IN POWER Online Workshop

Date: 27 October 2020

Time: 09:00 – 14:00 (CET)

Particles as heat transfer fluid and storage material in concentrating solar heat and power production.

The Next-CSP Project

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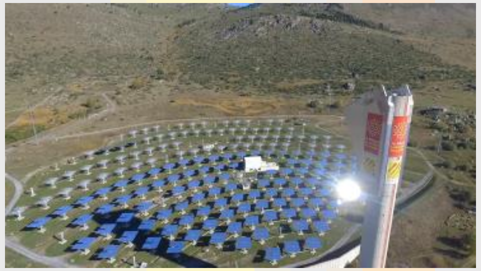

Grant agreement N° 727762 – Next-CSP: High Temperature concentrated solar thermal power plant with particle receiver and direct thermal storage

Content

- Objectives
- Concept
- Critical components
- Prototype development
- Scaling up for a peaker plant

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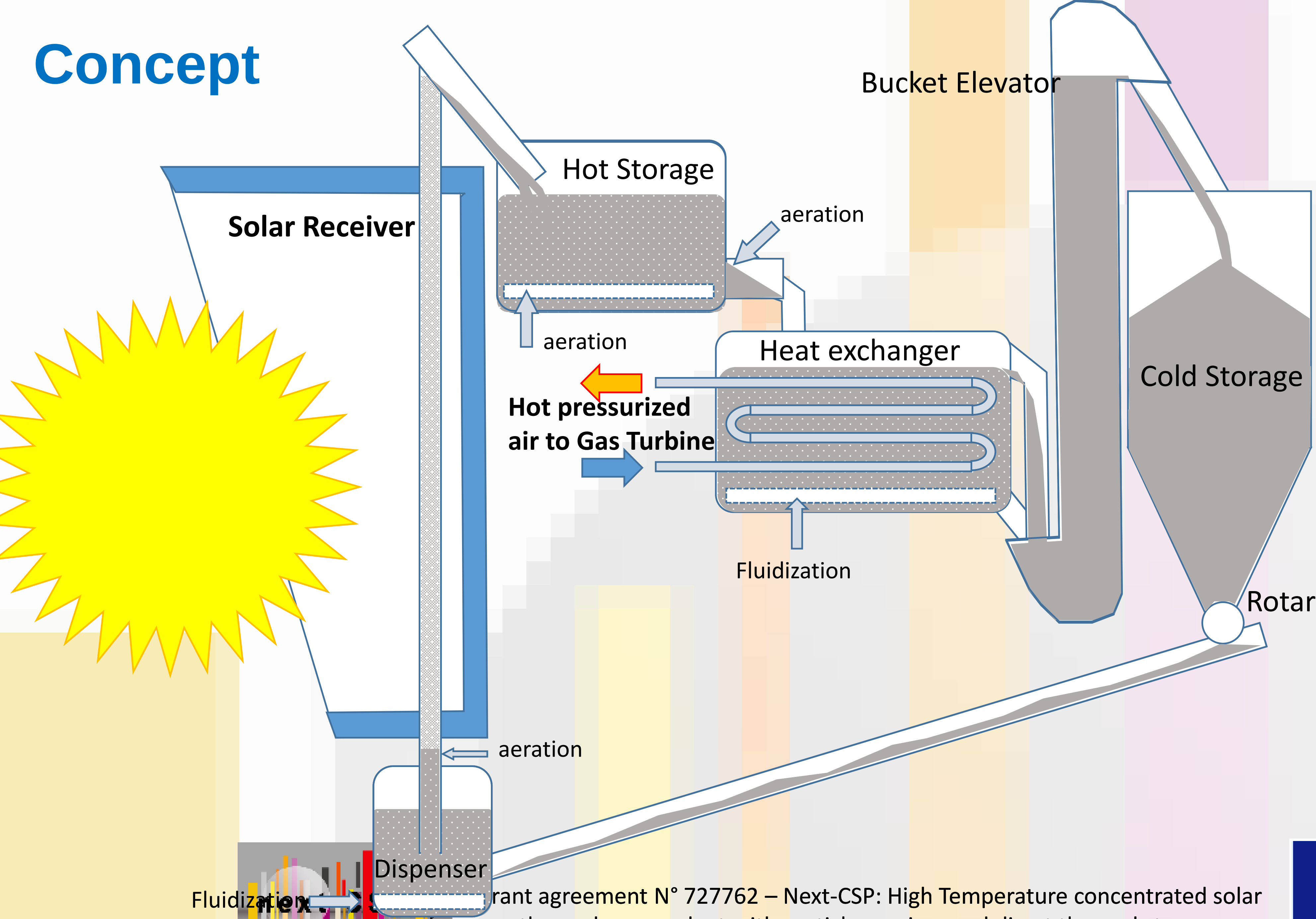
Objectives

- Develop an original solar technology able to strengthen European CSP industry.
- Increase the power block efficiency by 20% with respect to the state-of-the-art (particles heated at 750°C and more)
- Offer a dispatchable production through the cheap storage of hot particles.
- Demonstrate the technology at prototype-scale.
- Identify the barriers to large scale deployment of the technology.
- Estimate cost and cost reduction potential.

