The proposed technology is set forth by an **interdisciplinary partnership spanning the entire CSP value chain**, comprised of leading research centers, universities, innovative SMEs and large enterprises, including ancillary services providers and technology end-users.

The ABraytCSPfuture project began in November 2022 and has a duration of 4 years.

Technical Objectives

COST-EFFECTIVE & RELIABLE:

Low cost (<2€/kg) production of redox oxides-based porous structures and scaled-up estimation of **LCOE** < 7 c€/kWh. **Mechanical stability in the range of 700-1000 ˚C** for at least 200 cycles.

HIGH PERFORMANCE:

ABraytCSPfuture will ensure **high energy density** (>300 kWh/m³) **for at least 500 cycles, operating temperature** > 950 ˚C **and high thermal-to-electric efficiencies** > 50 % with Combined Cycle (CC).

HIGH ENVIRONMENTAL PERFORMANCE:

Renewable electricity generation with **air-based CSP** together with TCES system based on **earth-abundant and non-toxic oxides.**

Horizon Europe ABraytCSPfuture Project

Get in touch with us and benefit from a strong international network.

On our internet portal, you will find useful and interesting documents as well as current news and relevant events: **www.abraytcspfuture.eu**

Follow us on:

X (@ABraytCSPfuture) - LinkedIn (/abraytcspfuture-project)

Contact ABraytCSPfuture Project Coordination:

Dr. CHRISTOS AGRAFIOTIS
German Aerospace Center (DLR)
Institute of Future Fuels, Linder Höhe -51147
Cologne – Germany

christos.agrafiotis@dlr.de, Tel. +49 2203 601-4132

ABraytCSPfuture - Air-Brayton cycle concentrated solar power future plants via redox oxides-based structured thermochemical heat exchangers/thermal boosters

Supported by

ABraytCSPfuture

Supported by

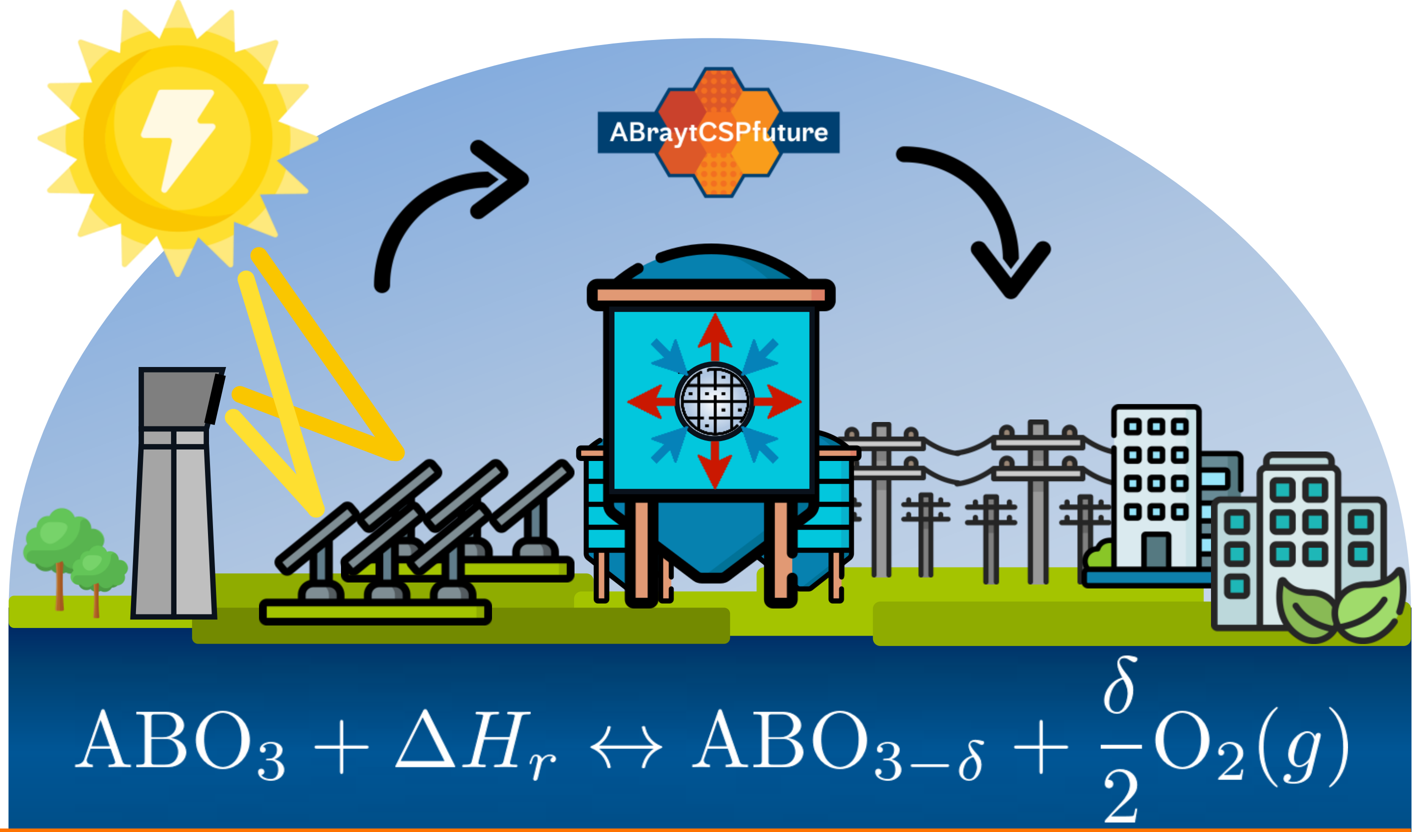
Responsible for Dissemination and Communication

