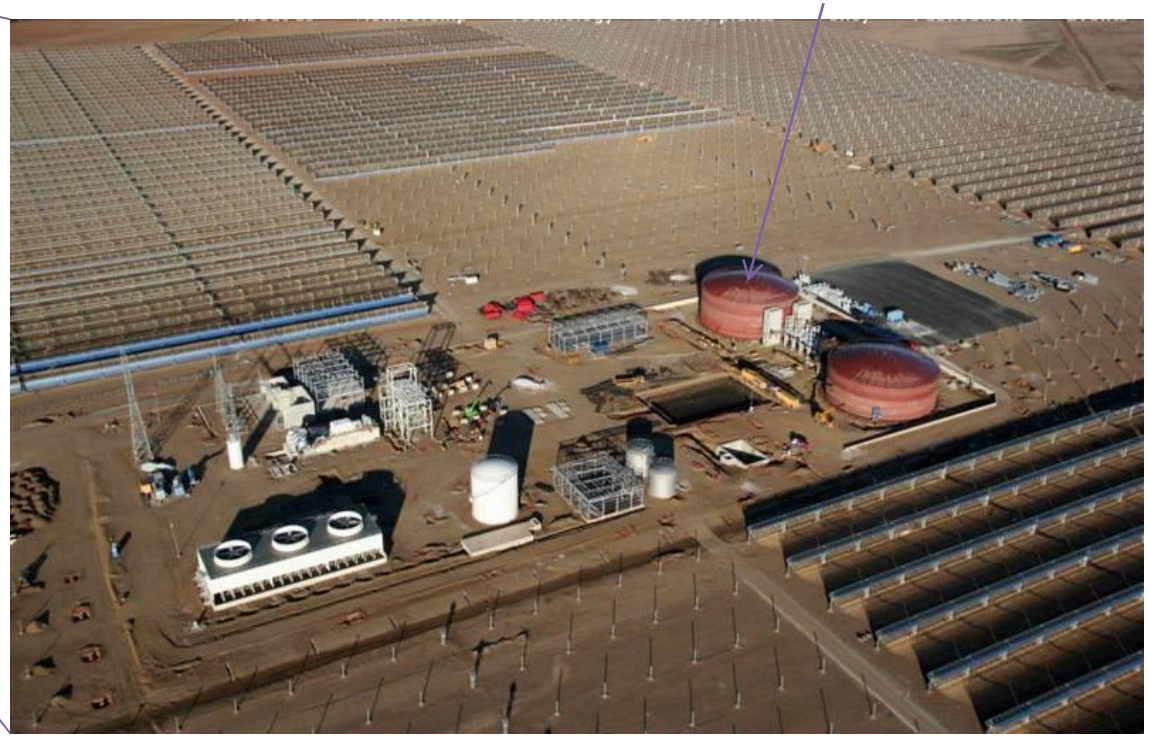


CST is able to provice heat at a defined temperature, adaptable to the process

Why are we talking about concentrated solar?

- CSP already implemented in South Africa:
  - Bokpoort, Khi Solar One, ….
- LCOE higher than PV
- Dispatchable through thermal storage

thermal storage



- CST can provide heat at competitive cost
- Cheap thermal storage gives the opportunity for dispatchable energy production

High Temperature Process Heat: CentRec® Particle Receiver

- Direct absorption receiver
- Bauxite particles suitable for high flux and temperatures >> 1000 °C
- Low cost materials for reduction in levelized cost of heat and low cost provision of thermal storage
- Experimental campaign in Jülich under ~10 % part load already provided >960 °C

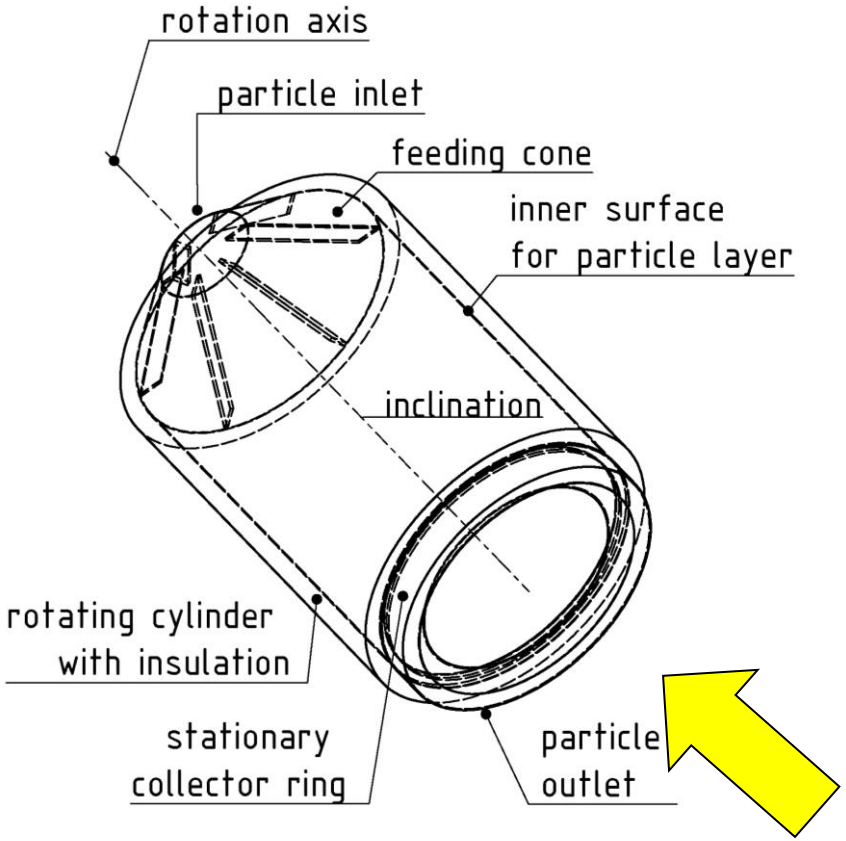
HELIOHEAT

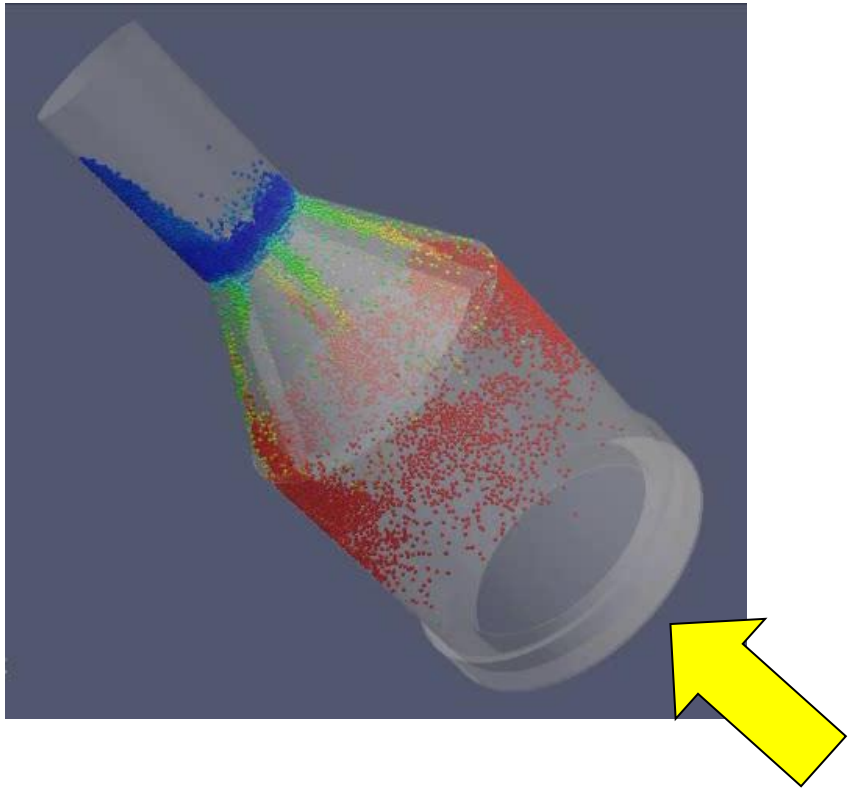
See: ***24/7 renewable high temperature heat utilising ceramic particles as heat carrier***
By Dr. Lars Amsbeck, HiTemp-2, 16.03.2020;

HelioHeat is a startup commercially providing the CentRec receiver.

