FINAL PROJECT FACT SHEET
EUROPEAN UNION CO-FUNDED PROJECT

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Horizon 2020

LCE-02-2015 - DEVELOPING THE NEXT GENERATION TECHNOLOGIES OF RENEWABLE ELECTRICITY AND HEATING/COOLING

Project acronym:

SOLPART

High Temperature Solar-Heated Reactors for Industrial Production of Reactive Particulates

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1. SUMMARY

The main objective of the SOLPART project is to develop, at pilot scale, a high temperature (950°C) 24h/day solar process suitable for particle treatment in energy intensive industries (e.g. cement or lime industries). The project aims at supplying totally or partially the thermal energy requirement for $CaCO_3$ calcination by high temperature solar heat thus reducing the life cycle environmental impacts of the process and increasing the attractiveness of renewable heating technologies in process industries. This will be achieved by the demonstration of a pilot scale solar reactor suitable for calcium carbonate decomposition (Calcination reaction: $CaCO_3 = CaO + CO_2$) and to simulate at prototype scale a 24h/day industrial process (TRL 4-5) thereby requiring a high-temperature transport and storage system. The system will operate at about 900°C and will include a 30 kWth solar reactor producing 30 kg/h CaO and a 16h CaO hot storage able to deliver 10 kg/h CaO. Life cycle environmental impacts of the solar-based solution in comparison with standard processes will be developed as well as economic evaluation. Thanks to the solar unit integration in the industrial process (potentially combined with CO_2 capture), this should result in the considerable reduction of the carbon footprint of the CO_2 emitter industries and open a new market for renewable energies.

2. PROJECT SCOPE

The specific objectives and main ideas: In addressing the topic LCE-02-2015 "Developing the next generation technologies of renewable electricity and heating/cooling" and specifically the second challenge on Concentrated Solar Power, SOLPART provides the new alternative and cost-effective process solutions based on technologies that can be integrated into industrial plants and processes. The proposed innovative concept develops and merges three advanced technologies: a high temperature solar reactor, a transport of high temperature solid materials and a storage tank of high temperature solid materials / intermediate products. The synergy between the technologies lies in using the solar-treated particles as storage medium.

The main models or assumptions involved: The main models involved are: concentrating optics and radiative heat transfer, theory of solid-gas reaction at high temperature, two-phase flow mechanics in tubes and at high temperature, gas solid-wall heat transfer processes and scaling laws for gas-solid reactors.

The overall methodology: The approach includes modelling and experimental parts in order to achieve the qualification of the proposed innovative solar technology. The experimental validation will be performed at two scales, lab-scale and pilot scale. The main idea of the approach is to develop an easily scalable solar reactor concept that may be used for various types of solid-gas chemical reactions and that may be integrated in existing plants. Combined with modeling, experimental results will be used to define the basic laws for scaling up.

Description of innovation potential: The main innovations of the SOLPART project are emphasized as follows:

1. Design and comparative testing of various innovative solar reactor concepts based on rotary kiln, fluidized bed or moving bed principle at lab-scale. The use of innovative materials and assembly technology are expected.
2. Quantification of performances of one selected solar reactor concept at pilot scale (>30 kWth) for calcination of calcium carbonate-based materials at about 900°C. The expected product flow rate is about 30 kg/h of CaO, which correspond to about 7.5 times the state-of-the-art.
3. On-line characterization of flue gas composition and solid product.
4. Quantification of the pilot solar reactor performances for calcination of various solids such as cement raw meal, dolomite and phosphate ores
5. Development of a 900°C/160 kg particulate storage system combined with the solar reactor and able to deliver 10 kg/h CaO.
6. Assessment of the complete loop - solar reactor + storage – 24h/day during several days.
7. Particle handling solutions at high temperature (>900°C).
8. Concept for integration of high temperature solar heat in a large industry at the scale of 300 tons/day lime, of 1500 tons/day phosphate and 3500 tons/day cement production plan.. The study will include as well

hybrid solutions in which variable proportion of thermal energy provided by fossil fuel combustion is substituted by solar energy to find the best economical solution for each region.

9. Complete environmental, risk and economic assessment of the solarized process with respect to the traditional route (business as usual).
10. Business analysis on the basis of case a study.

The main deliverable: The main deliverable of the project is a pilot scale process starting from Technology Readiness Level (TRL) 3 and ending at TRL 4-5 with the demonstration of the main building blocks, solar reactor and high temperature storage at pilot scale, and operation of a pilot scale loop over a relevant period of time in a continuous mode.

The use of the deliverable by others: The project results are supposed to be used in follow-on collaborative research project with the final goal to bring the technology to TRL 7 or 8. Within the dissemination and exploitation strategy, the research will be also transferred to as many industries as possible in order:

- To contribute to the development of high temperature solar receivers/reactors (materials and concepts);
- To raise awareness in the energy intensive solid processing industries;
- To enable the sustainable development of the technology;
- To develop sustainability for the continuation of the project after the EU-funding.

3. PROJECT TECHNICAL DESCRIPTION & IMPLEMENTATION

The main technologies under investigation: The main idea of the approach is to develop an easily scalable solar reactor concept that may be used for various types of solid-gas chemical reactions. The first step consists in a complete review of potential chemical reactions (apart from $CaCO_3$ calcination, which is already covered well by the consortia) and of existing technologies for particle thermal processing and storage. This first critical analysis will lead to: (1) the testing of two lab-scale high temperature solar reactors and (2) the development of storage and particle conveying technologies.