National Renewable Energy Centre of Spain (CENER)
C/ Ciudad de la Innovación nº7
31621 Sarriguren (Navarre) – Spain

Tel. +34 948 25 28 00

Image sources: DLR, FlatIcon, Images without copyright

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101084569.



A fascinating concept for a bright CSP future

Project Summary

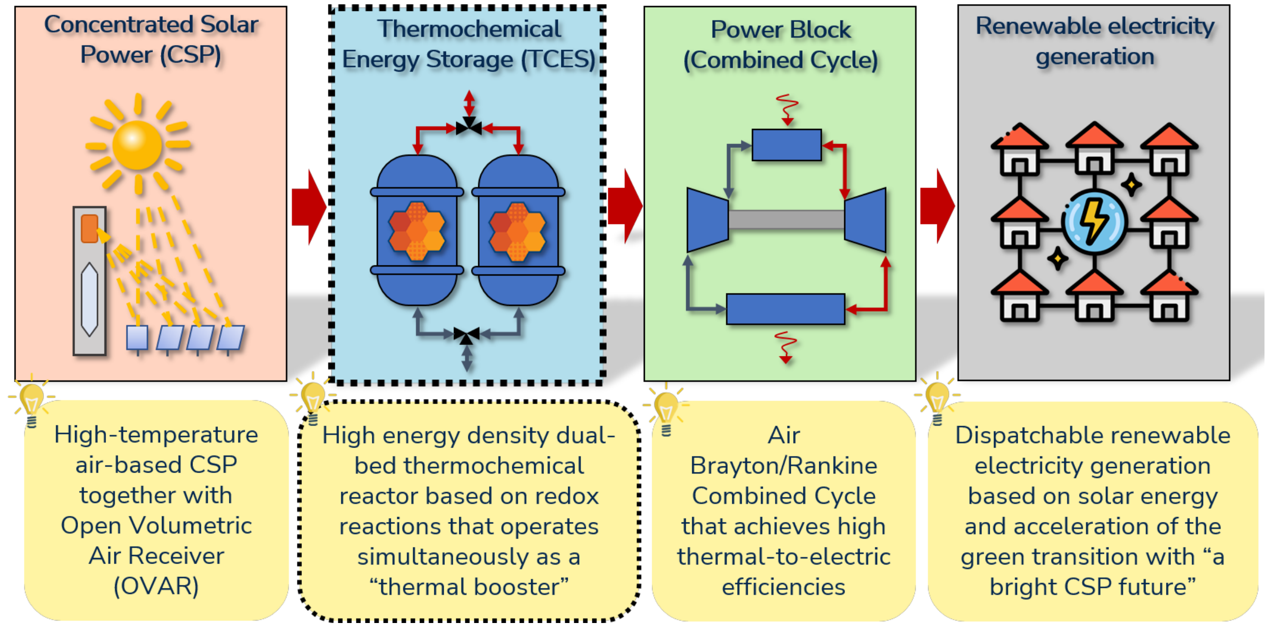
ABraytCSPfuture sets forth an innovative, carbon-neutral way for implementing into future **air-operated Concentrated Solar Power (CSP)** plants the inherently much more efficient air-Brayton gas turbine power generation cycles in order to achieve **higher solar-to-electricity efficiencies**, significantly increasing in parallel the plants' storage capability.