DLR

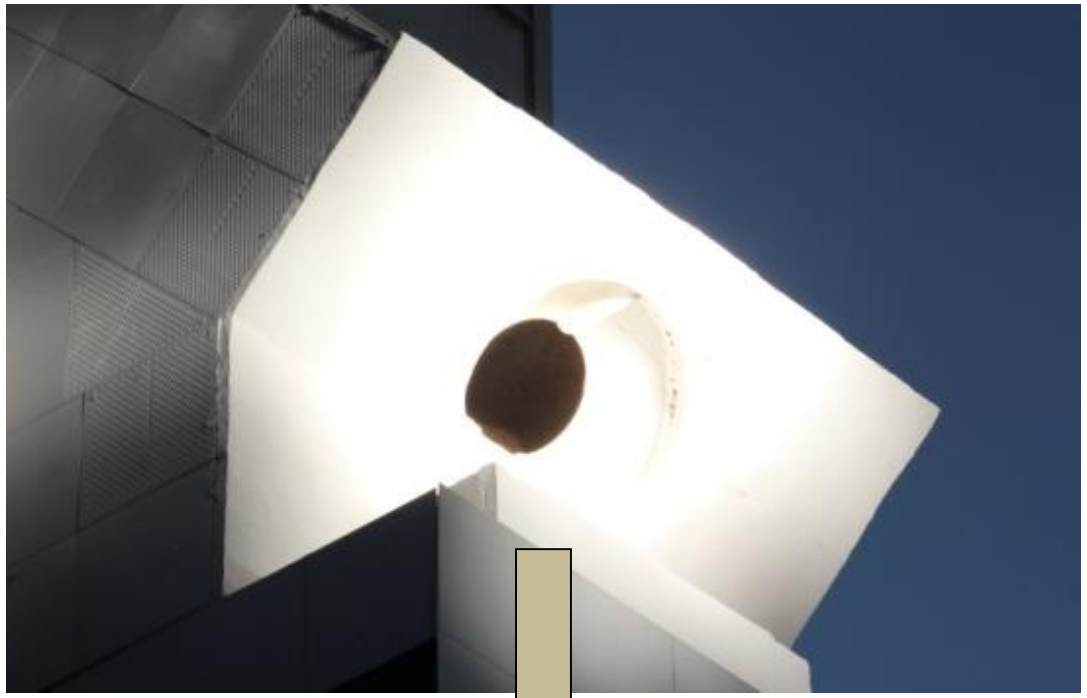
Introduction CentRec®





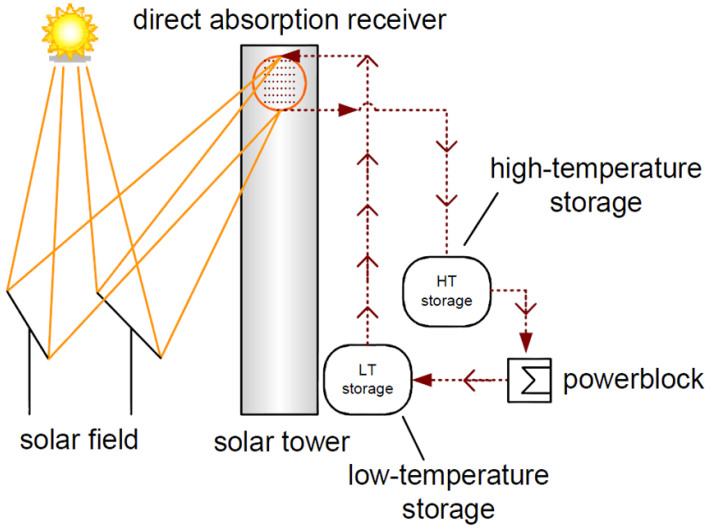
- Particle residence time / receiver outlet temperature controlled by adjusting rotational speed
- Thin, optical dense layer for all load conditions