Concept

« On Sun » operation



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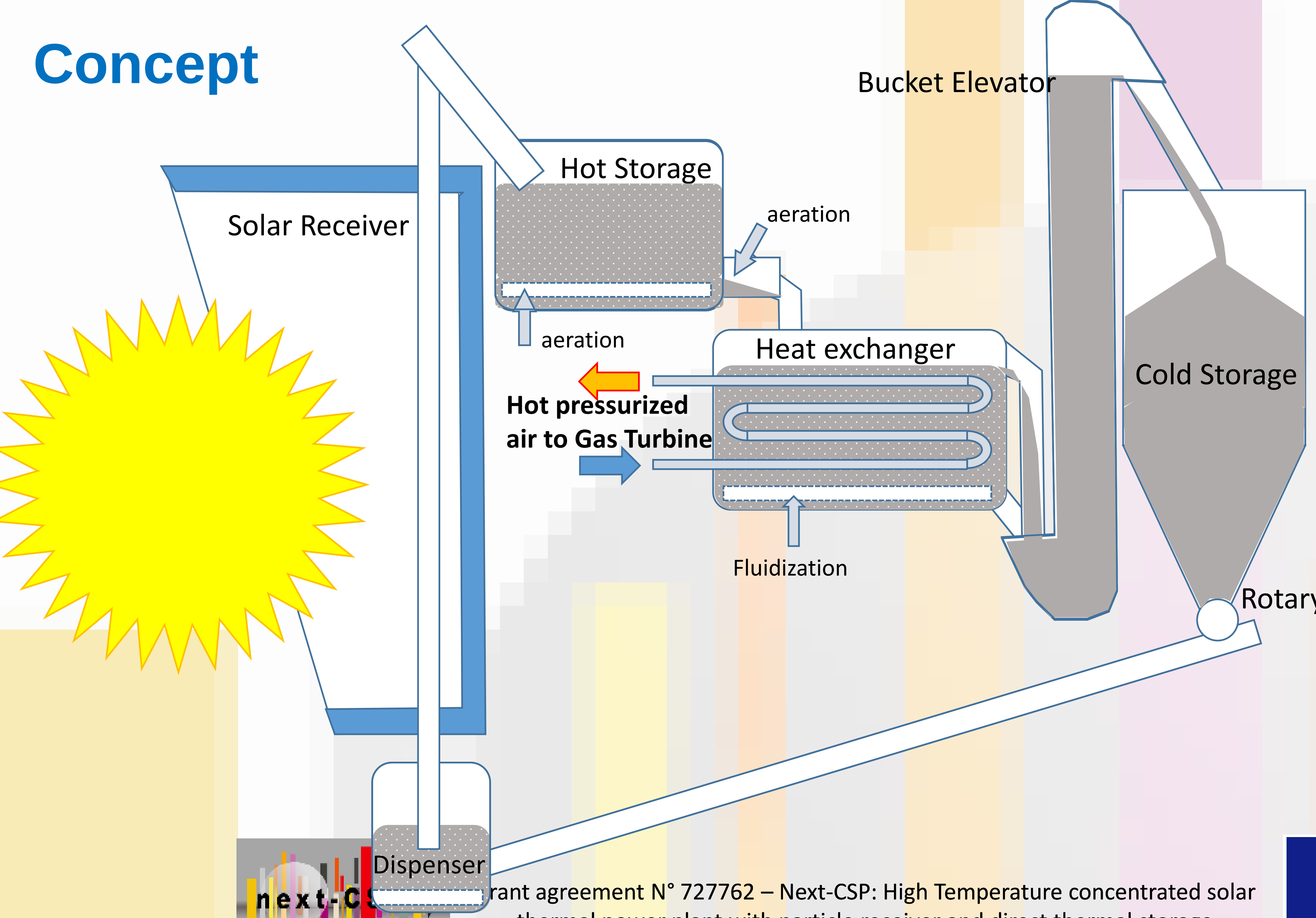
Concept

« Off Sun » operation



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The critical components

- The solar receiver
- The heat exchanger
- The particle conveying system (at large scale)
- The thermodynamic cycle

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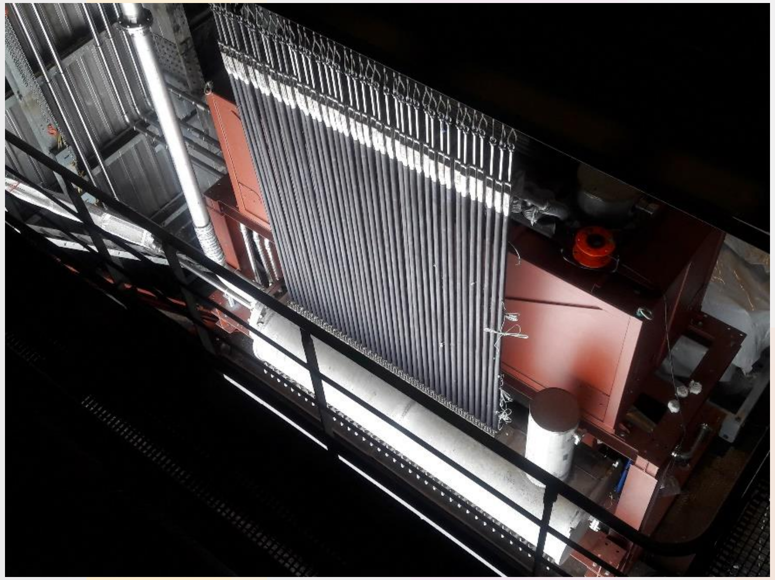
The solar receiver

- An upward flow of small size fluidized particles is created in tubes irradiated by concentrated solar energy,
- The particles (~50µm) are heated up to 750-800°C and then stored.

30 kW_{th} 1m-long single tube solar test



3MW_{th} 3m-long solar receiver (40 tubes)

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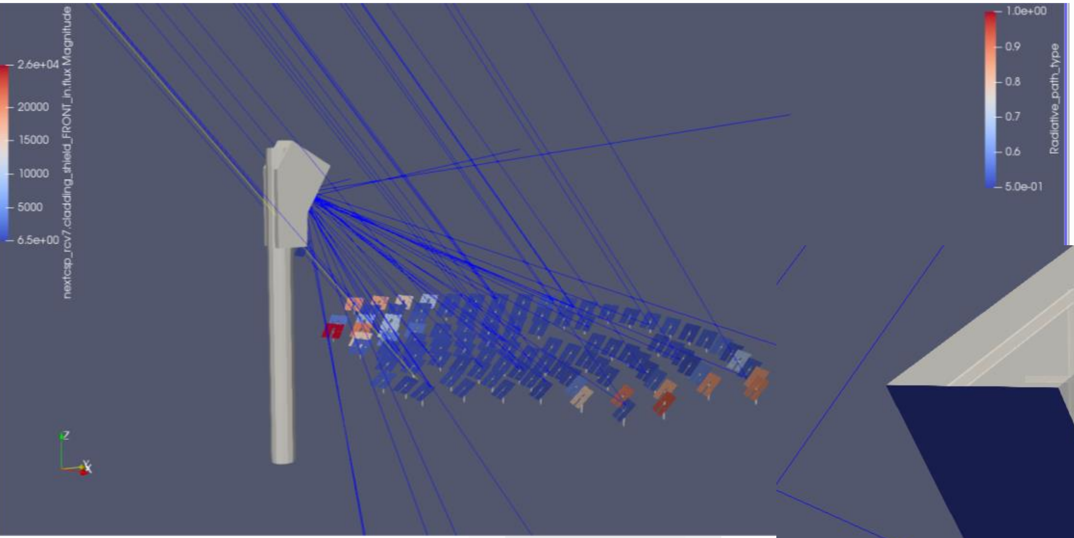
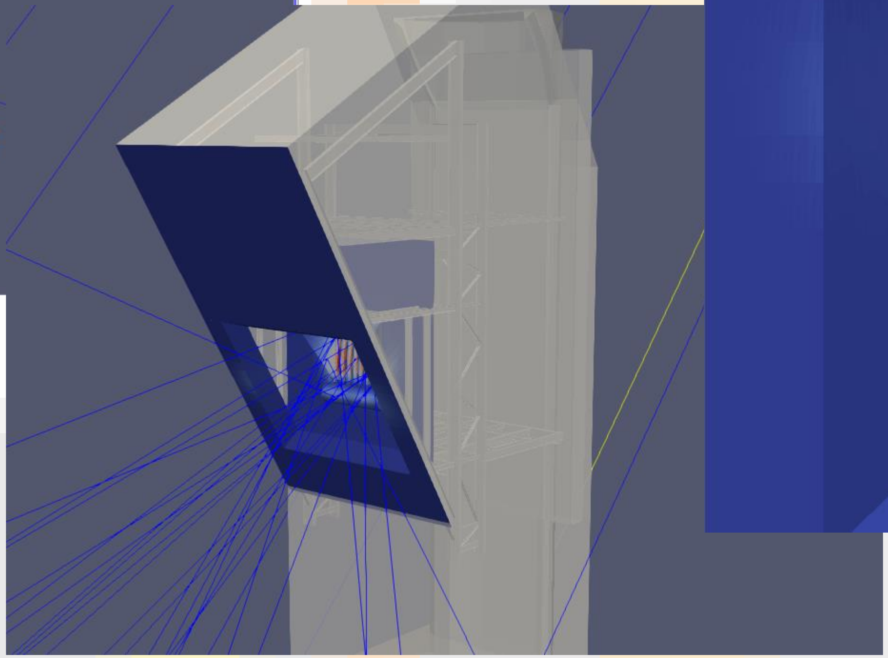
The solar receiver

