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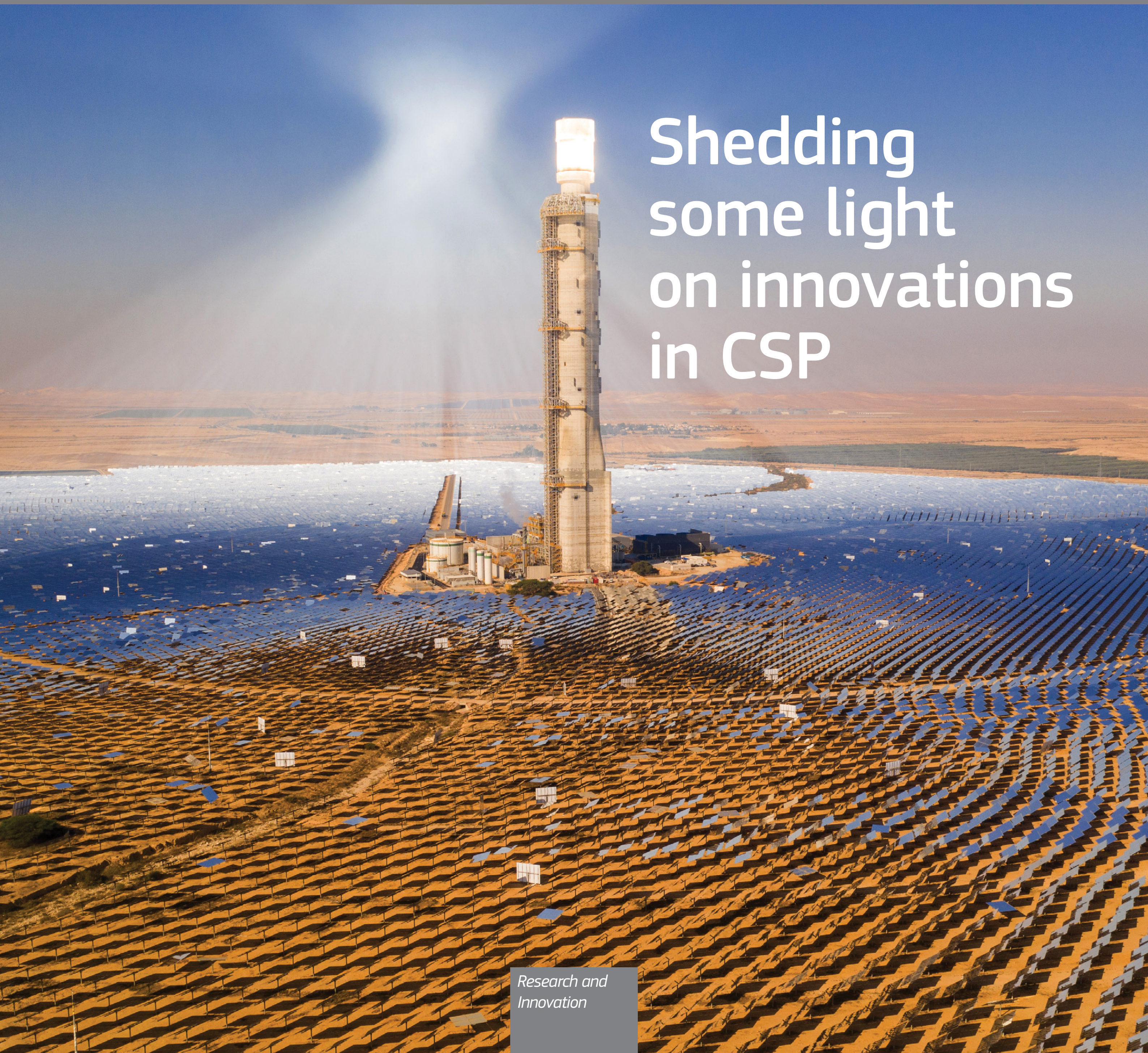
European Commission

CORDIS Results Pack on

solar heat for power and industry

A thematic collection of innovative EU-funded research results

September 2020



Shedding some light on innovations in CSP

Research and Innovation

Contents

Editorial

The sun could be the world's largest source of electricity by 2050, ahead of fossil fuels, wind, hydro and nuclear. Specifically, solar thermal electricity from concentrated solar power (CSP) systems could provide over 10 % of the world's electricity by mid-century and prevent the emission of billions of tonnes of CO_2 per year. This CORDIS Results Pack showcases some of the cutting-edge projects in research and innovation that boost development of CSP and encourage uptake of solar thermal energy.