The CentRec® Particle Receiver



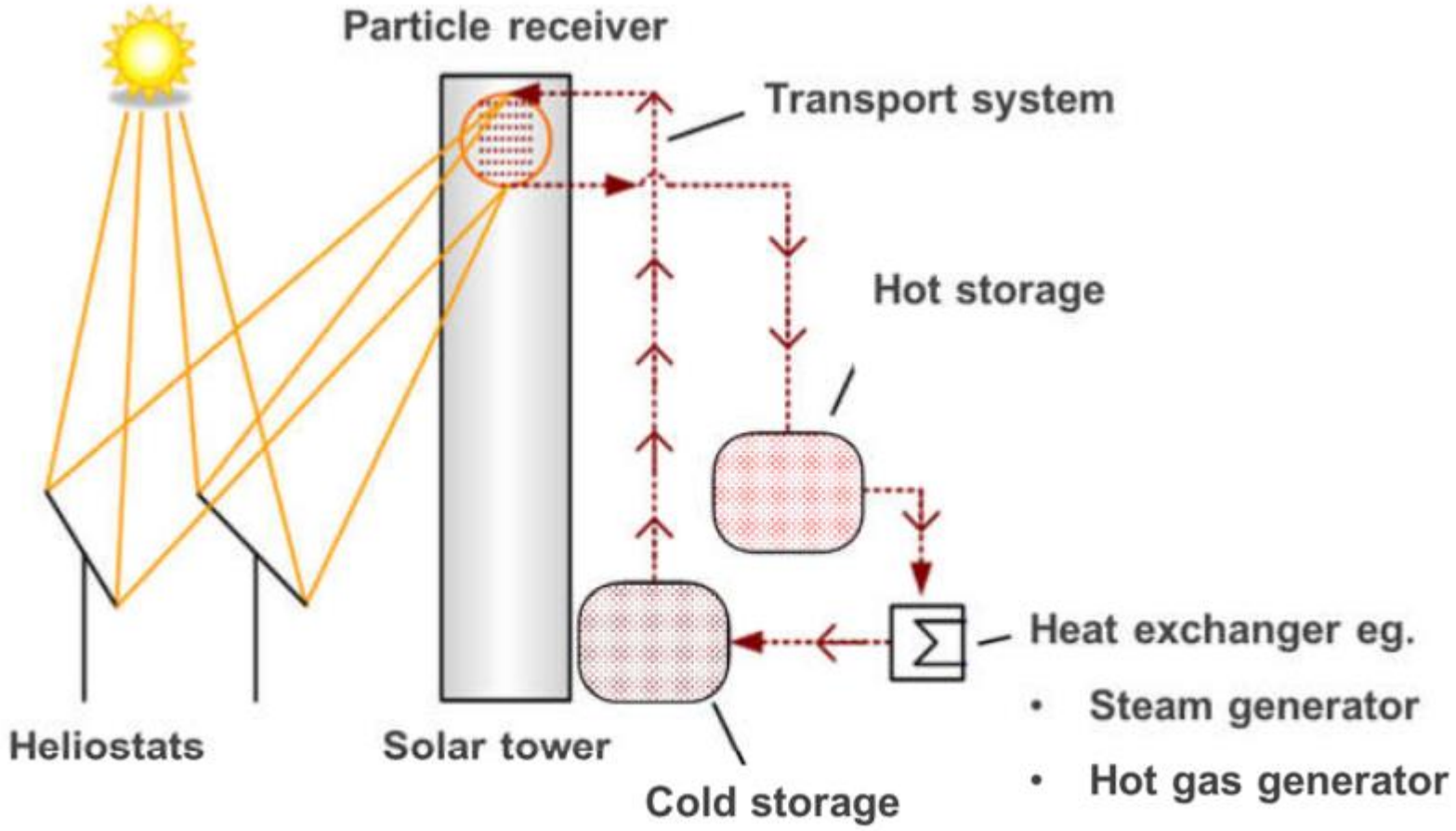
particles at 1000 °C

Example of a plant configuration where the heat exchanger supplies a power block



- **Power generation** (e.g. suited for steam turbine at 620 °C or next generation sCO2 technologies at ~700 °C)
- **Process heat**, e.g. air at 800 °C
- **Solar thermal** chemical reactor / reaction (including using catalytic particles)
- Heat provision for **Solar Fuels** production

Particle system for process heat generation



particles at 1000 °C

steam

air

Other gases

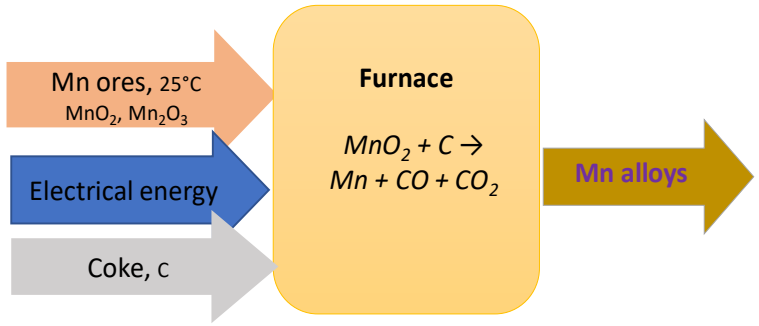
up to ~ 800 °C

PREMA – Reduced CO_2 emissions and consumption of electrical energy in Mn-alloy production

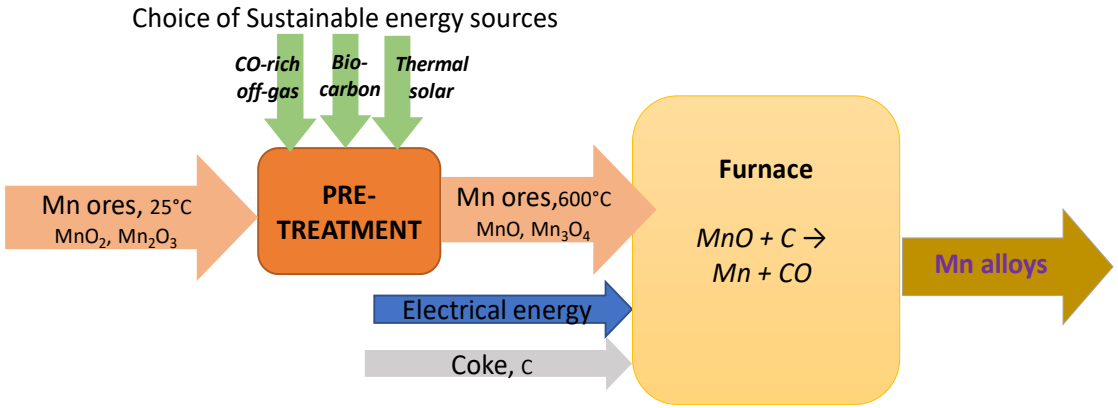
Energy efficient, primary production of manganese ferroalloys through application of novel energy systems in the drying and pre-heating of furnace feed materials

PREMA project is supported by EU Horizon 2020 Research and Innovation Programme under Grant Agreement No 820561