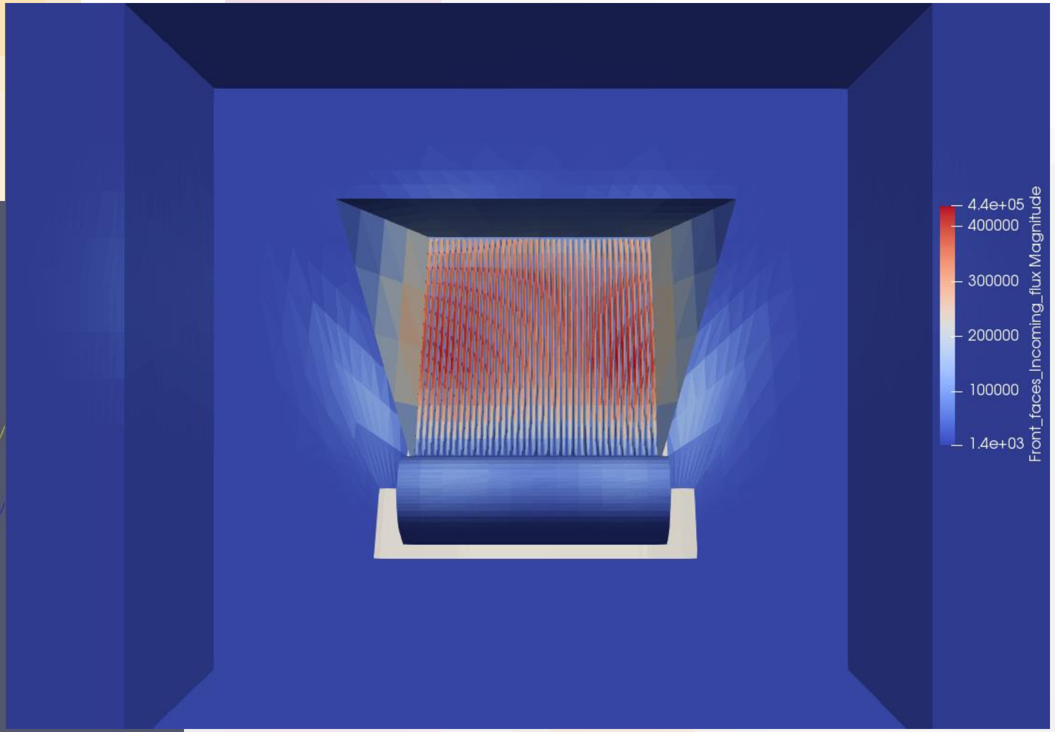
Integration of the solar receiver at Themis solar tower



Optical simulation of the heliostat field



Thermal simulation of the solar receiver



Aimaing strategy to limit the maximum solar flux to 500kW/m^2

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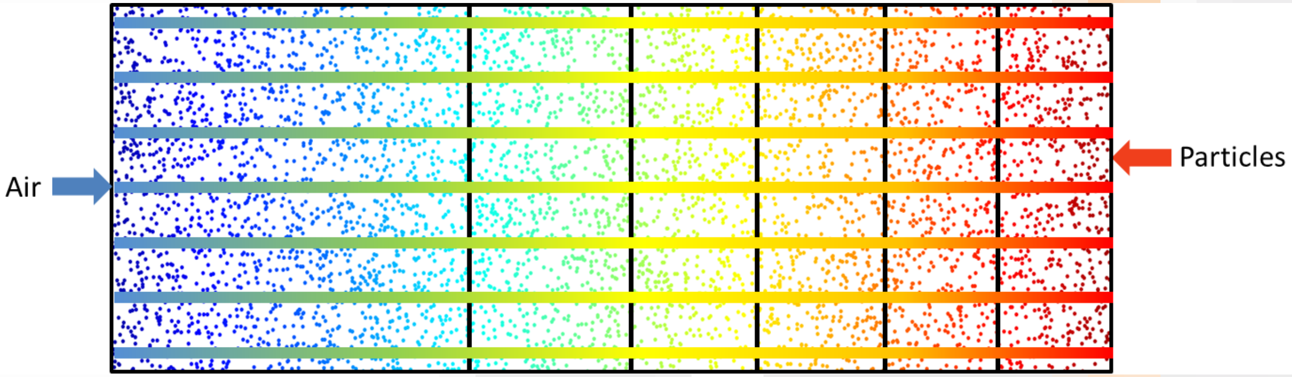
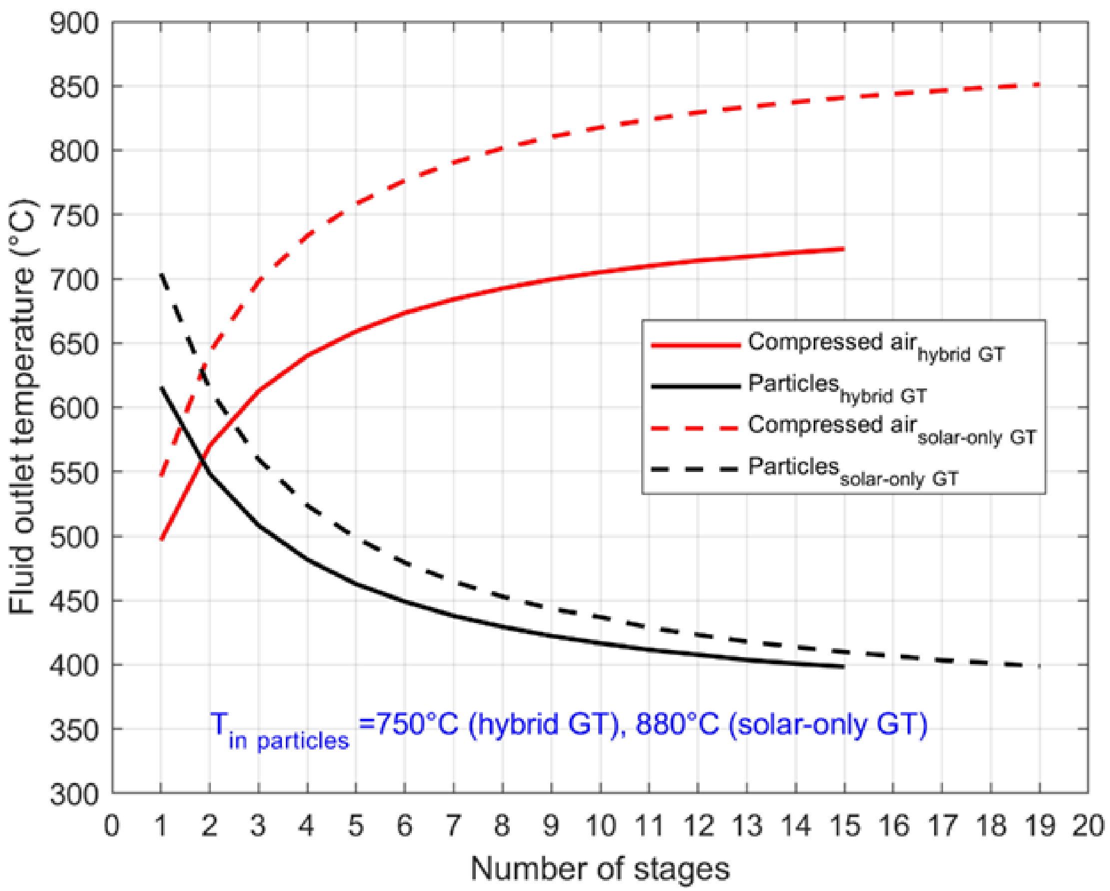
The heat exchanger