Both these functionalities will be made possible by developing and demonstrating the integrated operation of a first-of-its-kind, compact, dual-bed **thermochemical reactor/ heat exchanger design**, comprised of non-moving, flow-through porous ceramic structures (honeycombs or foams) based on earth-abundant, non-toxic oxide materials, capable of performing simultaneously the following:

- Transferring **heat from a non-pressurized air stream to a pressurized one**, while operating simultaneously as a "**thermal booster**", raising the temperature of the pressurized stream to levels required for gas turbine air-Brayton cycles.

- **Increasing significantly the volumetric solar energy storage density** of such air-operated CSP plants by rendering their current sensible-only regenerative storage systems to hybrid **sensible-thermochemical storage** ones, within the same storage volume.

The concept is based on exploiting reversible reduction/oxidation reactions of such oxides in direct contact with air, accompanied by significant endothermic/exothermic heat effects.



Thermochemical Reaction

The **Thermochemical Energy Storage (TCES)** operates between the **oxidized and reduced form of a metal oxide** with multiple oxidation states in a cyclic process. The heat received by the solar field is used to carry out the thermal reduction step, where the higher-valence oxide state releases oxygen and transforms to the lower-valence form (1). When it is required, exothermic oxidation (2) takes place and the reduced form is transformed to the oxidized form, releasing the stored heat.

$$MeO_x + (N_2) + \Delta H_r \rightleftharpoons MeO_{x-\delta} + (N_2) + \frac{\delta}{2}O_2 \quad (1)$$

$$MeO_{x-\delta} + (N_2) + \frac{\delta}{2}O_2 \rightleftharpoons MeO_x + (N_2) + \Delta H_r \quad (2)$$

The ambition of project is to demonstrate for the first time ever and at a proof-of-concept level this radically new idea by the development and operation of a **first-of-its-kind, compact, dual-bed thermochemical reactor/heat exchanger**, comprised of non-moving, flow-through porous ceramic structures (honeycombs and/or foams) based on such oxides. The project focuses on **inexpensive, non-critical, abundant and environmentall**y safe Ca-, Mn- and recycled Fe-based perovskite materials.