Before **PREMA**



After **PREMA**

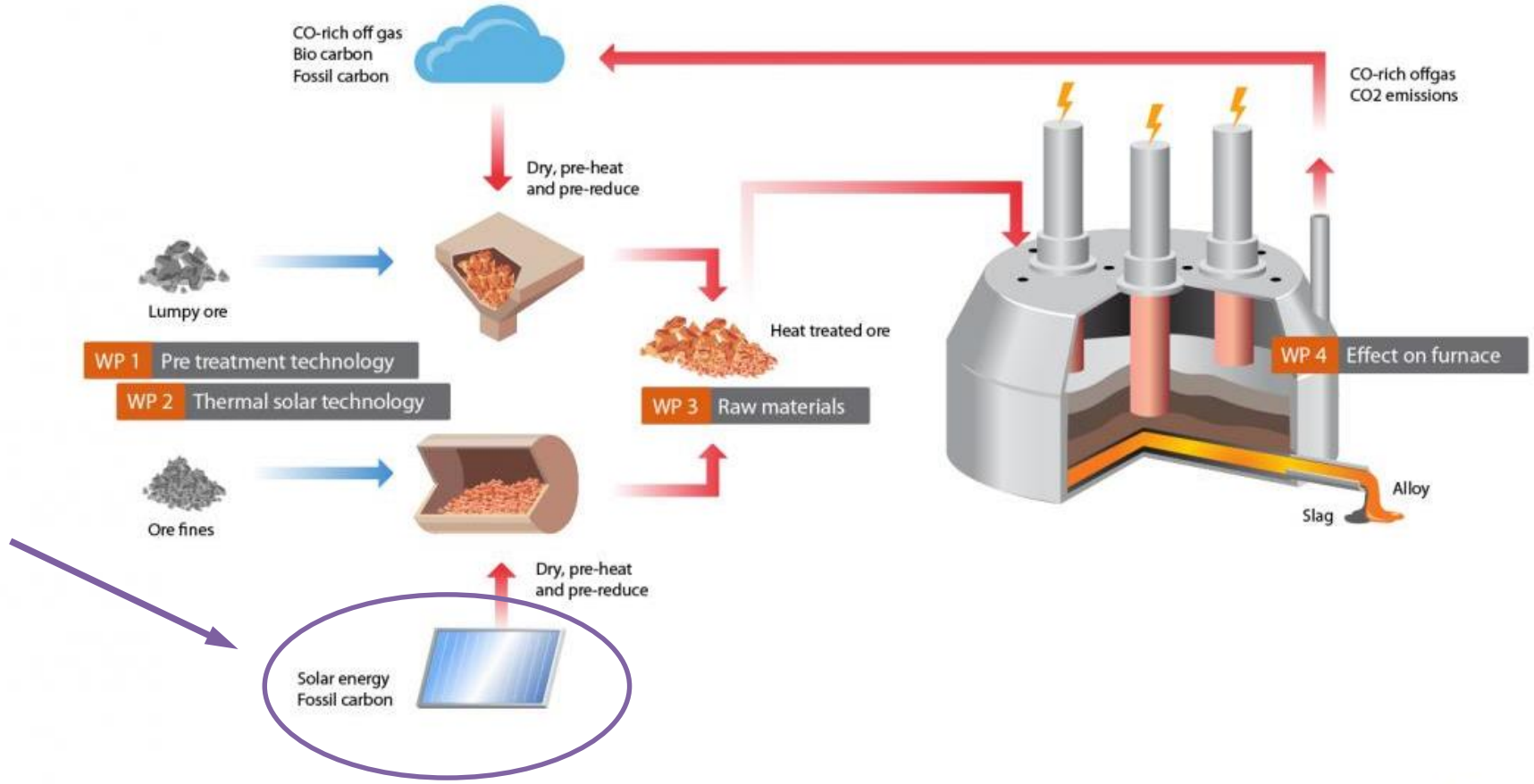


PREMA

Pre treatment of manganese ores

Demonstration of solar process heat introduction in two pilot facilities:

- solar thermal particle test plant with thermal storage for continuous production of hot air at 800°C (DLR Solar Tower, Germany)
- solar thermal plant to preheat manganese ores with hot air continuously at 800°C (South Africa)



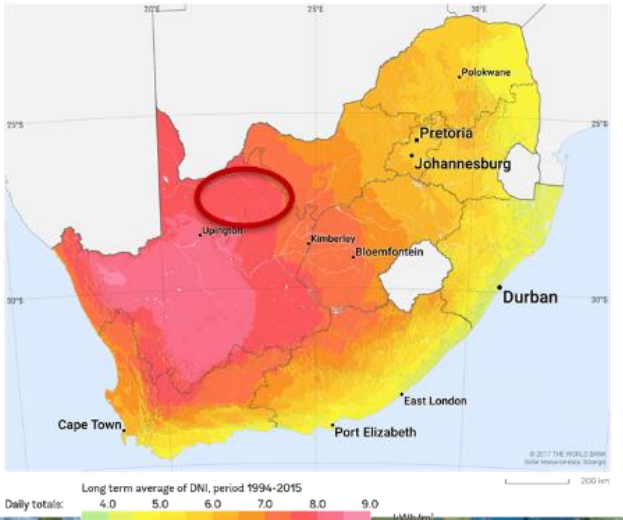
https://www.spire2030.eu/prema

Case Study: Kalagadi Manganese Sinter plant, Northern Cape, South Africa

Kalagadi Manganese mine and sinter plant

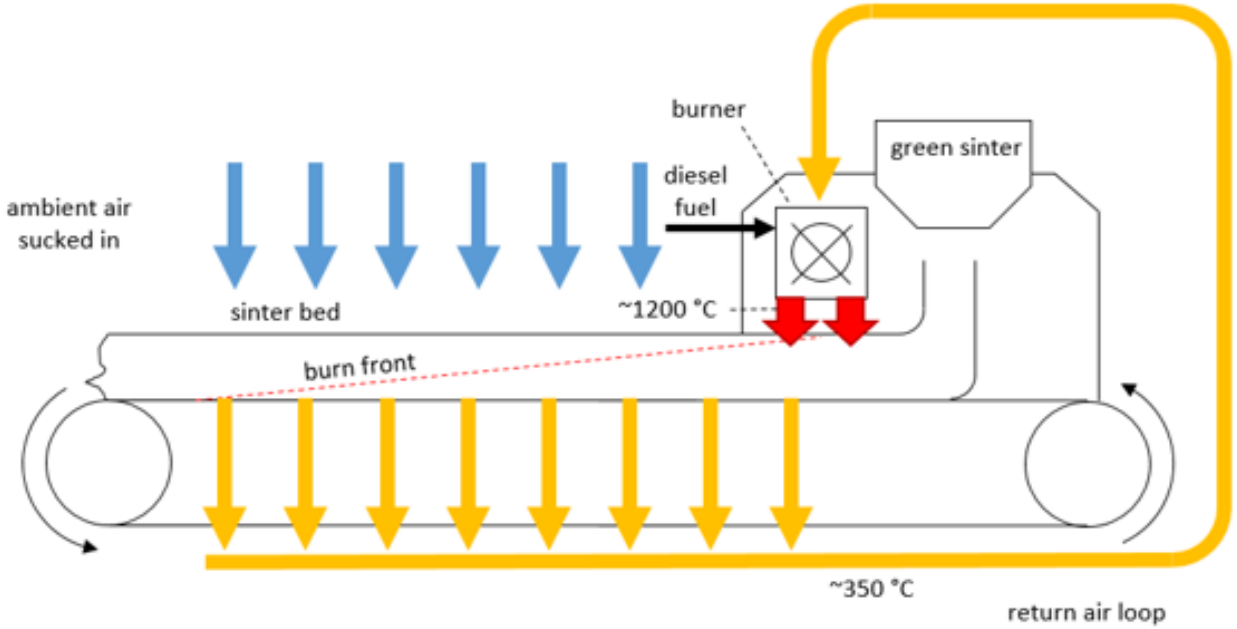
Location of Kalagadi Manganese in South Africa

