Raising the Lifetime of Functional Materials for Concentrated Solar Power Technology

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Dear Readers,

Our newsletters focus on raising the lifetime of key functional materials for concentrated solar power (CSP) technologies. In this first edition of the newsletter you will learn about the project in general and the project team members.

These newsletters are addressed to all stakeholders who are active in the field of Concentrated Solar Power Plants, from power plant developers / operators and technology suppliers to the scientific community as well as governmental bodies. Members from the general public who are interested in topics related to the RAISELIFE project, such as concentrated solar power, and material durability will also gain from our newsletter. You will receive information about RAISELIFE on a regular basis, covering project progress, special topics, news, where to find further information and where to meet us at events.

Enjoy reading!

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The RAISELIFE project at a glance

RAISELIFE addresses the challenges of materials for CSP technology focusing on the 2020 targets stated in the Materials Roadmap (SEC(2011)1609). The overall aim of the the RAISELIFE project is to decrease CAPEX (capital expenditure) and OPEX (operational expenditure) of components to reduce the cost of renewable electricity from CSP by understanding and improving the in-service durability of functional coatings and materials all equally relevant for successful operation of concentrated solar power (CSP) plans on one hand, and by minimizing the O&M cost on the other hand.

The project is funded by the European Union's Horizon 2020 research and innovation programme and is running from April 2016 to March 2020.

Project Objectives and Technologies

This proposal focusses on raising the lifetime of five key functional materials for CSP technologies:

- Primary reflector coatings
- High-temperature mirrors for secondary concentrators
- Receiver coatings
- Corrosion resistant high-temperature metals and coatings for molten salts
- Impact of degradation on performance of components and systems

Primary reflector coatings

One of the main objectives of this activity is to test two recently developed protective coatings for primary reflectors (for parabolic-trough collectors, PTC, linear Fresnel collectors, LFC, and solar towers, ST) at eleven relevant environments and in-service at commercial power plants, covering humid coastal conditions and dry desert sites with high irradiations, understanding of their failure modes and determining which type of coating is suited for which corrosivity class. Matching the protective coatings to the corrosivity class reduces CAPEX and extends the long-term lifetime of the solar power plants. In order to improve the methodology to make service lifetime estimations of these reflector coatings, the improved coatings developed will be subjected to accelerated aging tests in climate chambers in parallel to field testing, in order to correlate the degradation rates of laboratory tests with outdoor corrosivity classes.

Another objective is the evaluation of two anti-soiling coatings for primary reflectors (for PTC, LFC and ST) regarding dust repellent properties, durability and cost

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effectiveness through long-term exposure under realistic conditions at PSA (Spain) and Missour (Morocco). In addition, the anti-soiling coatings will be exposed to accelerated aging tests in climate chambers to realistically reproduce the outdoor degradation effects and to derive a long-term lifetime estimation method for anti-soiling coatings.

The last goal of this activity is the design and production of low cost, high reflective and light weight composite heliostat. The long-term lifetime of high-reflectance ultra-thin glass mirrors for heliostats applied on light-weight composite-material substrates through field-testing under realistic conditions in eleven representative outdoor sites, in CSP demonstration plants and accelerated aging tests in climate chambers will be evaluated. For the same purpose, the evaluation and comparison of the lifetime and degradation mechanism of two adhesion methods and three composite-material structures, used for supporting and stabilizing the ultra-thin-glass mirrors will be carried out. This evaluation will include in-service testing of a prototype heliostat installed at a ST-plant (Israel) from BrightSource Industries Israel (BSII), mechanical stress and shape measurements.

High-temperature mirrors for secondary concentrators

The final goal of this activity is the development of high-temperature secondary mirrors with protective top coatings. In order to achieve this objective, improved high-temperature mirrors will be tested in field experiments under elevated solar irradiance, using hard protective top coatings (i.e. high power impulse magnetron sputtering (HIPIMS) or plasma-enhanced chemical vapour deposition (PECVD) top coatings with improved lifetime), which are expected to enhance the mirror durability under realistic operation conditions. Solar testing in ST facilities is expensive and no small-scale testing benches are available to assess the durability of high-temperature mirrors under solar flux conditions. Therefore, a solar testing bench for high-temperature mirrors will be designed and set-up in the solar furnace at CIEMAT and the durability of the reflector with different protective coatings will be evaluated. As the material is also exposed to the environmental conditions, it will also be tested in accelerated aging tests in climate chambers and ovens, allowing to understand the degradation mechanisms by analysing the tested samples. The accelerated aging testing campaign for secondary reflectors will be adapted from the testing program used for primary reflectors, taking into account the operating conditions under elevated temperature.

Receiver coatings

In order to develop improved coatings to withstand high thermal stresses in harsh desert conditions while maintaining its optical properties of high solar absorptance (HSA), lifetime and durability estimation of several HSA coatings will be tested under realistic solar flux profiles and lifelike thermal cycling and stresses (accelerated tests) to

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understand their failure mechanisms. In addition, an on-tower application method and solar curing of one HSA coating for recoating or repair of coatings to save O&M cost will be examined. Furthermore, the development of an automatic application machine for one HSA coating will be carried out for improvement of coating durability and optical performance due to improved homogeneity of the layer deposition.