- Multi-stage fluidized bed concept





Approximately 15 stages for 30°C ΔT
And 9 stages for 50°C ΔT

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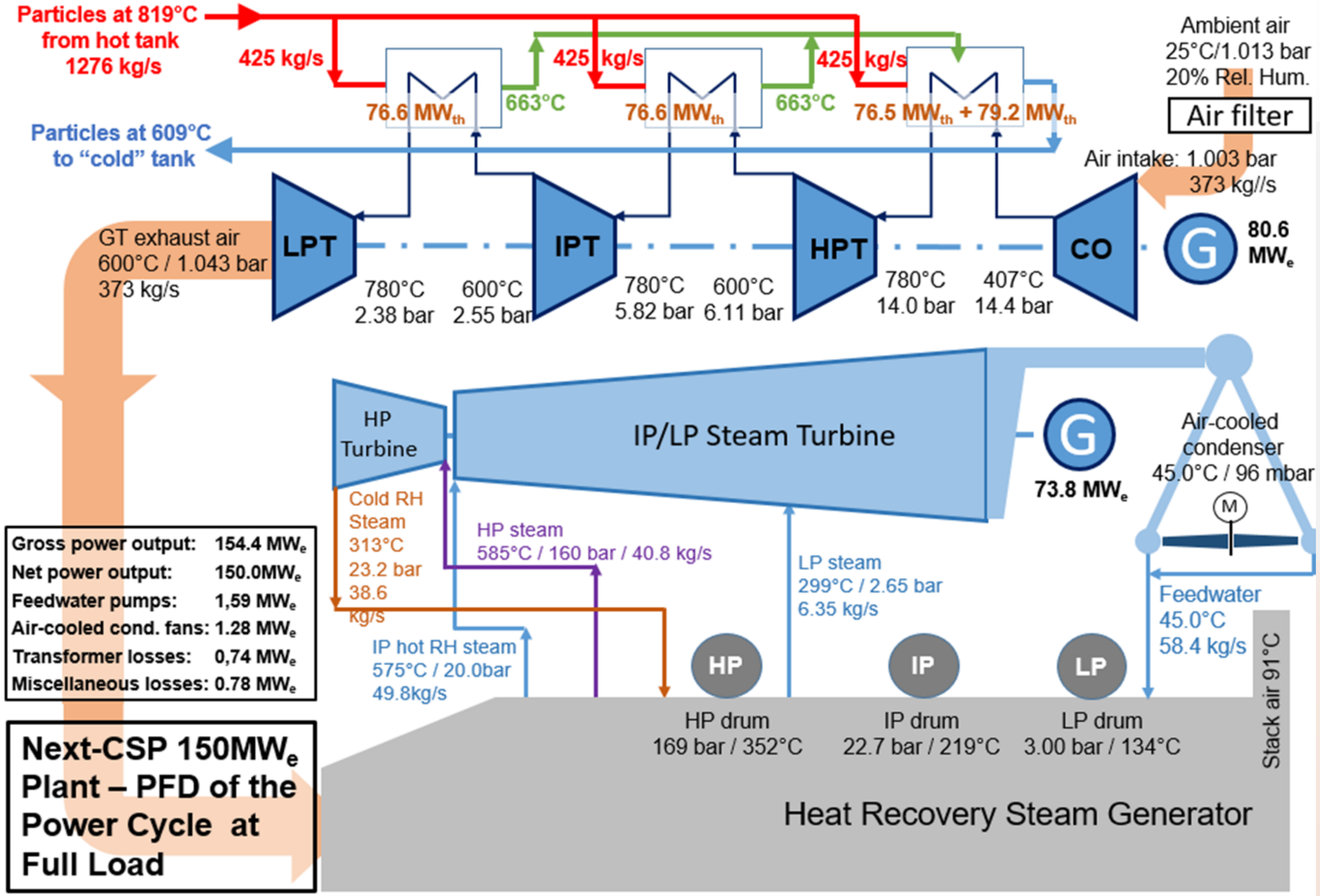
The thermodynamic cycle

