Components' and Materials' Performance for Advanced Solar Supercritical CO2 Powerplants

COMPASsCO2

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Presentation structure

- Project Summary
- Objectives & expected impact
- Scope
- Main results/outcomes
- Options for exploitation/collaboration/follow-up activities

Project summary

Funding source	Horizon2020 Topic: Novel high performance materials and components (RIA)
Budget	Approx. 6 Mio. EUR
Duration	48 months (November 2020 – October 2024)
Start TRL	2
End TRL	5

Partners

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Objectives

1. Develop highly durable and efficient particles for CSP plants
2. Develop optimized structural materials for heat exchanger tubes in contact with particles and sCO_2
3. Demonstrate material lifetime by measuring and modeling the degradation of the materials
4. Design, construct and operate a particle/sCO_2 heat exchanger section in order to validate the degradation and heat transfer models
5. Evaluate the economic benefits of a CSP-sCO_2 plant using the materials and components developed and compare it with state-of-the-art CSP plants

Expected impact

- **Sun-to-electricity efficiency of the overall system improved by 30%** compared to the current state-of-the-art CSP plants
- **100% CO2-reduction for electricity production** by replacing a fossil power plant with the new sCO2-solar-tower-system
- **20% longer service life of the particles** compared to absorber coatings of molten salt receivers.

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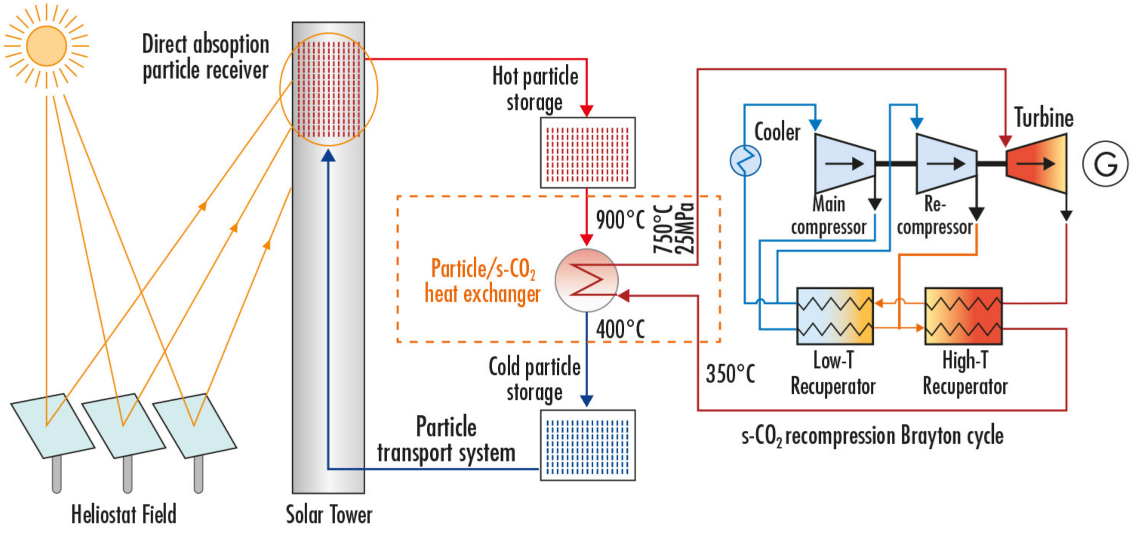
Scope

The project focus is to develop **new materials for extreme conditions** in order to integrate two innovative systems:

CSP plants with particles and sCO2 Brayton power cycles



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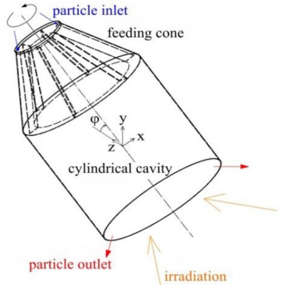
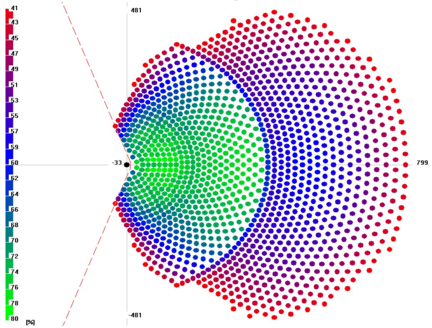
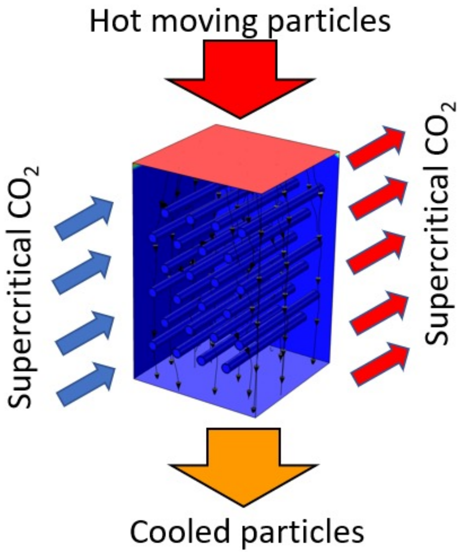
Main results/outcomes