Kalagadi sinter plant

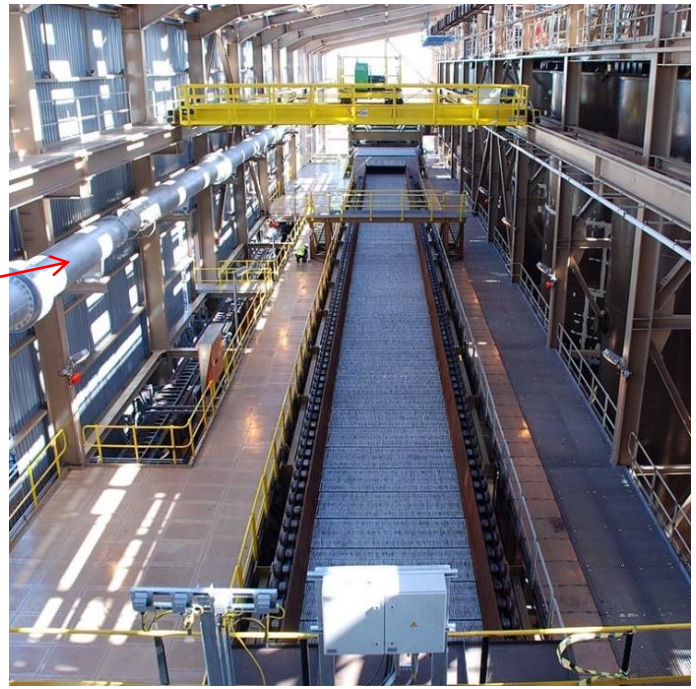


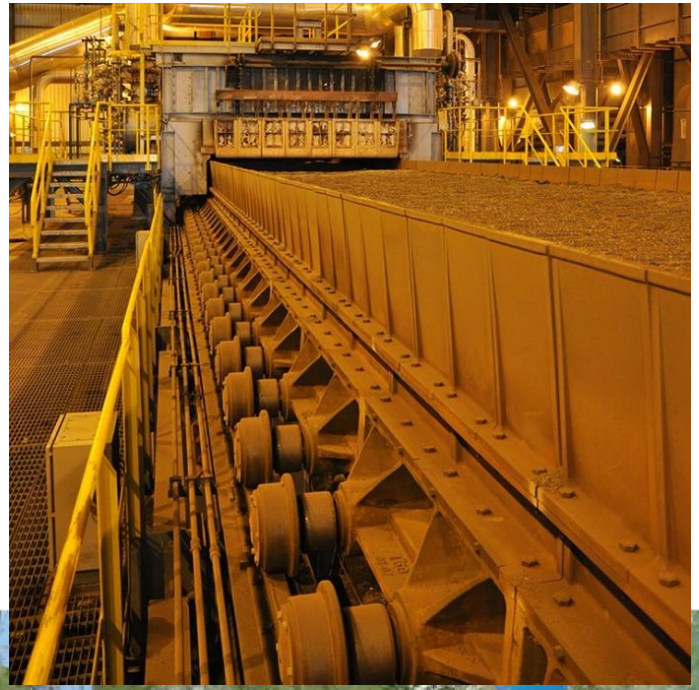
Solar Ressource (DNI) in South Africa

Case Study: The Kalagadi Manganese Sinter plant, Northern Cape, South Africa



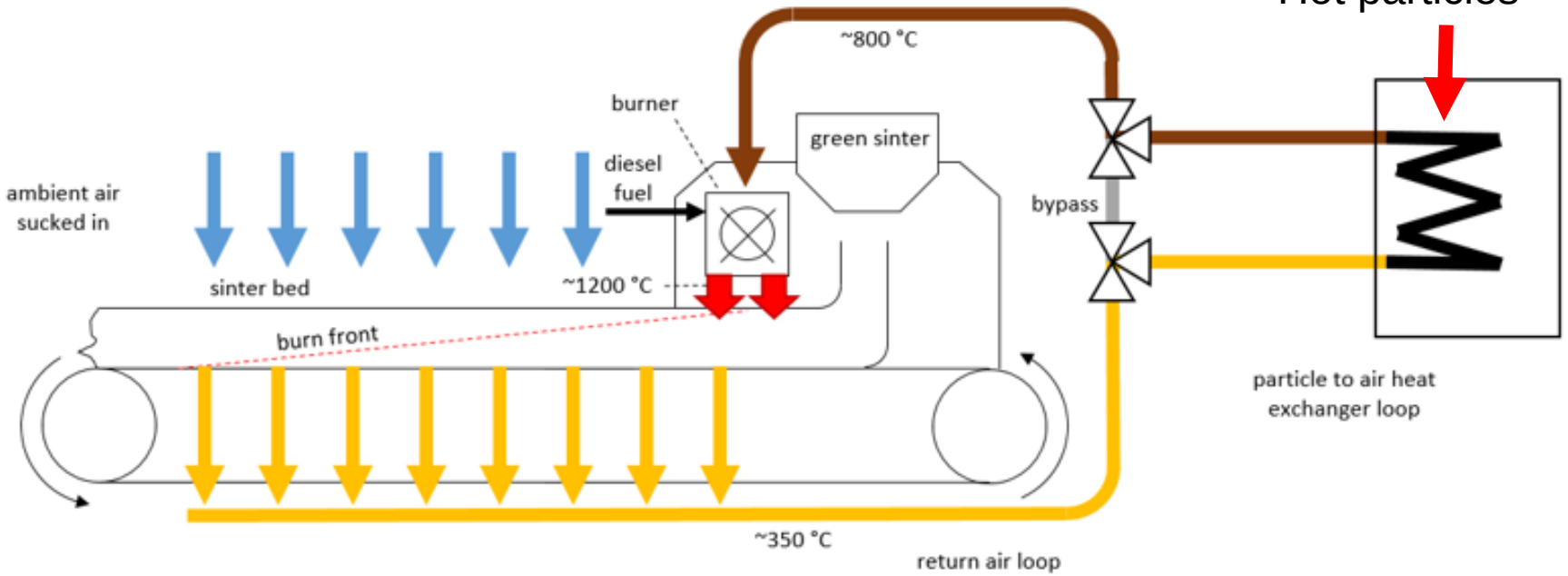
Air return pipe





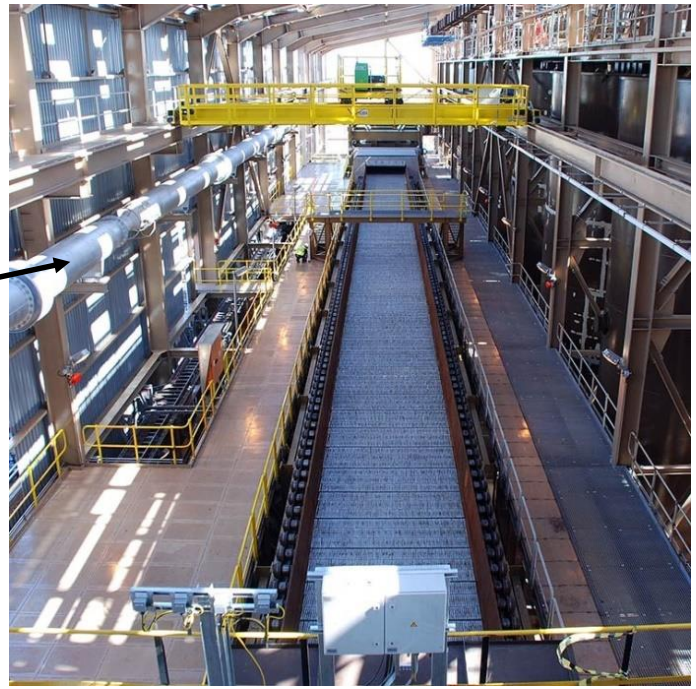
images: Outotec

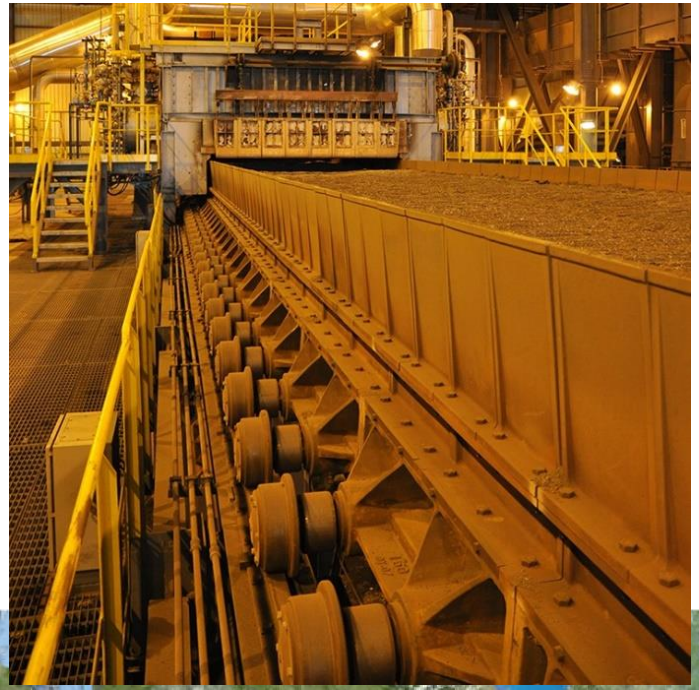
Case Study: The Kalagadi Manganese Sinter plant, Northern Cape, South Africa