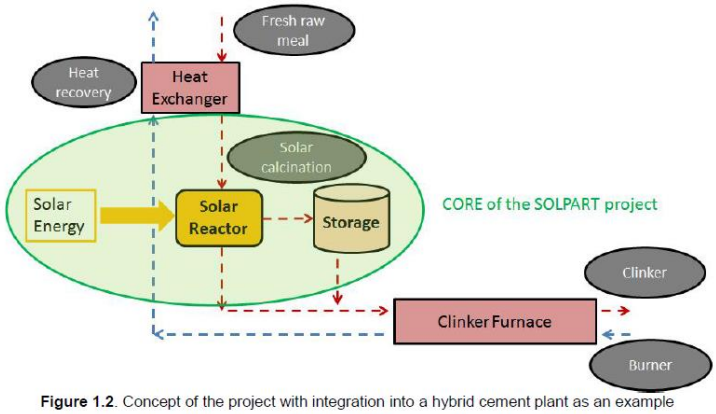

Figure 1.2. Concept of the project with integration into a hybrid cement plant as an example

The expected results to go beyond the state-of-the-art:

Item	state-of-the-art	Project target
Solar reactor power	10 kW_{th}	>30 kW_{th} (3x state ot art)
Solar reactor thermochemical efficiency (η_{ch})	30 %	>50 %
CaO flow rate from the solar reactor	max. 4 kg/h	>30 kg/h (7.5x state of art)
Decarbonation degree	98%	>95 % (exact number will depend on economics and criteria of product acceptability –lower for cement than for lime, for example-)
Process Type	batch	continuous
Storage Type	none	High temperature storage
Constant Running Time	max. hour	24/7 for several days

The positioning and scale of the technology: SOLPART addresses the use of solar heat way above 200°C (project goal: > 900°C) in particle processing industries. The proposed innovative concept is based on technologies that can be integrated into industrial plants and processes. It will bring the technology solutions (high temperature solar reactor, transport of high temperature solid materials and storage of high temperature solids / intermediate products) from TRL 3 to at least TRL 4-5 by testing a 30 kW_{th} solar reactor for continuous processing of carbonate-based materials

The implementation of the project, phase of the project, main milestones, outcomes: The work plan of the SOLPART project is divided in 9 work packages, 7 are devoted to S&T development and 2 are related to communication, dissemination and exploitation of results, and management respectively. The first 3 WP of the work plan address a complete state-of-the-art of the standard and solar technologies for processing and storing particles, and the development and testing of lab-scale high temperature solar reactors and particle storage. The critical milestone of the project is proposed in month 18 in order to choose the technologies to be developed at pilot scale. On this basis, WP4 and WP5 are devoted to the design, construction and testing of the pilot unit (30 kW solar reactor and 16h particle storage). The performance evaluation of the pilot unit includes product characterization, and heat and mass balance during continuous operation. The results of this critical step will then be used in WP6 and WP7 for developing an environmental life cycle assessment of the solar process and the scaling up of the solar technology for three main applications: calcite (and dolomite) and cement raw meal decarbonation, and phosphate ores calcination.

4. RESULTS ACHIEVED

After 6 months activity the main achievements are related to the measurement and modeling of decarbonation reaction kinetic data as a function of temperature and particle diameter and the selection of lab-scale (5-10 kWth) solar reactors design. Rotary kiln and fluidized bed concepts have been selected and construction of the experimental setup has started to be ready end of September 2016.

5. IMPACT

The contribution SOLPART has on:

Replicability: The project opens new application domains for solar heat. The project is of general interest for many mineral industries e.g. lime and cement and even the metallurgy industry (e.g. hematite to magnetite, roasting of sulfides to oxides and others).

Socio-economics: There is no equivalent project anywhere in the world, including in the USA, China and Japan. Thus, beside the impact at the environmental and economic levels, the results and achievements of the SOLPART project considerably improve the European industry competitiveness (e.g. technologies for solar processing of minerals at high temperature; high temperature materials for solar thermo-chemistry and next generation of solar power plant; high temperature storage vessels, and other) as well as the European employment sector.

Environment: Compared with the current standard technologies and by allowing solar system integration, SOLPART will allow a reduction in the environmental footprint. The first evaluation results in at least a 50% reduction on the standard technology across different impact categories, with the climate change impact reduced by at least 80%.

Market Transformation: All the equipments related with the solid particles handlings targeted by the project have direct and also critical applications in other technological and industrial sectors with need for energy storage at high temperature. Another important impact derived by achieving the main goals of the project, will be the possibility to export and sell to other countries around the world this high level technology developed within the project; thus offering new market opportunities.

Policy: The European Commission has published its proposal on a climate and energy framework for the decade 2020-2030 on 22nd of January 2014. The proposal features a 40% emissions reduction target and an EU wide 27% renewables target to contribute to solve the global climate challenge. In this way, the new technology development within this proposal would contribute to the strategic energy policy objective fixed by the EU to develop technologies able to reduce considerably greenhouse emissions.

6. ADDITIONAL INFORMATION

None