Concentrated solar technology systems use mirrors or lenses with tracking systems to focus a large area of sunlight onto a small area. In theory, it is a very simple idea and certainly not a new one. Legend has it that Archimedes had set fire to Roman vessels attacking his home city with a giant mirror focusing the sun's rays. Concentrating technologies exist in four optical types, namely parabolic trough, dish, linear Fresnel reflector and solar power tower.

Solar thermal power plants generate electricity indirectly: the concentrated light is used to heat a fluid. The steam produced from the heated fluid powers a generator that produces electricity. The solar concentrators used in CSP systems can also be used to provide industrial process heating or cooling. Often, excess thermal energy (heat) can be stored in tanks or materials and used to generate electricity on demand.

European Union support for CSP

Horizon 2020, the EU's funding programme for research and innovation in the period 2014-2020, has allocated almost EUR 6 billion to non-nuclear energy research through its societal challenge "Secure, Clean, Efficient Energy". More specifically, the energy challenge supports the transition to a reliable, sustainable and competitive energy system.

The projects in this Results Pack have successfully risen to meet this energy challenge, focusing on technologies that help reduce costs and increase performance of solar thermal plants. Their objectives are in line with the European Strategic Energy Technology Plan (SET Plan), specifically the Implementation Plan for CSP, which aims to maintain (or regain in some cases) the EU's global leadership on low-carbon technologies.

Nine shining research and innovation projects

This CORDIS Pack covers a mix of research demonstration and market uptake actions aimed at fostering CSP development in Europe for electricity generation and industrial process heating or cooling. All of them are supported by the European Union's framework programme Horizon 2020.

CAPTure focused on a high-efficiency power plant concept that combines several towers, heliostats and, importantly, combined gas and steam turbine cycles. This new configuration maximises overall efficiency, reliability and dispatchable operation of CSP plants. Another action, HyCool, demonstrated a cost-efficient and easy-to-install linear Fresnel system that can be adapted to supply industry's cooling and heating needs.

Then we have MOSAIC, which used fixed spherical concentrators that eliminate the need for tracking systems to focus light. Unlike their mobile counterparts, they reflect the sun's light onto a solar receiver, without ever moving. MUSTEC proposed concrete solutions to overcome the market barriers that hinder the deployment of CSP cooperation projects.

Meanwhile, NEXT-CSP used fluidised crystal particles as a heat transfer and storage medium, which are an alternative to molten salts. In a similar vein, PEGASUS demonstrated an innovative concept combining sulfur and a new rotating cylindrical receiver that can store more solar energy for longer periods of time.

ORC-PLUS demonstrated an innovative thermal energy storage system optimised for midsized CSP plants. SOLPART developed a technology that could provide heat for a wide variety of industrial processes, including the processing of lime and other non-metallic minerals. Finally, WASCOP proposed a holistic solution helping reduce water use and facilitate water management in CSP plants.

Novel components to economically generate and store high-temperature solar heat

A key advantage of concentrated solar power (CSP), a technology that generates solar power by using mirrors to concentrate a large area of sunlight onto a receiver, is the very cost-effective way it stores thermal energy. Although it's a promising means of providing renewable electricity on demand, the conversion efficiency of today's commercial plants is quite low and the cost of generating electricity isn't competitive enough yet.

© CAPTure

The EU-funded CAPTure project set out to significantly boost the competitiveness of CSP by focusing on an innovative high-efficiency power plant concept, and on smart calibration and mass production of the mirrors that reflect sunlight onto a small receiver area, which in turn generates high-temperature heat. "Both ways may significantly reduce the levelised cost of electricity (LCOE)," notes coordinator Fritz Zaversky.

The solar power plant can produce significantly more electricity per mirror area compared to conventional approaches. Additionally, simplified mirror operation – less operation and maintenance costs – and mass production of the reflecting mirrors lead to significant cost reductions. "Thus, higher conversion efficiency – higher energy output – and less investment and operation and maintenance costs will result in a lower LCOE and make CSP more competitive," Zaversky explains.