Air return pipe

Hot particles



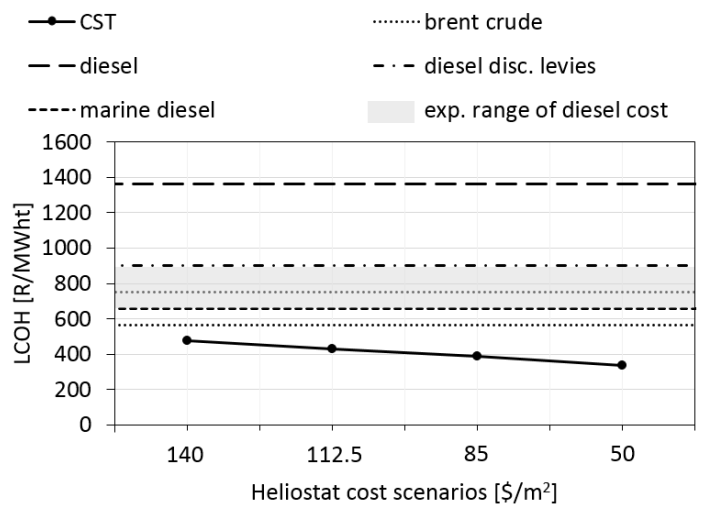


images: Outetec

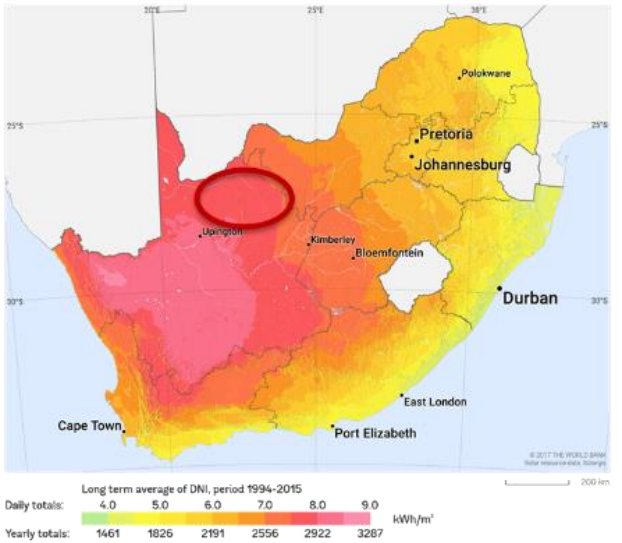
⇒ Introduction of solar hot air from stored particles can replace large fraction of Diesel fuel

Case Study: Kalagadi Manganese Sinter plant

100 AUD
60 USD
50 AUD
30 USD



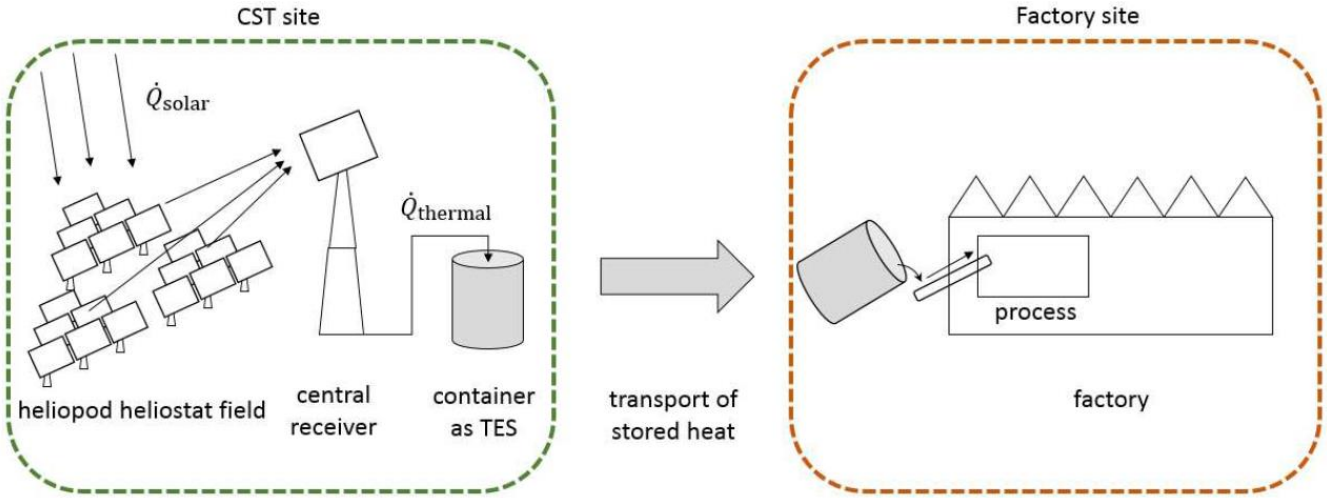
Kalagadi sinter plant

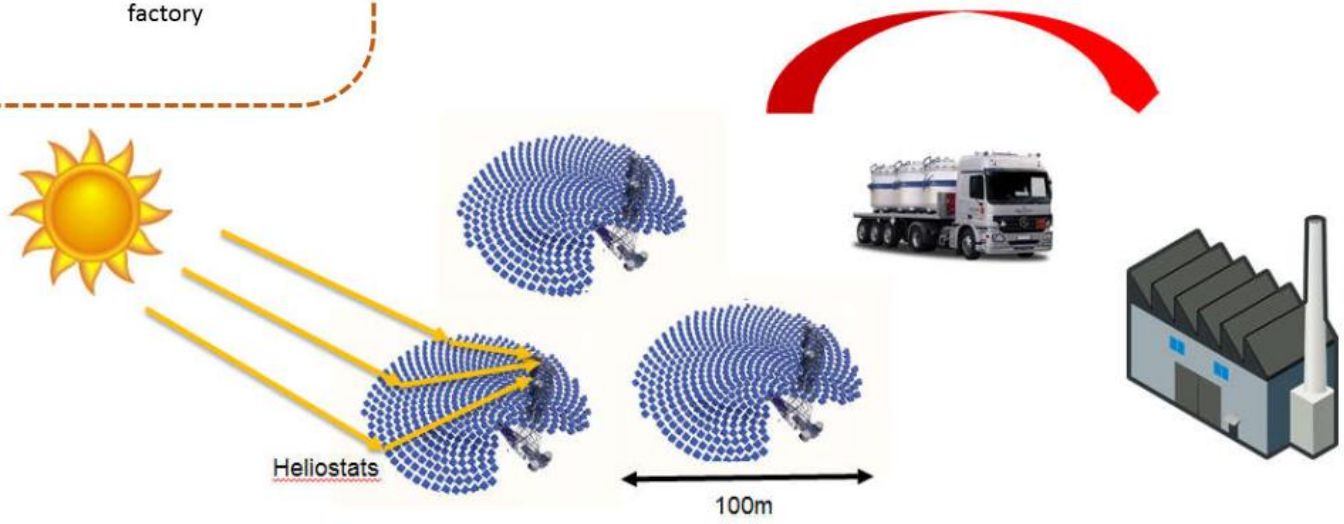


- Remote location with high annual DNI, high fuel price
- LCOH from solar process heat: projected at ~50% of burning Diesel (assumption: mature system cost, brent crude at 75 USD/barrel)
- payback period ~6 years estimated