Two options: combined cycle and sCO_2 cycle

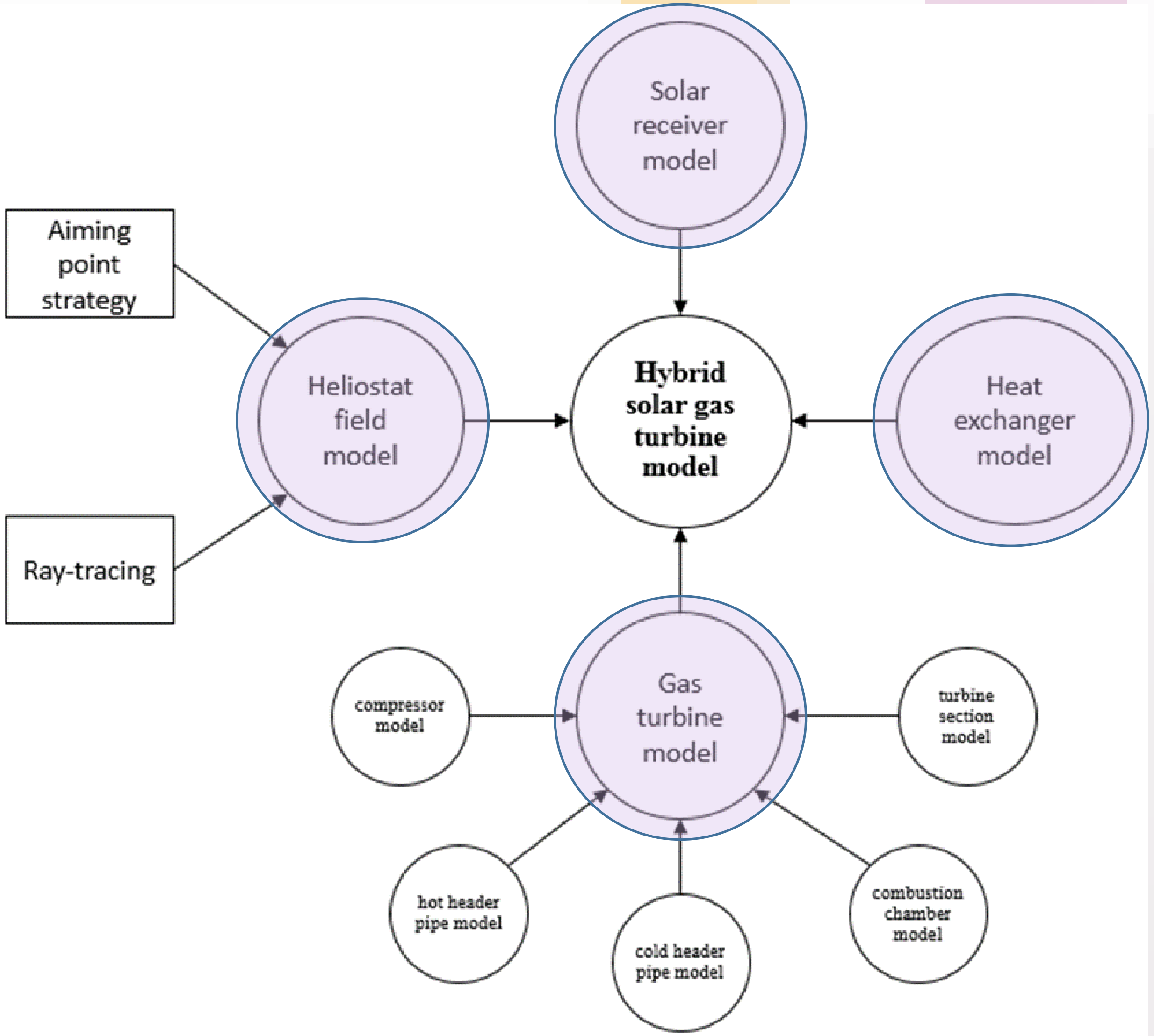
Combined cycle with a double reheat GT & three stages steam turbine with particle inlet at 819°C

