# High Temparature concentrated solar thermal power plan with particle receiver and direct thermal storage

## Reporting

Project Information

NEXT-CSP

Grant agreement ID: 727762

Project website

Status
Ongoing project

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1 October 2016

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H2020-EU.3.3.2.

Overall budget
€ 4 947 420

EU contribution
€ 4 947 420

Coordinated by
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS
France

## This project is featured in...


19 August 2020

## Periodic Reporting for period 2 - NEXT-CSP (High

# Periodic Reporting for period 2 - NEXT-CSP (High Temparature concentrated solar thermal power plan with particle receiver and direct thermal storage)

**Reporting period:** 2018-04-01 to 2019-09-30

## Summary of the context and overall objectives of the project

Context

Within the topic LCE-07-2016-2017 “Developing the next generation technologies of renewables electricity and heating/cooling” and specifically the change on “Concentrated Solar Power: Innovative components and configurations for CSP plants”, Next-CSP project proposes environmentally and socially safe innovative components and systems validated in a relevant environment (a solar tower). After integration in new generation of CSP plants they will significantly reduce the Solar Thermal Electricity (STE) cost. The proposed concept relies on the use of particles, which act as heat transfer fluid as well as storage medium. Compared to molten salts, particles can operate at ambient temperature and can reach much higher temperature (750°C or higher). These two aspects lead to lower CAPEX and parasitic consumption, as well as higher thermodynamic cycle efficiency.

Objectives

The main objective of the Next-CSP project is to develop and integrate a new technology based on the use of high temperature (750-800°C) particles as heat transfer fluid and storage medium with the aim of improving the reliability and performance of Concentrated Solar Power (CSP) plants. This first-in-kind technology will contribute to the greater built-in thermal storage capacities of CSP plants allowing supplying solar electricity on demand and consequently reinforcing their competitiveness for a better integration into the renewable energy mix within the climate change challenge.

This objective will be achieved by the demonstration of an innovative technology for solar thermal plants in a relevant environment (TRL 5) and a significant size (3 MWth). The proposed fluidized particle-in-tube concept is a breakthrough innovation that opens the route to the development of a new generation of CSP plants. High efficiency thermodynamic cycles (50% and more), a 20% improvement of CSP plant efficiency and an electricity cost reduction by 38% are expected, hence enhancing the cost attractiveness of CSP on the renewable energy market as energy able to drastically decarbonise the energy system. A 3-MWth tubular solar receiver able to heat particles up to 750-800°C will be constructed and tested as well as the rest of the loop: a two-tank particle heat storage and a particle-to-pressurized air heat exchanger coupled to a 1.2 MWel gas turbine. A life cycle assessment of the proposed Next-CSP system will be performed in comparison with other current conventional and renewables energies.

The main deliverable

The main deliverable of the project is an industrial pilot scale process starting from the TRL 4 and ending at TRL 5 with the demonstration of the key building blocks, high temperature solar receiver, high temperature particle storage system, particle-to-pressurized air heat exchanger, and operation of a pilot scale power plant in a relevant industrial environment for a significant time. The pilot process will be installed at the Themis solar tower for on-sun testing and demonstration of the complete system (solar loop + hybrid gas turbine). An examination of the potential improvement of the plant efficiency will be achieved by investigating other innovative high temperature cycles. This entire upstream work helps optimizing the scaling-up to commercial size to enhance the overall performance and reliability of the technology. An environmental and life cycle assessment study will analyze the main benefits of this innovative particle technology with respect to current solutions.

## Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

The work performed during the first 36 months includes,

A critical analysis of best-adapted type of particles for the process including availability, thermal and mechanical properties, cost, health (toxicity of fines) criteria. Olivine was selected.

The preparation of the heliostat field of the Themis solar tower (107 54 m2-heliostats) and of the solar flux control at the focus. The tasks includes: canting, development of a heliostats aiming strategy, design and implementation of a moving flux bare for measuring, during experiment, the real solar flux at the receiver aperture.

The study of fluidized particle flow and heat transfer in a single tube using numerical simulations and an experimental campaign. The experimental campaign was carried out at the CNRS solar furnace. Results validate the project assumptions in terms of particle mass flow rate and wall-to-particle heat transfer coefficient.

The development of a tool for assessing thermodynamic cycles with efficiency of approximately 50% compatible with the targeted particles temperature (750-800°C). Super-critical CO2 and hybrid combine cycles can achieve this goal.

The manufacturing and installation of the complete solar pilot system atop the Themis tower. It is composed of the particle closed-loop - the solar receiver, the hot storage, the particle-pressurized air heat exchanger, the particle elevator and the cold storage – and the gas turbine.

The design of a commercial scale power plant accounting for the constraint on the limited size of a single solar receiver.

## Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

The project prepares the next generation of CSP plants with high performance thermodynamic.