Transportation of Heat to Factory

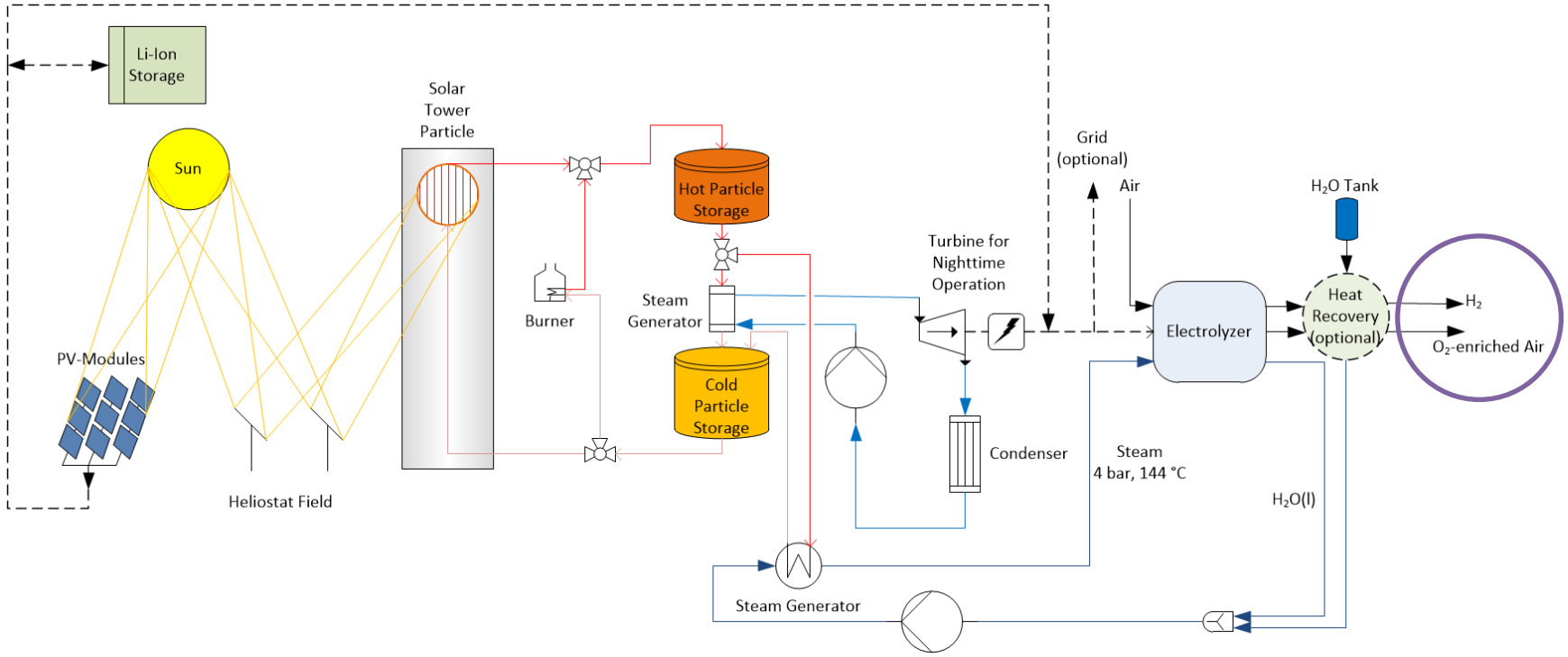
Ground particle transport by truck (electric and autonomous if possible) or rail enables multitower systems to achieve higher capacities and locating the solar plant some km away from the location of use





CSP-H2Pyro - Hydrogen production with solar energy systems

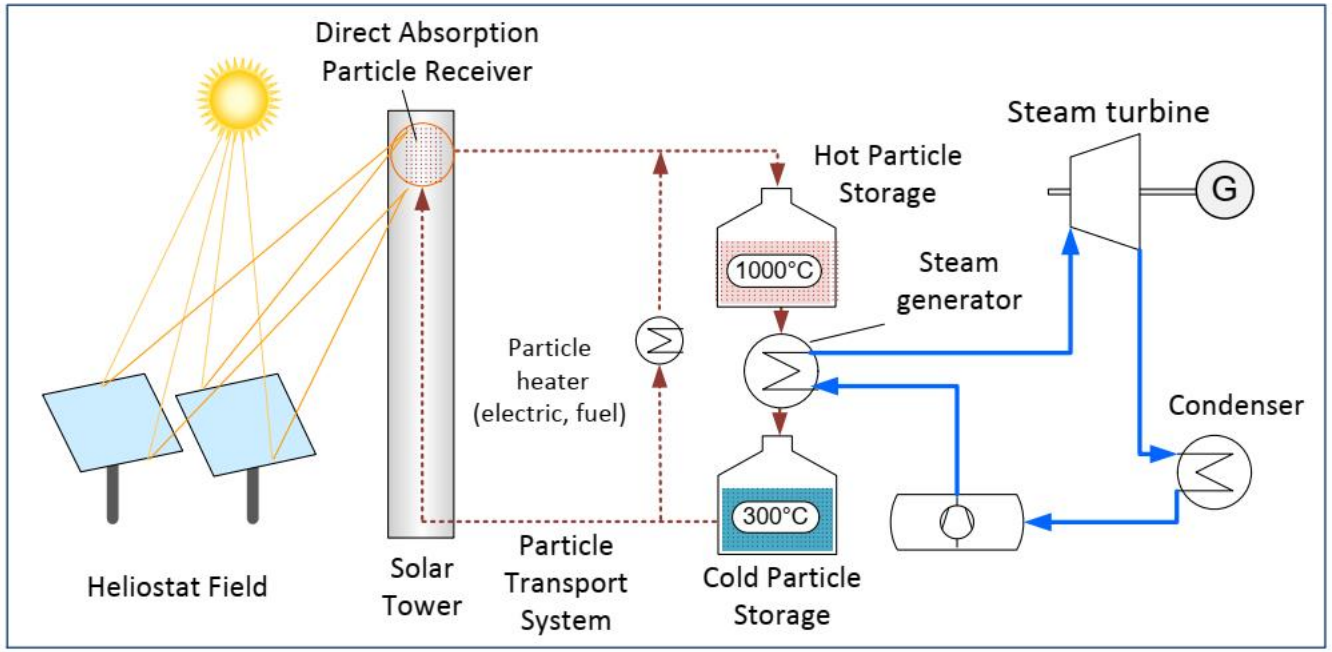
- System analysis for production of H_2 with High Temperature Electrolyzer
- Coupling of electrolyzer with renewable energy sources
- Comparison of CSP/ CST and CSP/CST + PV systems
  - Continuous H_2 supply
- Techno-economic evaluation



H_2 for e.g. mining industry, steel production

HIFLEX
HIgh Storage Density Solar Power Plant for FLEXible Energy Systems

- Demonstration of a complete pre-commercial flexible CSP prototype plant featuring cheap solid particles as storage and heat transfer medium
- system integration in an existing pasta plant in Foggia, Italy
- steam generation at 620°C through solar tower with particle receiver
- production of pressurized water (135 °C / 3.6 bar) for drying process in pasta production
- thermal storage system providing 2.5x higher energy storage density at 50 % lower energy storage cost