Solar receiver & field optimization

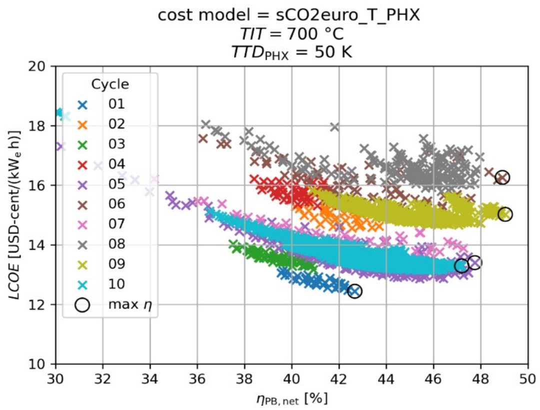




Heat Exchanger conceptual design



sCO2 Brayton power block investgation



See public Deliverable 1.1 and 1.2

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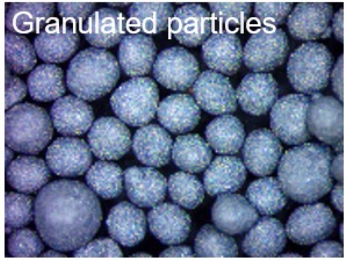
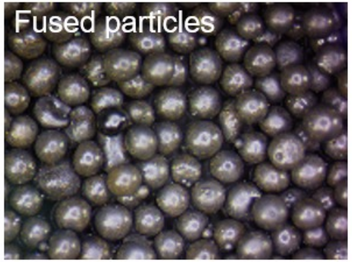
Main results/outcomes





Light weight proppants

Intermediate strength

High strength

State of the art proppants

Al_2O_3 rich

Price: ~1 – 1.2 €/kg

SaintGobain stopped proppant production → alternatives are needed!

3 generations developed

Raw material : recycled iron oxide from steel industry (~1 €/kg possible)

Very good thermal stability

2 generations developed

Raw materials : >70wt. % of recycled products (today)

Very high absorptance

Electrofusion process is expensive (~3 €/kg)

New particles

Tailored for CSP/CST application

See publication about development and testing of new particles

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Main results/outcomes

ETN Global

Metals for HX tubes

- State-of-the-art steels and Ni-based alloys selection
  - P92, IN740, Haynes 282, Sanicro 25, IN617
- Characterization (hardness, microstruture, precipitates, grain size, etc.)
- **Development and production of novel Cr-NiAl alloys**
  - Paper in preparation, ageing behavior > 1000 °C, corrosion test, simulations, mechanistic studies
- **Development of Cr-based with silicides intermetallics alloys and coatings for conventional Fe-, Ni-base materials**
  - Slurry coating, diffusion coatings with increase hardness.
- Modelling (precipitates, diffusion bonding, microstructure, etc.)

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Main results/outcomes

Particles + Metal + sCO2 interation

- Creep tests in air
- Creep tests in CO2
- Corrosion tests in air and CO2 at 700 and 900 °C
- Cyclic oxidation testing in air and CO2
- Isothermal oxidation tests in CO2 at 700 °C
- Preparation of corrosion tests under supercritical CO2
- High temperature erosion in air
- Simulation of corrosion and erosion

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Main results/outcomes

Heat Exchanger pilot testing plant

- Pneumatic particle transportation system tests
- Electric particle heater design
- Cold test to assess particle flow field
- Hot long-term abrasion test design
- Heat exchanger and final demonstrator design

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Options for exploitation/ collaboration/ follow-up activities

- Optimization of sCO2 Brayton cycles for CSP applications
- Development of particles as heat carriers for high temperature processes (>1000°C)
- Development of structural materials for harsh conditions regarding temperature, pressure, erosion, oxidation, corrosion, thermal cycling, etc.
- Testing and modelling of material degradation
- Scientific publications, joint dissemination events, etc.

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