Cost-efficient generation and storage of high-temperature solar heat

Project partners developed 3 key components to achieve higher conversion efficiency: a solar receiver, a regenerative heat exchanger and a solar field (mirrors and trackers). The mirrors concentrate the sun onto the solar receiver that heats atmospheric air to high temperatures (1 000 °C). Heat is exchanged between the pressurised air flow and the atmospheric air flow from the solar receiver by the regenerative heat exchange system. A hot air turbine then converts heat into electric energy.

"CAPTure's most significant achievement was the successful design, production and commissioning of a 300-kWth prototype installed at a solar research facility in southern Spain," says Zaversky. It contains all three components, as well as pipes and valves. In addition, the CAPTure team designed a downsized, sun-tracking mirror or heliostat that has been optimised for cost-effective mass production.

CAPTure's most significant achievement was the successful design, production and commissioning of a 300-kWth prototype installed at a solar research facility in southern Spain.

Individual components show great promise

Team members successfully validated all key components and the plant configuration concept in real-life settings. They demonstrated that the concept is technically feasible. A techno-economic optimisation and benchmarking analysis presented the power plant concept's potential. Results show that the air receiver technology is a very promising solution for an efficient, combined-cycle solar-thermal power plant. About 30 % of peak solar-to-electric energy conversion efficiency can be achieved, which is a significant improvement on the state-of-the-art technology of around 21 %.

At this point in time, the proposed power plant layout is not profitable for large-scale, high-capacity deployment; however, it will be very beneficial for a range of uses. "The components are highly valuable for several applications," concludes Zaversky. In particular, the solar receiver and regenerative system can be used for high-efficiency solar-heat integration in several processes. The regenerative system can work as a means of high-temperature thermal-energy storage, cost-effective heat exchanger between atmospheric and pressurised air circuits. It can also be used as a chemical reactor for either thermochemical energy storage with high-energy density or other types of high-temperature reactors.

PROJECT
CAPTure – Competitive SolAr Power Towers

COORDINATED BY
National Renewable Energy Centre, Spain

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/640905

PROJECT WEBSITE
capture-solar-energy.eu

Solar power plants to benefit from solar energy at night thanks to storage technology

Thermal energy storage (TES) systems can boost the conversion of solar heat into electricity. They allow the efficient storage of heat during the day so that electricity production continues at night.

© ORC-PLUS

Currently, the expansion of small and mid-sized CSP plants is limited because of the shortage of tailor-made TES systems. TES plays a key role in making CSP systems more competitive than their photovoltaic equivalents. It allows adjustment of the plant design and/or operation to different potential strategies. For example, to match consumer demand in isolated energy systems, or to maximise the electricity production for plants connected to the power distribution grid that can export electricity, thereby boosting revenues.

The EU-funded ORC-PLUS project addressed this challenge by exploring the suitability of employing organic Rankine cycle (ORC) systems as heat engines to produce electric energy in small CSP plants. In these applications, the ORC uses thermal energy harvested from the sun to evaporate its high molecular mass working fluid and generate electricity, thanks to the expansion of the vapour in a turbine coupled to a generator.

"These systems are a good technological option because they're highly reliable and can be implemented in remote locations, but an important technical limitation is their need for a constant heat supply," says project coordinator Walter Gaggioli. "TES helps to overcome this shortcoming."

24/7, on-demand electricity

After testing two different TES options and three prototypes, the ORC-PLUS team developed an innovative TES system optimised for mid-sized CSP plants. The system extends the power production of an existing solar thermal power plant in Morocco comprised of linear Fresnel collectors and a 1 MWe ORC power unit.

The TES system boosts energy production by up to 4 hours during evening hours (18:00-22:00) for the plant located in Ben Guerir's Green Energy Park, enabling it to cover the power peak loads of the local medium-voltage grid.

Improved power production offers many benefits

There's huge potential for small- and medium-scale CSP plants to substitute expensive electro-diesel groups in rural on- and off-grid applications, hence reducing greenhouse gas emissions.