- http://hiflex-project.eu/

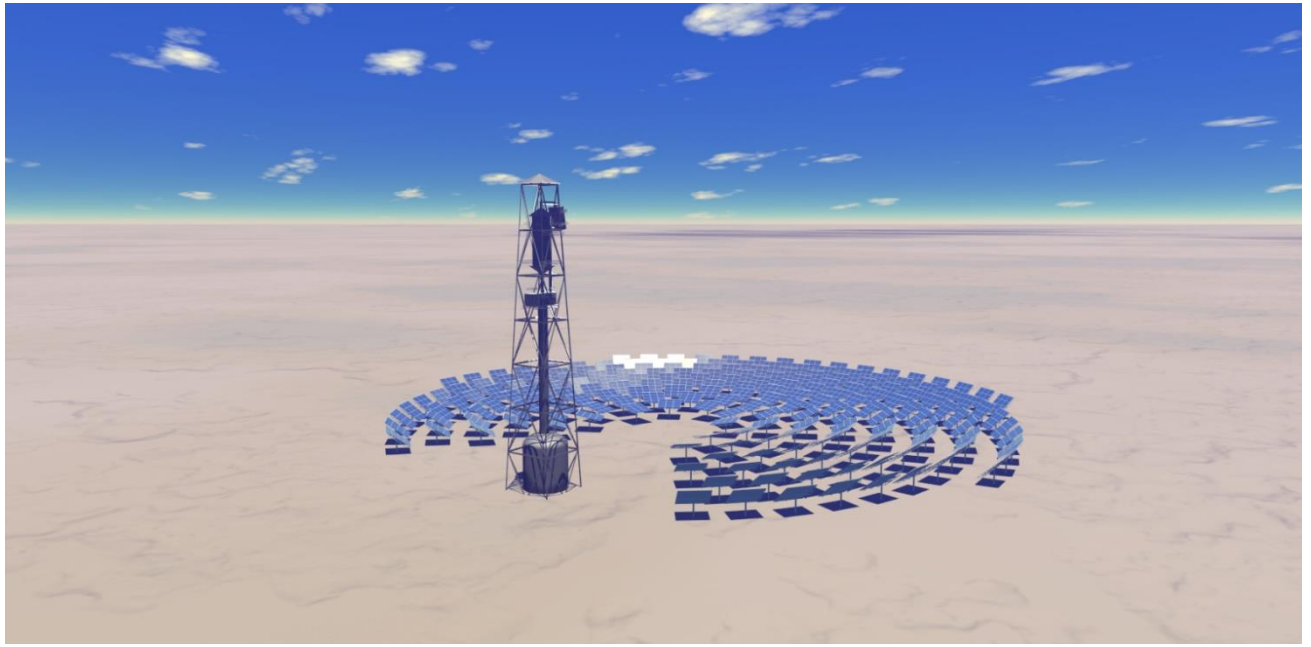
Opportunities for South Africa

High temperature solar process heat for a variety of applications:

- Different solar technologies, adaptable to power and heat demand:
  - Temperature level
  - Time of supply (storage)
- Supply at predictable cost
- Co-generation possible

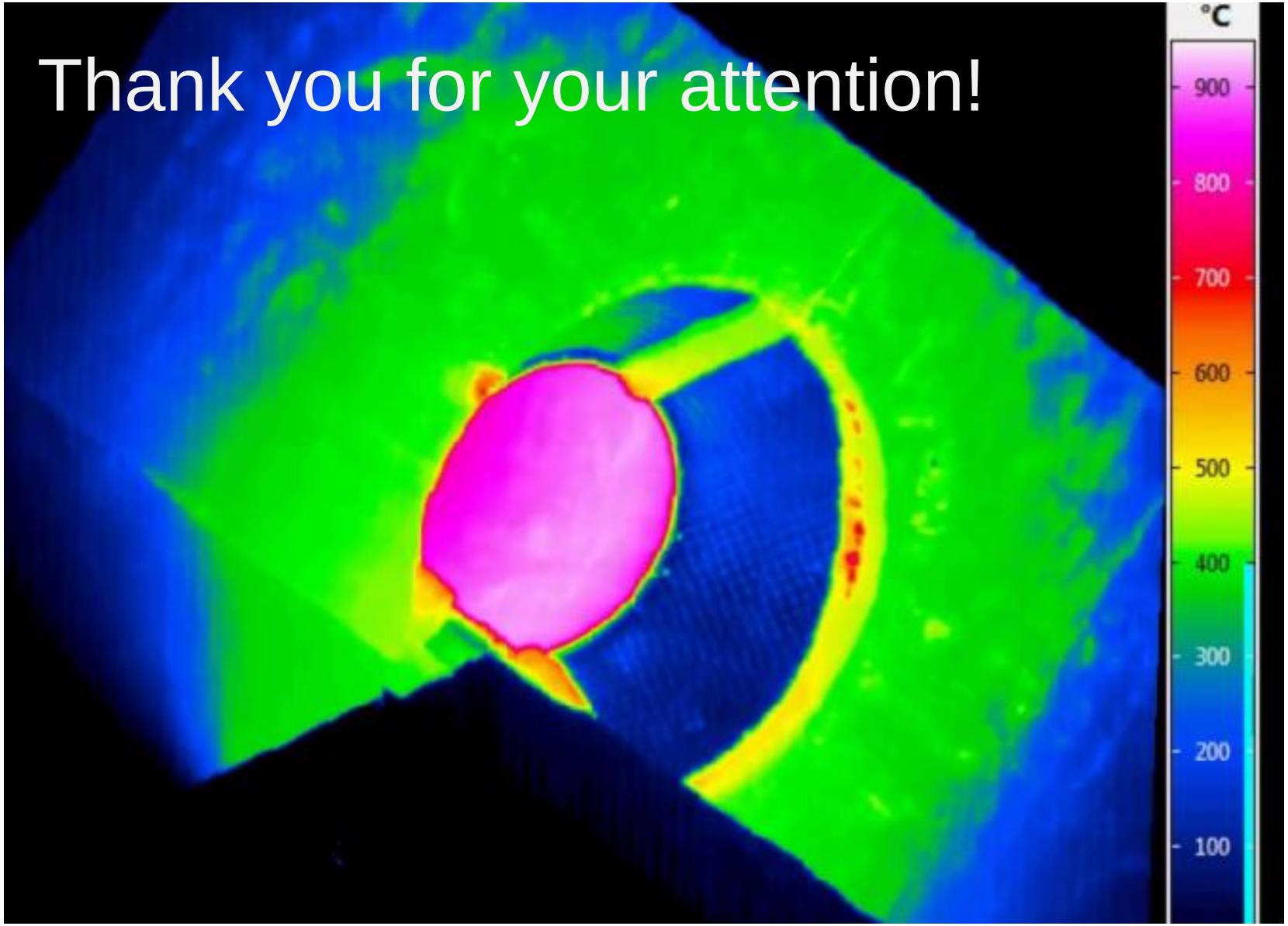
What DLR can provide:

- Analysis of high temperature process heat opportunities
  - individual opportunities
  - holistic studies of opportunities / application fields
- Development of ideas, concepts, case studies
- System integration into process



Artists rendering of a 2.5 MW CST plant

Thank you for your attention!



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