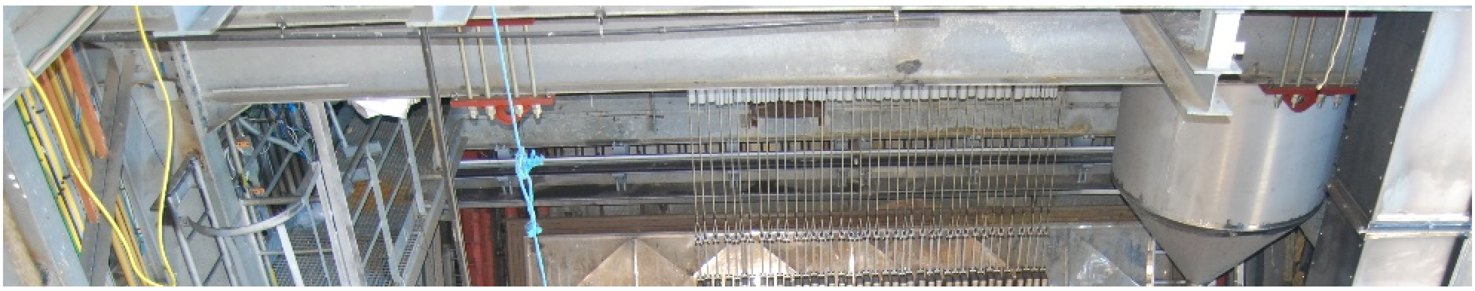
The following impact is expected:

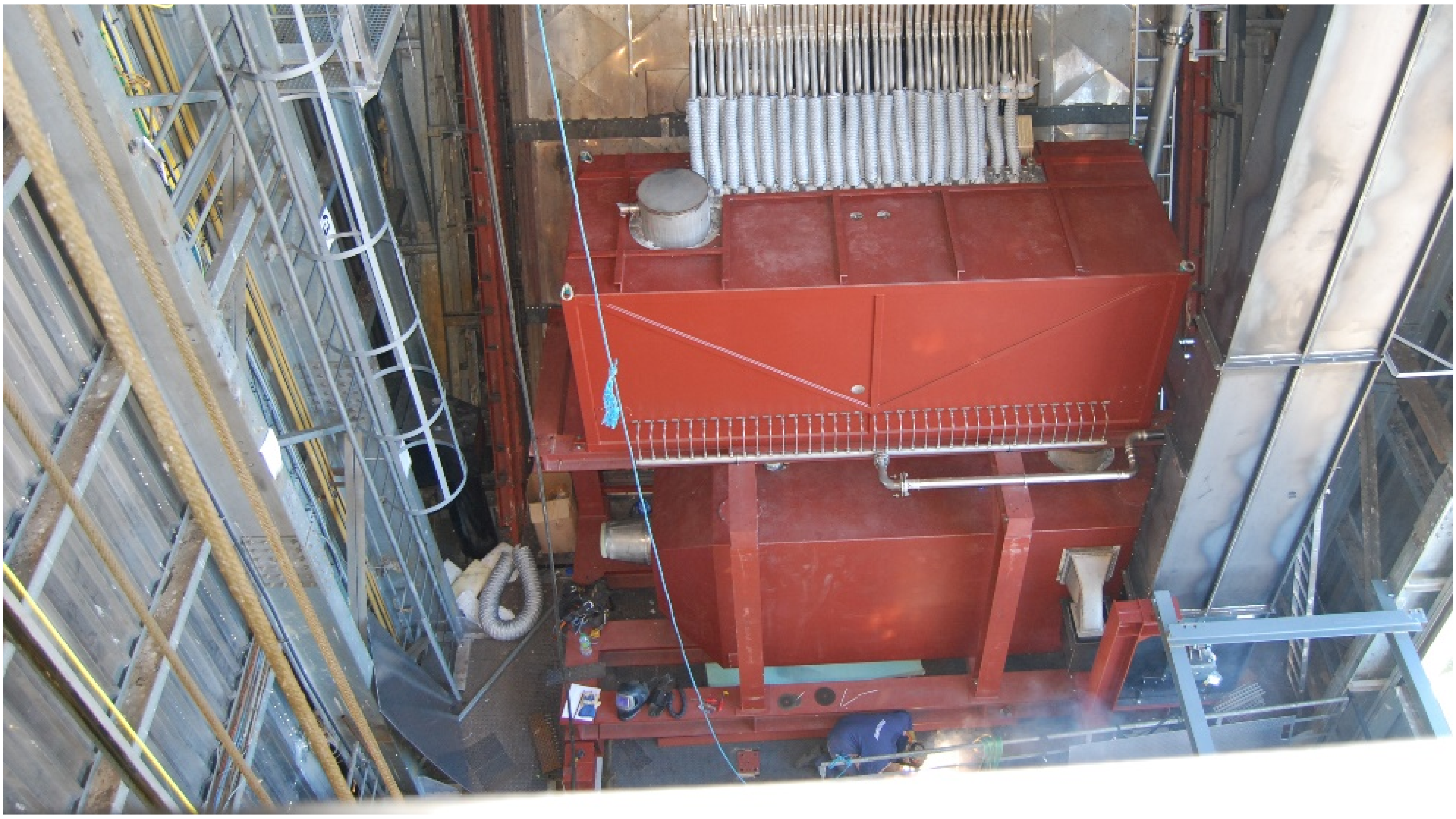
- Reduction of CO2 emission: CSP is a CO2 free technology that can produce dispatchable electricity. The project features a 40% emissions reduction target and an EU wide 27% renewables (RE) target.

- Increase of solar energy use in industry for greater EU energy security: Proposed Next-CSP technology will provide a unique dispatchability to Europe thanks to thermal storage at reasonable cost. The cost target is, LCOE of about 80 €/MWhel in 2030, 23% cheaper than that of molten salt towers.

- Job creation: an original and proven technology to develop particle receivers increasing reliability and lifetime and decreasing O&M costs of the CSP plants will enable the EU companies to go for new competitive development with about 100 000 expected jobs in Europe and around 200 000 jobs worldwide.

Installation of the solar receiver tubes and the cold store





Particle bucket elevator, hot store and particle-to-pressurized air heat exchanger installed

Lifting of the solar receiver particle dispenser atop the Themis tower

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