ORC-PLUS contributes to tackling several climate and energy challenges. "There's huge potential for small- and medium-scale CSPs (1-10 MWe) to substitute expensive electro-diesel systems in rural on- and off-grid applications, hence reducing greenhouse gas emissions," explains Gaggioli. "The dispatchable nature of the energy produced by ORC-PLUS is complementary to the less dispatchable energy produced by other renewable energy systems like photovoltaics and wind."

Dispatchable refers to the production of electricity on demand. "This makes the system a potentially strategic technology for complementing other renewables and targeting a high overall percentage of renewables in the global energy supply," Gaggioli says.

The ORC-PLUS plant will be commissioned in late-2020, creating jobs and revitalising local industries along the way. The technical solution developed improves the annual average efficiency of solar heat-to-electricity transformation by up to 20 %. Overall, the project reduced the payback time by 30 %, down to 8 years, thus improving market penetration potential.

The lower investment required for small- and medium-scale CSP plants is expected to raise considerable interest from market investors. ORC-PLUS improved the manufacturing of solar Fresnel collectors, reducing the investment cost for future solar power plants by about 20 %. "The developed engineering pre-packaged solutions tailored to these CSP plants can be widely replicated across Europe and Africa," Gaggioli concludes.

PROJECT
ORC-PLUS - Organic Rankine Cycle - Prototype Link to Unit Storage

COORDINATED BY
National Agency for New Technologies, Energy and Sustainable Economic Development, Italy

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/657690

PROJECT WEBSITE
orc-plus.eu/

Water management tech for more financially and environmentally sustainable solar power plants

Concentrated solar power (CSP) is one of the most promising and sustainable renewable energy technologies because of its ability to include storage to capture heat from the sun and convert it into electricity, on demand. However, successful mass adoption will ultimately depend on CSP plants overcoming major obstacles like economic viability and limited water access.

To function properly, steam-based power plants like CSP plants consume significant amounts of water. Such plants use up to 3 000 m3/GWh in areas where water is scarce. The majority of plants consume enough water to empty one Olympic-sized swimming pool per day. What's more, sunny areas where CSP performs best are usually arid. Saving water is thus a key issue in ensuring CSP remains financially competitive and runs sustainably.

To reduce water use in CSP plants, the EU-funded WASCOP project team developed a more flexible and adaptive integrated solution. Its toolbox is composed of different innovative technologies and optimised strategies that cool power blocks and clean solar field optical surfaces. "This holistic solution provides an effective combination of technologies adaptable to any solar field, power block cooling configuration and CSP plant location," says Delphine Bourdon, project coordinator." The innovation supports a reduction in water consumption in the range of 70-90 % and a significant improvement in the water management of CSP plants."

Optimising cooling and cleaning methods in CSP plant processes

Project partners modelled the toolbox components for cooling and cleaning operations. With respect to cooling, they studied technologies like delayed heat exhaust through different kinds of heat storage methods, a hybridised wet/dry cooler and an innovative versatile cooler. They designed and tested functional prototypes for each, and then fitted them with numerical models. This was done to predict the water and energy saved from each technology with the associated economic parameters for any kind of plant location and configuration. "The water traditionally consumed by power block cooling operations is cut by 90 %, and the performance of dry-cooled plants in high temperature operating conditions is increased," explains Bourdon.

For cleaning, different types of lab prototypes for soiling sensors show promising results by achieving correspondingly accurate


© CIEMAT

soiling information levels. This data, together with the preparation of the developed soiling and dew model, will help plant owners to save water and schedule the cleaning cycle operations in a more convenient way. In addition, dust prevention technologies that comprise both dust barriers for the solar fields and anti-soiling coatings for absorber glasses and reflectors also show significant effects after being validated in outdoor operational conditions. "Water cleaning operations for CSP plants that integrate these technologies are expected to be half as frequent than those without," says Bourdon.

WASCOP has enabled end users to take a more global view of current water usage in CSP plants and the potential of CSP technologies and their applications.

Huge water savings, better energy production

The WASCOP team successfully tested and validated the toolbox in real conditions at three testing sites in France, Spain and Morocco. Team members assessed the technical, economic and environmental impacts on CSP plants for all the developed technological solutions. Plant operators, plant owners and service providers have already shown interest in the technologies.