In RAISELIFE, the application process and the environmental resistance of a sol-gel absorber and anti-reflective (AR) coatings for non-evacuated linear receivers will be improved by optimizing the thermal treatment in the sol-gel deposition technique. This improved technique will lead to obtain better optical properties and outdoor and thermal durability.

Corrosion resistant high-temperature metals and coatings for molten salts

In RAISELIFE, the corrosion of in-service steel samples from commercial molten salt power plants will be analysed. Laboratory corrosion tests will be performed on the currently used steels in BSII power plants, on promising steel candidates for future projects and on low-alloyed material samples with protective coatings (multi metallic diffusion and aluminide coatings, developed by Dechema and Instituto Nacional de Técnica Aeroespacial (INTA) respectively).

The conducted tests will also focus on determining the impact of commonly present salt impurities such as chlorides and sulphates, which affect the chemical and thermal stability of the salt and the corrosive effect on materials. In addition, slow strain rate tests (SSRT), wall thinning due to fluid flow and thermo-mechanical fatigue tests will be carried out. Basic immersion tests allow separating the pure corrosion effects from overlaid mechanical and erosive effects. A detailed analysis and understanding of the failure mechanism of coated steel samples will be performed in order to give feedback to coating developers for improved corrosion protection in molten salts. Based on this analysis, a best practice for material selection for molten salt plants will be elaborated, determining the maximum admissible amount of molten salt impurities to be compatible with the O&M of the plant.

In order to control corrosion rates in commercial power plants, electrochemical sensors for on-line corrosion monitoring will be adapted by Universidad Complutense de Madrid (UCM) to molten salt environments. These sensors will work with electrochemical perturbation by Electrochemical Impedance Spectroscopy (EIS) and measure the temperature at the same time. Accuracy and response tests are planned at 650 and 700°C with probes of different steels and coated substrates in contact with molten salt. After the lab tests, the system will be employed in a molten salt plant of BSII to continuously measure the corrosion rates of steel in contact with molten salt.

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Impact of degradation on performance of components and systems

O&M will impact the durability and performance of materials and coatings, e.g. due to cleaning cycles in harsh CSP environments. This interdependency and the economic effects will be investigated. On the other side, a key goal will be to evaluate the environmental impact on the materials studied in the frame of the project (coatings and molten salts mixtures). This shall be achieved using a Life Cycle Analysis tool.

- Impact of in-service degradation on the performance of functional materials and coatings: On a component level, the results of the materials and coatings testing and analysis activities will be evaluated in terms of performance changes. This allows for a comparison of coatings performance over the expected lifetime and their economic impact.
- Evaluation of materials and RAISELIFE-developments using an integrated simulation tool: An integrated CSP plant simulation tool will be developed based on the adaption and extension of existing simulation tools. In addition to the usual performance data of CSP plants, such as electricity production and component efficiencies, this tool will focus on the impact of the improved materials developed in the project. The tool will be used to assess and optimize the implemented measures for different sites. Only by taking into account the whole system and adequate economic models, the impact of the various measures can be assessed properly.
- Environmental impact of materials and molten salts: best performing coatings developed in the project along with the molten salts systems will be evaluated from an environmental point of view. Life Cycle Analysis will be performed using the commercial software SimaPro.

The RAISELIFE consortium

The RAISELIFE project is coordinated by Dr. Florian Sutter from the German Aerospace Center, DLR, whose consortium is made up of several organizations (industrial partners, SMEs, universities and research organizations) from both the concentrating solar thermal and the materials science areas, offering a broad set of interdisciplinary expertise. Besides European partners from Germany (DLR, Fraunhofer, DECHEMA and Flabeg), Spain (CIEMAT, Universidad Complutense de Madrid and INTA), France (PROMES, Corning and Vallourec) and Italy (Soltigua), the consortium includes two parties from the associated countries of Israel (BrightSource Industries Israel) and Morocco (MASCIR), giving access to in-service testing in CSP relevant environments and commercial installations.

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Learn more about the partner organizations: https://raiselife.eu/partners.php

Visit the RAISELIFE Website

Our website presents the different aspects of the RAISELIFE project. Find out more about the project, the technologies developed and the impact of the envisaged technical improvements.

www.raiselife.eu

Meet us at Events

SolarPaces 2016 Conference in Abu Dhabi (United Arab Emirates), 11–14 October 2016, represented by DLR, CIEMAT, and INTA.
http://2016.solarpaces-conference.org/home.html

8th International Conference on Advances in Material Technology for Fossil Power Plants in Algarve, Portugal, 10–14October 2016, represented by Fraunhofer
https://www.structint.com/resources/events/trade-shows/international-conference-on-advances-in-materials-technology-for-fossil-power-plants

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