$\eta_c \sim 49\%$



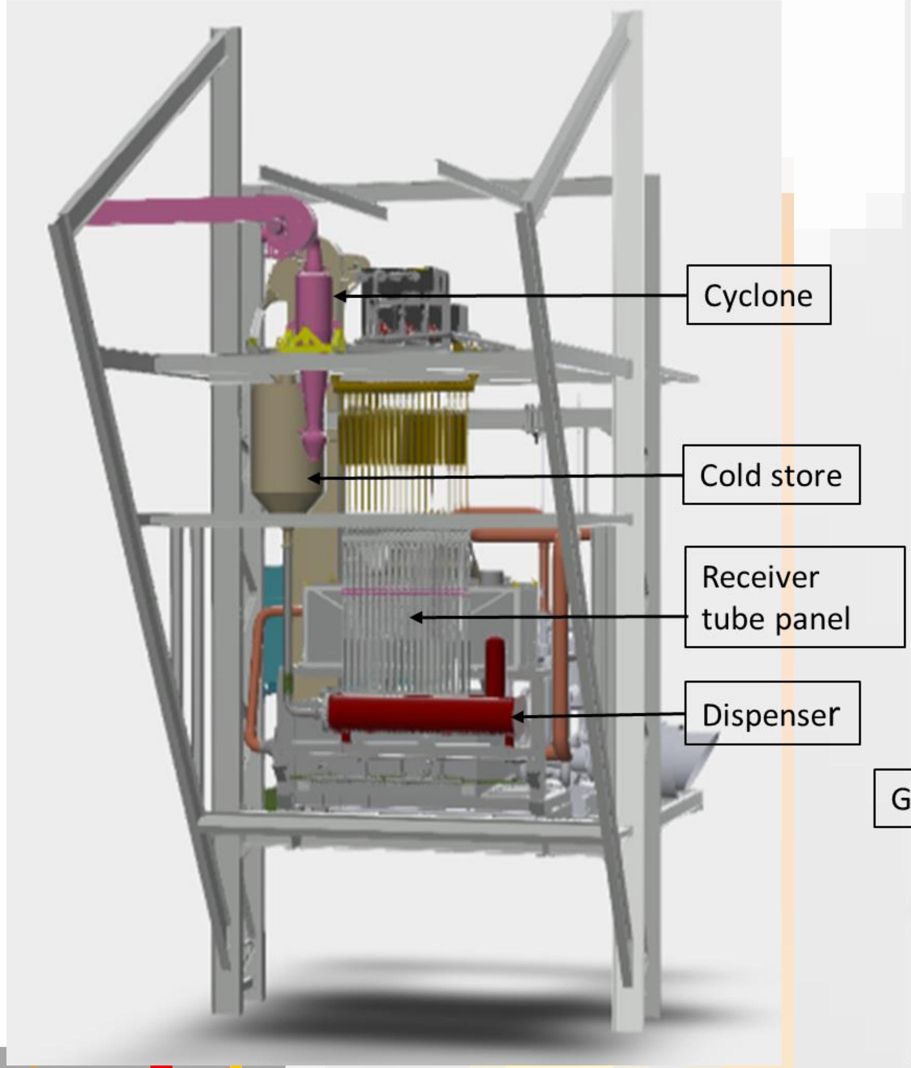
Source: EDF

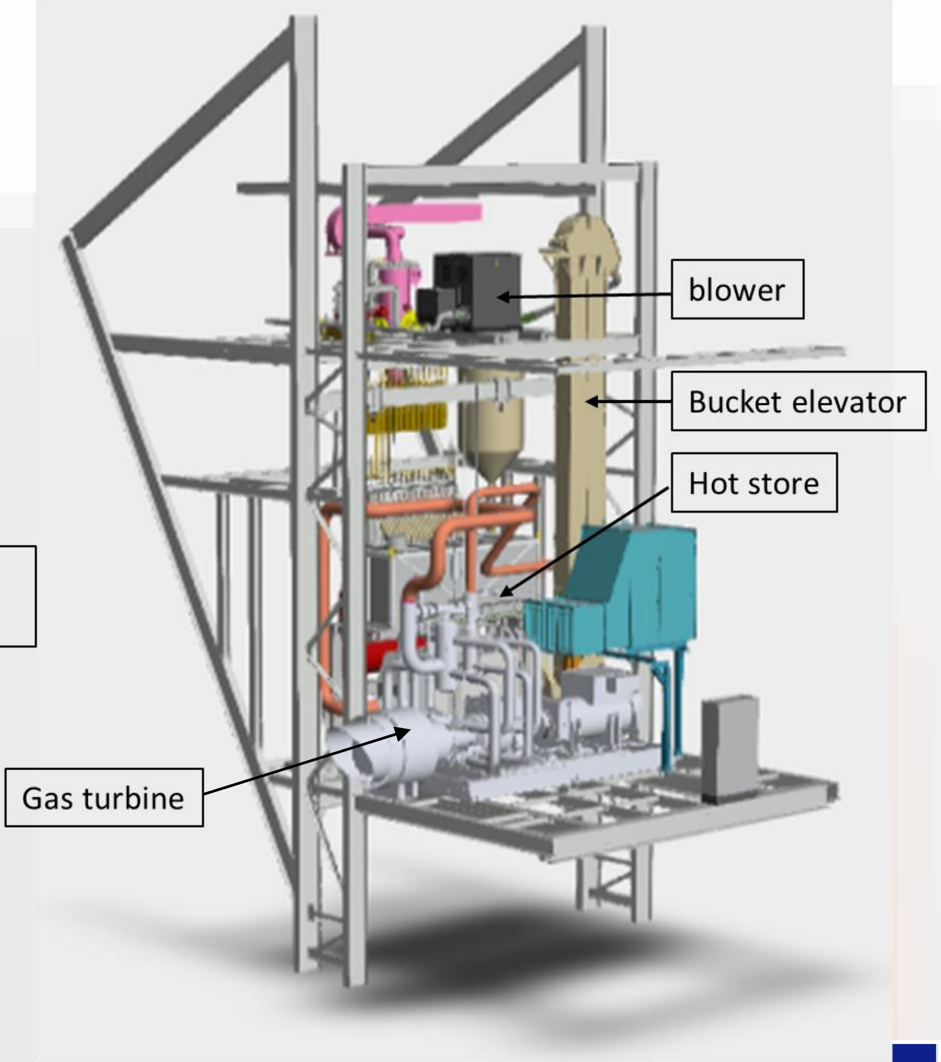
Overall system simulation



The prototype development

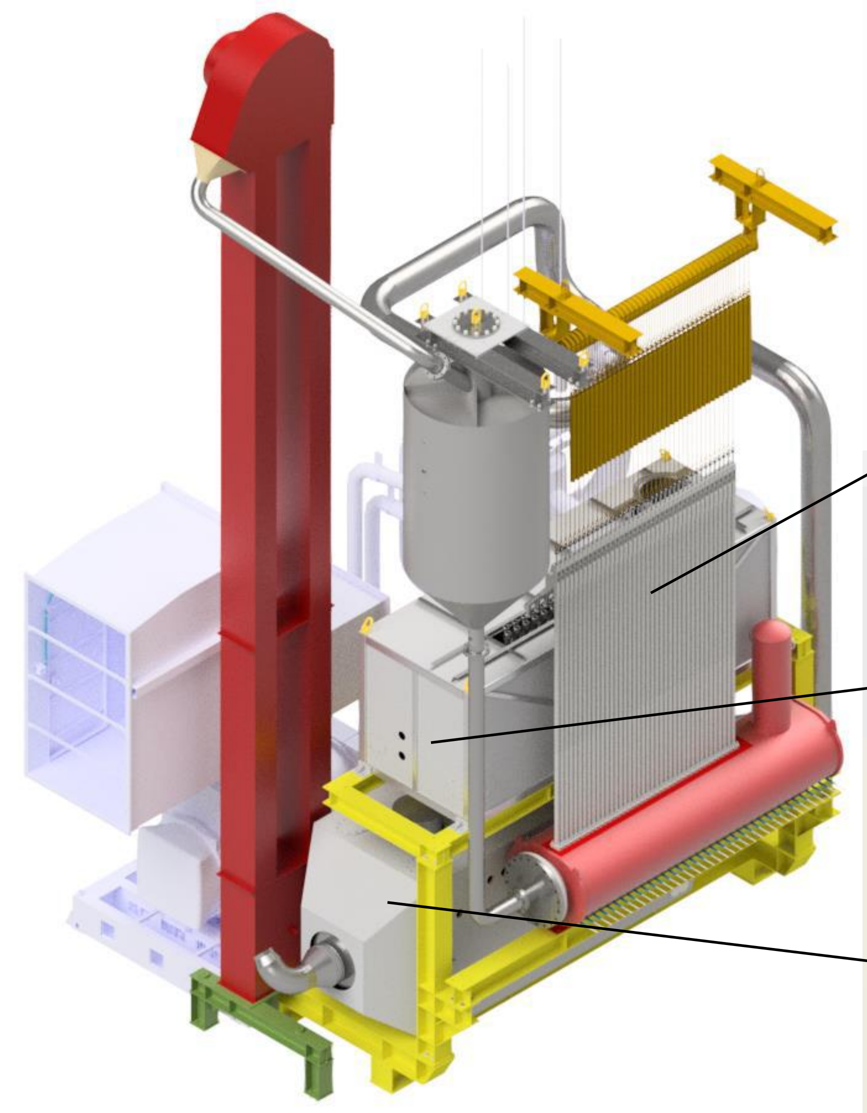
Integration at the Themis solar tower focal area





The prototype development

Component manufacturing



Solar receiver

Hot store

Heat exchanger

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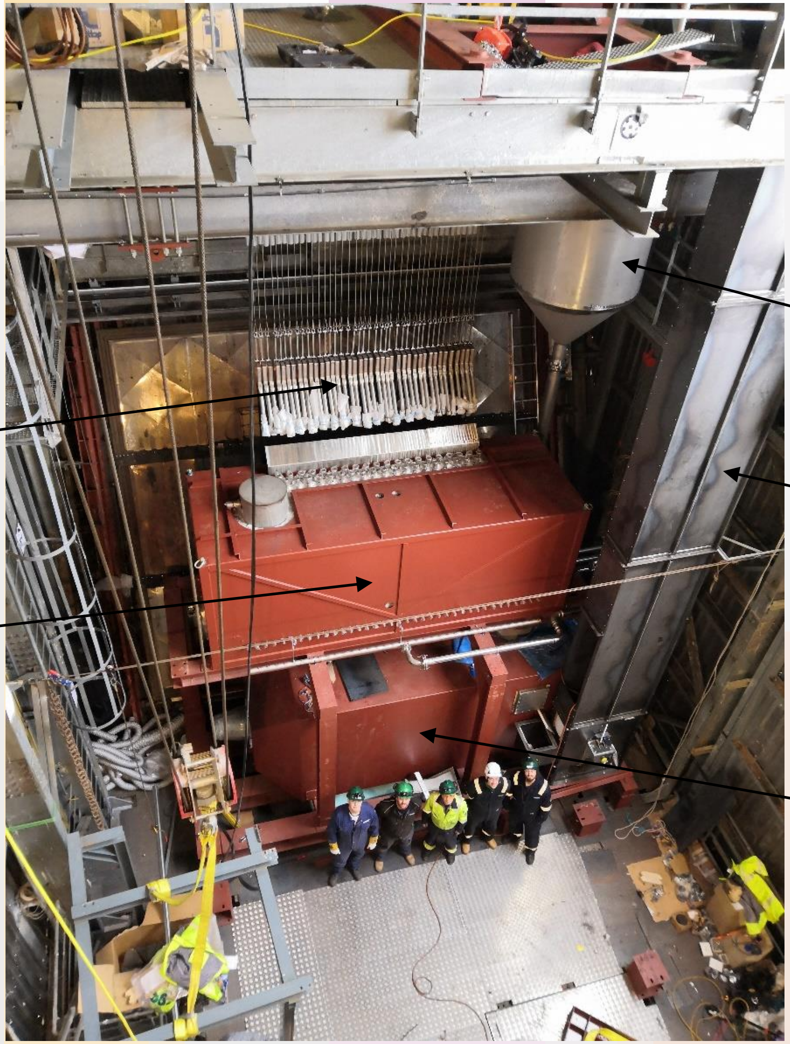
The prototype development