"WASCOP has enabled end users to take a more global view of current water usage in CSP plants and the potential of CSP technologies and their applications," concludes Bourdon. "It has identified different routes for overall improvement in terms of water consumption and commercial potential. Results will also support the development of renewable CSP energy in areas where competition for water access with local populations is becoming more notable."

PROJECT
WASCOP - Water Saving for Solar Concentrated Power

COORDINATED BY
Alternative Energies and Atomic Energy Commission, France

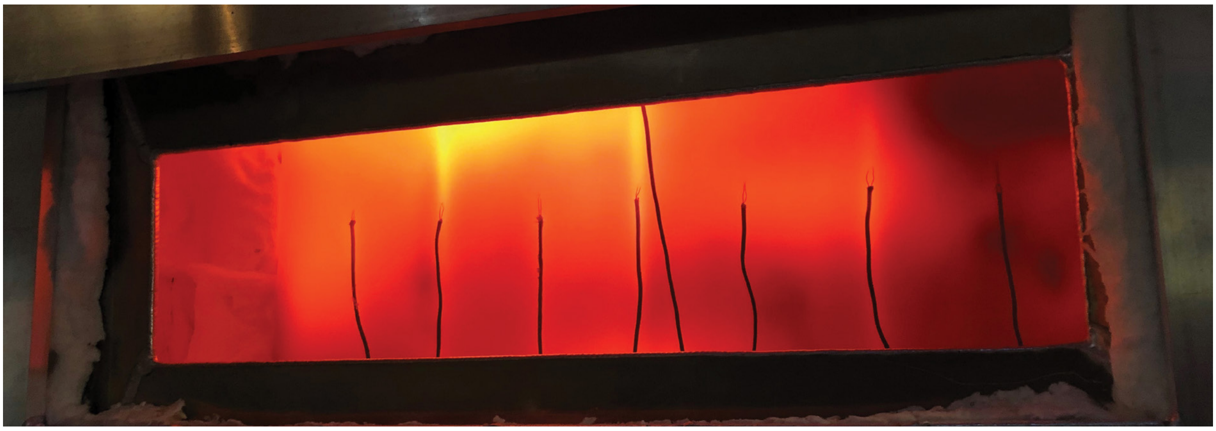
FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/654479

PROJECT WEBSITE
wascop.eu/

The next solar revolution could power cement production with sunlight

EU-funded researchers showcased innovative solar thermal technology that could almost halve the carbon footprint of industrial heat generation. The technology focuses the sun's beams to achieve temperatures as high as 950 °C, which in theory are high enough to provide the heat needed to process lime and other non-metallic minerals.



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The industrial processes underpinning modern civilisation are complex and diverse. But they share one key input: they require great amounts of heat, which takes staggering amounts of fuel to produce. Heat is critical to industrial operations, but it is also an overlooked and growing source of greenhouse gas emissions.

What if we could use heat from the sun instead?

The SOLPART project is a good example of how solar thermal energy opens up new applications outside the technology's core area of electricity generation or water heating. Solar thermal energy can also provide carbon-free heat for a wide variety of industrial processes.

Researchers successfully designed two different solar reactors each operating at 750-950 °C for processing several industrially useful raw materials such as limestone, phosphate and cement raw meal. These solar reactors were a rotary kiln and a fluidised bed (something like a meat grinder for rocks). SOLPART also commissioned a pilot-scale reactor with power of between 40 kW and 60 kW able to treat 20 kg/h calcium carbonate ($CaCO_3$). The decomposition on heating to high temperatures (calcination) of $CaCO_3$ into lime (CaO) and CO_2 is the first step towards cement production.

The quality of the solar lime produced by $CaCO_3$ calcination at pilot scale matched industrial quality standards. Furthermore, for the first time, researchers demonstrated the successful calcination of Moroccan phosphate at pilot scale using a fluidised bed reactor, with conversion rates exceeding 99 %.

Solar heat could replace fossil fuels in cement and lime production

"SOLPART uses solar energy as a substitute for energy from fossil fuels in processing industrial materials. Heat supply accounts for 40 % of CO_2 emissions released by $CaCO_3$ calcination, which can be fully avoided by substituting fossil fuels by solar heat," says project coordinator Gilles Flamant.