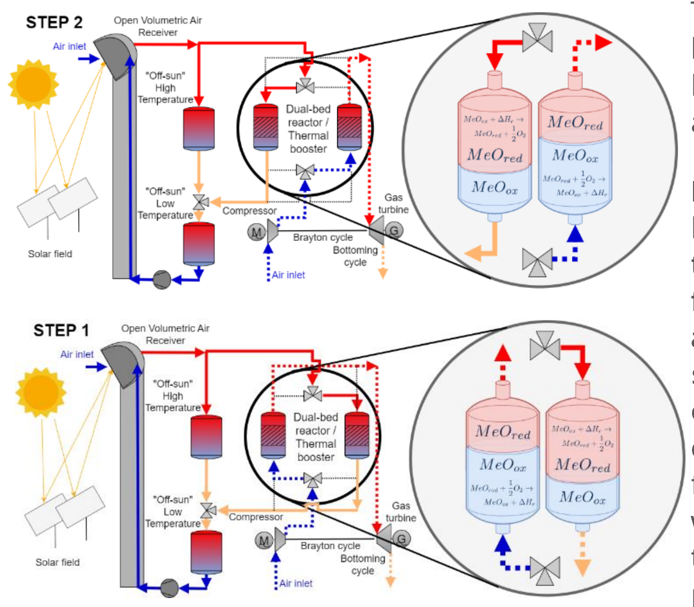
Project Path:

1- Specific evaluation of **novel redox oxide materials powder synthesis**. Preparation of redox oxides-based porous structures.
2- Dual-bed thermochemical **reactor scaled-up design**, CSP plant operation scenarios and systems integration strategies.
3- **Design, manufacturing and testing** of proof-of-concept dual-bed unit.
4- **Market study, life cycle assessment and techno-economic assessment** of proposed technology.

Dual-bed, regenerative sensible heat storage unit previously developed and built by project partners at Plataforma Solar de Almeria, Spain

ABraytCSPfuture concept's solar plant operation

During on-sun operation, part of the air from the receiver is diverted to the off-sun storage unit, while the rest charges one of the regenerator beds. **(Step 1)** This bed, containing oxidized oxide, is heated by the air, reducing the oxide (**endothermic reaction**) in a "**stratified" pattern**. The oxide remains reduced as long as its temperature remains above the reduction onset. Simultaneously, in the other bed, previously reduced, oxide undergoes **exothermic oxidation**, heating compressed air and **driving the turbine.**



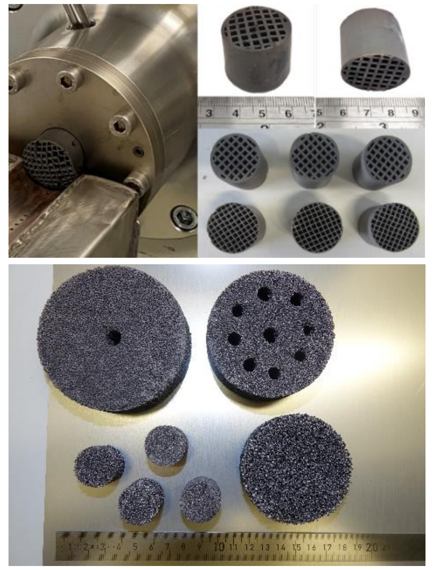
This process "**thermally boosts**" the air temperature beyond what sensible heating alone can achieve.

In **(Step 2)** the flow of the two beds is switched. As a result, **the gas turbine is always fed with a high-pressure and high-temperature air stream** from the discharged chamber. During off-sun operation, hot air is provided from the storage system which operates with exactly the same sensible-TCES principle as above.

Halfway to a brighter future

During the **first 24 months**, the project has achieved significant milestones. Notably, collaborators from DLR and CERTH have made remarkable progress in **experimental synthesis techniques and the development of perovskite structures** tailored for this purpose.

Various monolithic porous ceramic structures, such as honeycombs and foams **made entirely of perovskites**, have been produced in different sizes and **redox-cycled over 200 times**. These cycles demonstrated measurable temperature rises in both the structures and the air stream during exothermic oxidation, **showcasing for the first time the ability of a perovskite to generate repeatable measurable heat effects.**
The project has begun **modeling** the dual-bed thermochemical reactor using advanced computational tools to **optimize its design and assess environmental impacts.**



Sintered Ca-Mn-based perovskite honeycombs and foams prepared at CERTH and DLR