SOLAR CALCIUM-LOOPING INTEGRATION FOR THERMO-CHEMICAL ENERGY STORAGE

SOCRATCES

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CONTRACT Nº: 727348
Starting date: 1st January, 2018
Duration: 36 months

PROJECT INFORMATION

One of the great challenges for renewable energy widespread is the develpment of sustainable energy storage systems. Among the most promising energy storage technologies are the thermocheminal energy storage systems (TCES). In them, thermal energy is used to break chemical bonds, energy that is recovered when the products are mixed. They can reach verhy high energy denisities and allow seasonal storage.

The Ca-Looping (CaL) process based upon the reversible carbonation/calcination of CaO **is one of the most promising technologies for thermochemical energy storage (TCES).** The wide availability of natural limestone (almost pure $CaCO_3$), one of the most abundant materials in Earth, and its low price (<10€/ton) are key factors for the feasibility of the CaL process.

SOCRATCES is aimed at demonstrating the feasibility of this integration by erecting a pilot-scale plant that uses cheap, abundant and non-toxic materials as well as mature technologies used in the industry.

SOCRATCES global objective is to develop a prototype that will reduce the core risks of scaling up the technology and solve challenges; further understand and optimise the operating efficiencies that could be obtained; with the longer-term goal of enabling highly competitive and sustainable CSP plants.

SOCRATCES TECHNICAL APPROACH

The proposed system works as follows: solar irradiation is used to carry out the calcination of $CaCO_3$ (endothermic reaction) in a solar calciner reactor at high temperatures (725-950ºC). Once calcination takes places, the product (CO_2 and solid CaO) are stored separately.

When power is needed the stored products are brought together into the carbonator reactor, where energy is released through the exothermic carbonation reaction at temperatures between 650-1000ºC depending on the CO_2 partial pressure, which leads to a power cycle thermodynamic efficiency higher than in currently commercial CSP plants.

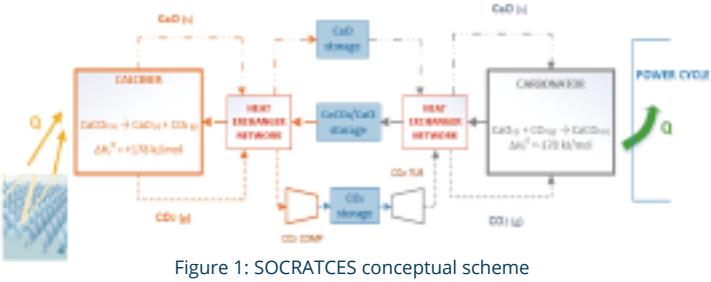

Figure 1: SOCRATCES conceptual scheme

The SOCRATCES concept stems from laboratory results of the partners in the consortium (TRL4) for testing the concept in relevant environment (TRL5). This concept goes beyond the current most advanced projects for developing next generation CSP concerning:

- **Integrated systems concept is used to redefine the TCES design** conditions allowing to use very cheap, abundant and non-toxic materials as heat transfer media.
- Solar receiver design to reduce the scale-up risk. **Temperature in the solar particle receiver could reach 1000ºC.**
- Higher temperature in the carbonator (>700ºC) usable for power generation. **High efficiencies of power cycle.**
- **High density seasonal energy storage** (theoretically ~3.2 GJ/m3).
- **Potential integration with commercially available technologies** (real gas turbines in direct integration, Stirling, Rankine cycles for indirect integration) at commercial scale.
- The use of **cheap, abundant and non-toxic materials** minimizes plant construction impact on the full life-cycle assessment (LCA).

EXPECTED RESULTS AND IMPACT

Main expected results **during the SOCRATCES project:**

Prototype demonstration of capacity for energy storage. System tested at TRL5. Solids and CO_2 storage.

Successful calcination at prototype scale by means of flash calcination technology.

Successful carbonator design with possibility for the scale-up. Integration of high temperature carbonator (>700ºC) and Stirling engine for power production.

Particles attrition, agglomeration and fouling analysis. Successful solids conveying and control system management.

Study of CaO precursor and process conditions to allow high and stable multicycle activity.

SOCRATCES is intended to open a new pathway for next generation of energy storage in CSP tower plants, technologically feasible, economically viable and sustainable (environmental, social and economic). The roadmap for advancing from the concept to commercial technology is conceived in three stages to be developed in a period of 10 years: 10KWth small prototype, 1 MWth scale pilot plant and commercial demonstrator.

SOCRATCES CONSORTIUM

SOCRATCES is an integral and multidisciplinary approach where different knowledge areas are involved: thermal machines, electronic engineering, solar energy, control, physics, chemistry, power generation, materials, reactors, LCA, etc. It integrates **multidisciplinary R&D groups, SMEs and other companies in an equilibrated structure** where all the required skills for the adequate development of the project are fully covered.

- Spain
- France
- UK
- Italy
- Portugal
- Greece
- Germany

PROJECT INFORMATION

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