The concept behind solar thermal technology is deceptively simple. Sunlight is captured and focused through mirrors into a thermal receiver. Project researchers skipped the electricity-producing step that involves heating a fluid. Instead, they used solar heat to power a rotary kiln reactor and a fluidised bed directly (or indirectly, using an absorbing wall).

SOLPART uses solar energy as a substitute for energy from fossil fuels in processing industrial materials.

Conventional cement production involves heating a mixture of limestone ($CaCO_3$) and other ingredients to temperatures up to 1 500 °C using vast amounts of carbonaceous fuels. "Such high temperatures may not be easy to achieve for now using solar thermal energy (concentrated solar power). But the first step in the cement-making process (the decomposition of $CaCO_3$) requires lower temperatures of around 900 °C. And it is in this stage that most CO_2 emissions occur," explains Flamant.

For now, SOLPART's pilot system remains an impressive experimental validation of a futuristic concept. Powering cement production with sunlight requires some kind of energy storage so that it does not rely on sunshine availability. It would also require heating much more limestone, scaling it up from a few kilograms piloted in this project to several thousand per day.

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

COORDINATED BY
National Centre for Scientific Research (CNRS), France

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/654663

PROJECT WEBSITE
solpart-project.eu/

Sulfur poised to transform the future of solar energy storage

While molten salts currently hog the spotlight for storing heat from concentrated sunlight, a new solar tower demonstrator combining bauxite particles with sulfur is showing strong potential. The new technology could hold more solar energy for longer periods of time and expel it on demand.

Thermal storage of surplus solar energy is an inherent feature of concentrated solar power plants. It not only provides for reliable base-load energy generation but can also meet the challenge of on-demand electricity from renewable energy sources. Heat can be stored at extremely high temperatures using a liquid or solid storage medium.

Finding cheaper and more efficient solutions that harvest more sunlight and store thermal energy for a long time is at the core of the EU-funded PEGASUS project. To reach their objectives, project partners have tapped into the potential of sulfur for thermochemically storing solar energy and generating carbon-free round-the-clock electricity. This concept was combined with an innovative centrifugal receiver that can heat bauxite particles to 900 °C by concentrated solar energy. The technology was tested at the Jülich Solar Power Tower of the German Aerospace Center.

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Sulfur storage cycle: no energy gets lost

The key concept behind storing solar energy in sulfur relies on sulfur combustion. The innovative process developed by the project team involves a number of steps.

The sunlight focused on the solar power tower is harvested in a centrifugal particle receiver which supplies the high-temperature heat to split sulfuric acid (H_2SO_4) into water, sulfur dioxide (SO_2) and oxygen. In a second step, SO_2 is transformed into elemental sulfur and H_2SO_4 in an innovative disproportionation reactor. Then, when energy is needed, sulfur is combusted to produce high-temperature heat and SO_2. "Sulfur combustion can produce high-quality heat at temperatures in excess of 1 200 °C, suitable for electricity generation using a gas turbine. Compared to other heat storage mechanisms, the stored energy (heat) can be retrieved at a temperature higher than that of the original heat input (900 °C), thereby allowing the use of more efficient power generation schemes," explains project coordinator Dennis Thomey.

During this cycle, the sulfur is collected to form a pile and the H_2SO_4 is stored in suitable tanks. When the sun is shining, the sulfur pile grows while the H_2SO_4 tank is emptied. During the night or when it is cloudy, the sulfur pile shrinks while the H_2SO_4 tank is filled. Renewable power is generated at constant production rates while H_2SO_4 and sulfur are used as energy carriers and recycled with virtually no energy losses.

Sulfur's promising potential

The elemental sulfur cycle can store and supply heat at a higher temperature than is possible with molten salts – the conventional thermal storage medium used in solar power towers. Moreover, in comparison to classical thermal storage systems that inevitably lose sensible heat to the environment over time, solar energy can be long-term stored in solid sulfur and released at will.

The sulfur cycle can permanently store solar energy with virtually no energy losses.

"The sulfur cycle not only can permanently store solar energy with virtually no energy losses but, being one of the lightest solid elements and extremely energy rich, it has 30 times higher energy density compared to molten salts. The long-term storage of solar energy is an important prerequisite to completely replacing fossil power plants with renewable energy sources," concludes Thomey.