Components delivery and assembly



Receiver tubes outlet

Hot store

Cold store

Bucket elevator

Heat exchanger

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The prototype development

The gas turbine integration

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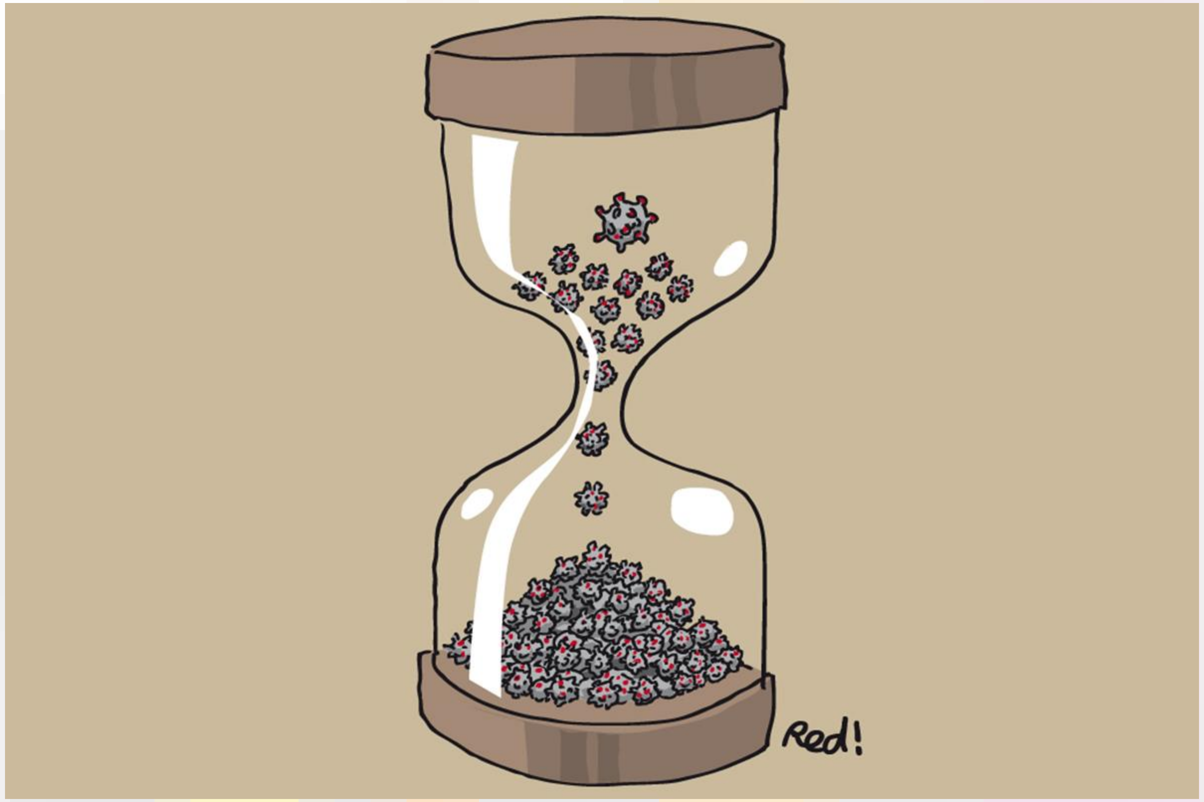
The prototype development

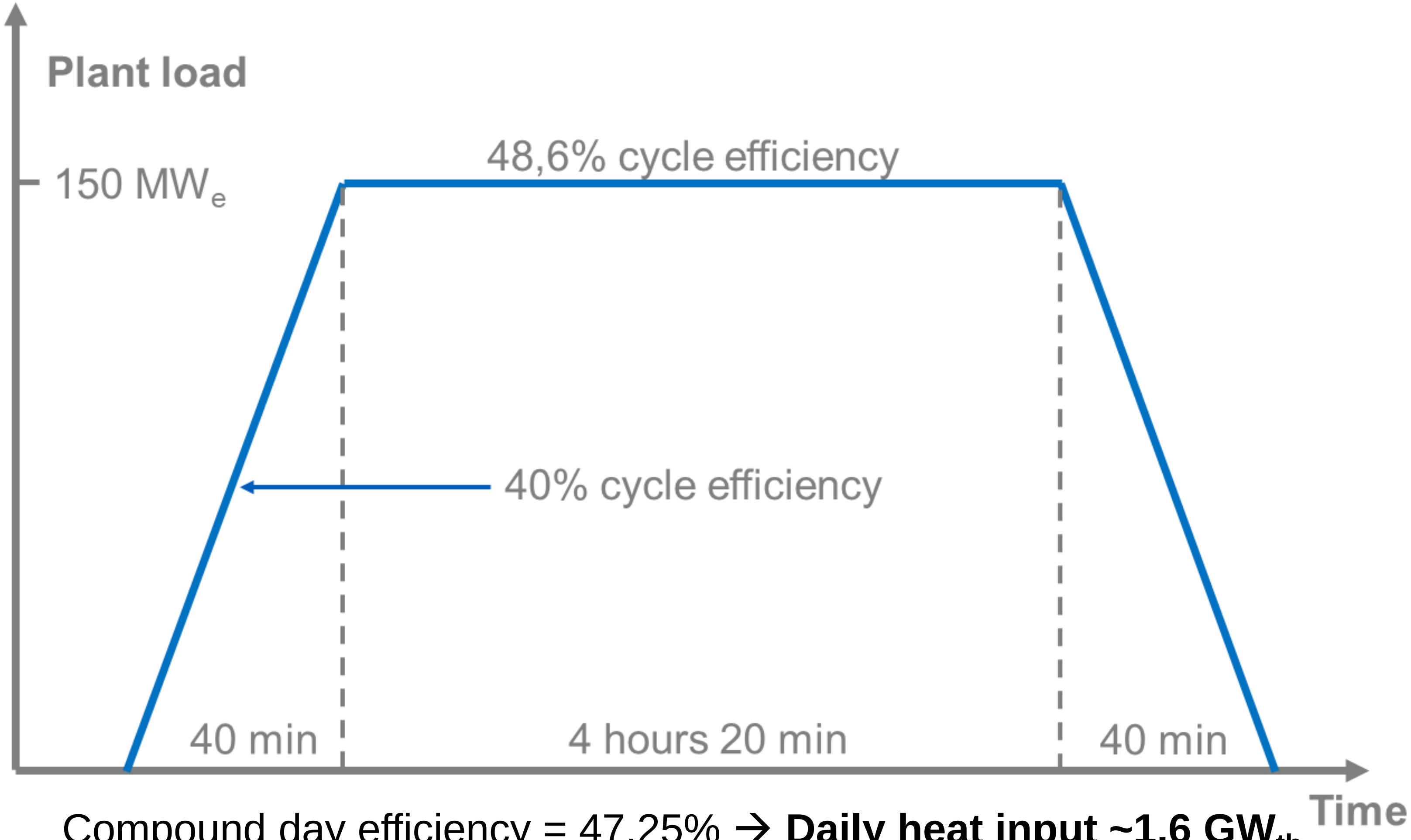
Commissioning

Hopefully next November



Scaling up for a 150 MWe peaker plant (peak load)

Production during high consumption / cost hours (evening and early night)



Compound day efficiency = 47,25% → **Daily heat input ~1,6 GW_{th}**

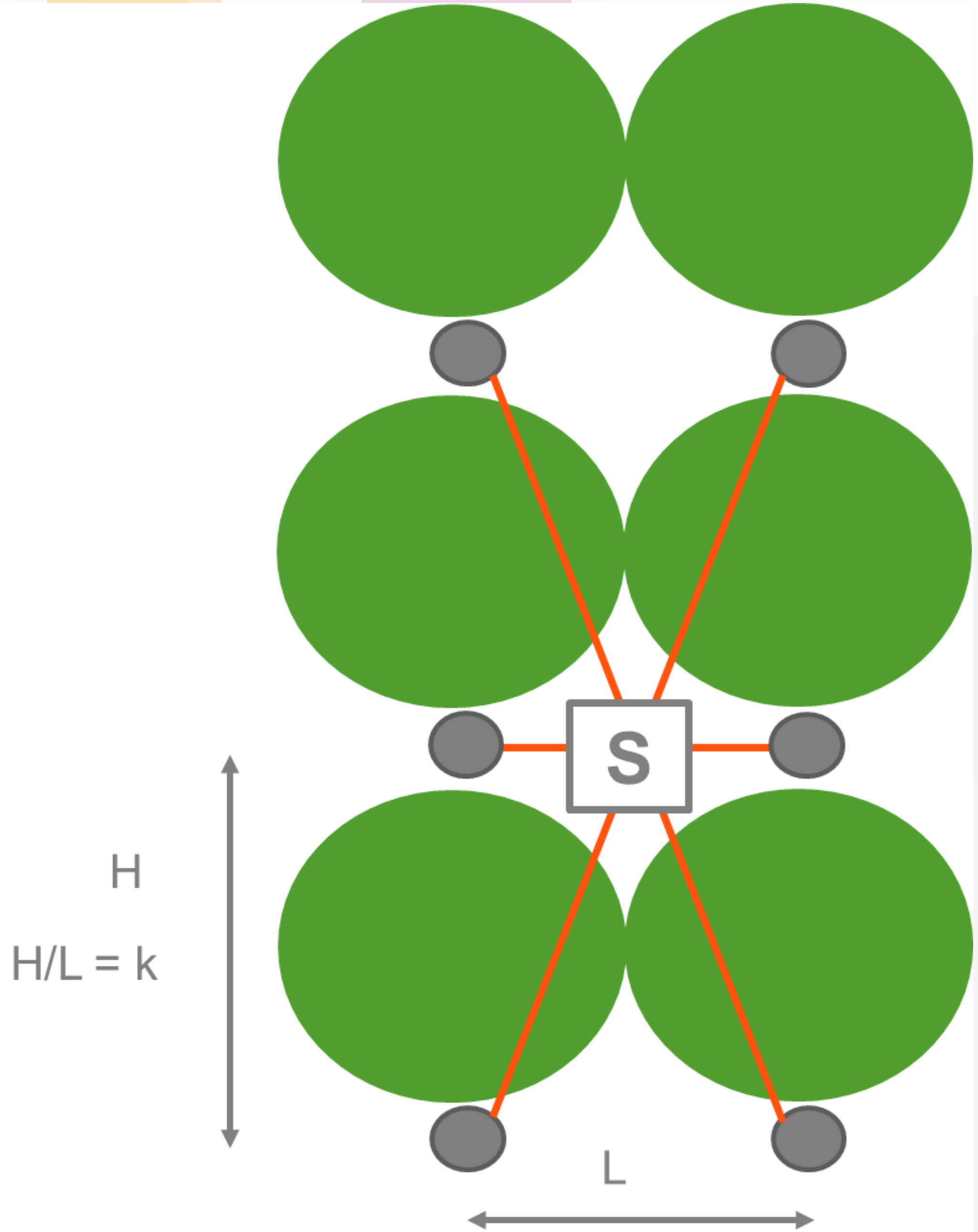
28 000 tons particles 150€/ton

Capacity factor ~20%

Scaling up for a peaker plant

Main issue: limited length of the receiver tubes → an array of tower modules ~ 50MW$_{th}$ each

→ Particle conveying technology



Scaling up for a peaker plant

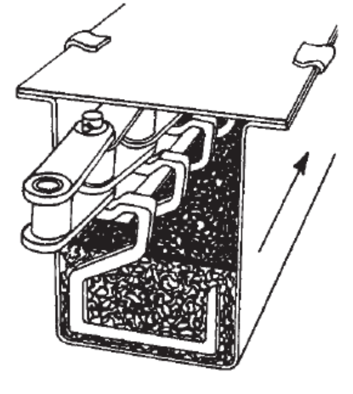
Particle conveying technology

Vertical: bucket elevators

- Number of elevators in parallel (mass flow) and in series (tower height) still to be defined according to chosen manufacturer

Horizontal: drag conveyors instead of apron conveyors

- Approx. 4 km of single mass flow (~220 kg/s) drag conveyors. thermal losses ~5%



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Scaling up for a peaker plant

LCOE calculation, in progress

Location Ouarzazate, Morocco

For a peaker plant (~20% capacity factor) with combined cycle

First estimate ~ 13-14 c€/kWh

For a base load plant (~70% capacity factor) with sCO_2 cycle

First estimate ~ 5 c€/kWh

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This project has received funding from the EU Horizon 2020 Framework Programme for Research and Innovation under grant agreement no 727762