PROJECT
Renewable Power Generation by Solar Particle Receiver Driven Sulphur Storage Cycle

COORDINATED BY
German Aerospace Center (DLR), Germany

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/727540

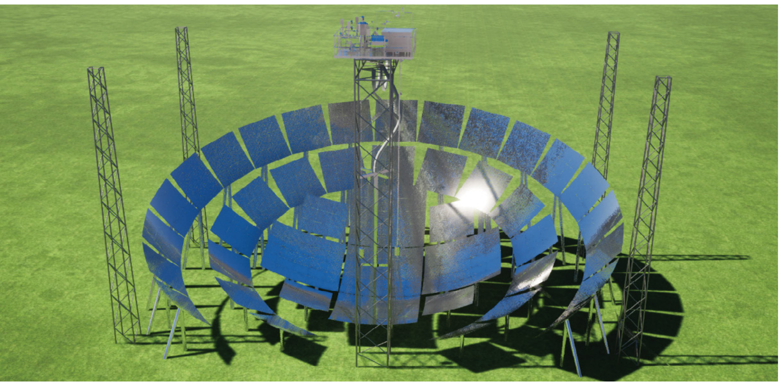
PROJECT WEBSITE
pegasus-project.eu/

A mosaic of shiny hollow spheres works its magic on sunlight

Concentrated solar power (CSP) plants rely on complex and expensive tracking systems to follow the sun and maximise conversion efficiency. Lots of little spherical 'solar bowls' that reflect the sun's light perfectly without ever moving could do wonders for CSP cost and efficiency.

CSP relies on mirrors or reflectors to concentrate the sun's energy and focus it on some type of solar receiver. To date, all have mobile concentrators that track the sun and reflect the concentrated light onto a stationary receiver. The solar 'field' or concentrators and their sophisticated tracking systems do not come cheap.

The EU-funded MOSAIC project exploited fixed spherical concentrators, or solar bowls, that eliminate the need for tracking thanks to their unique optics. MOSAIC implemented lots of them in an innovative modular design for significant cost savings with numerous technical and practical advantages.



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The shape of things to come

There are several different types of CSP plant designs that vary based on the shape of the reflectors and that of the receivers, and subsequently whether light is focused onto a line or a point. A parabolic trough collector concentrates the sun's energy on a receiver or absorber tube traversing the focal line of the trough. A solar power tower is now one of the fastest-growing solar technologies, using hundreds or thousands of small reflectors called heliostats to concentrate the sun's rays onto a central receiver placed atop a fixed tower. Linear Fresnel systems are a nascent technology, like the parabolic trough, but using many small mirrors rather than one large one.

MOSAIC uses small semi-Fresnel spherical concentrators in an innovative modular configuration. Each module consists of a fixed spherical mirror concentrator and a moving receiver driven by a low-cost cable tracking system.

Spherical concentrators reflect the sun's rays along a line pointing to the sun through the centre of the sphere at any time of day without moving. Despite their well-established cost-reduction potential, they have not received much attention. Project coordinator Cristobal Villasante of Tekniker explains: "MOSAIC uses small semi-Fresnel spherical concentrators in an innovative modular configuration. Each module consists of a fixed spherical mirror concentrator and a moving receiver driven by a low-cost cable tracking system.

This radical change in CSP plant operation is similar in concept to the Arecibo Observatory's huge radio telescope, the site of the most powerful broadcast ever deliberately beamed into space in the search for extraterrestrial intelligence. Energy from the sun is collected, concentrated and transferred to the heat transfer fluid by each module. The modules deliver their thermal load to the storage system that then supplies a single high-capacity (> 1 GW) power block where electricity is generated centrally."

The sky is the limit

The shorter distances between solar concentrator and receiver relative to typical solar tower technologies maximise energy collection efficiency, minimise atmospheric attenuation and decrease the required precision of tracking technologies. High concentration ratios and high working temperatures result in high cycle efficiencies. Fewer moving parts decrease the solar field costs. All these benefits decrease the capital cost while ensuring efficiency and reliability, significantly lowering the final cost of electricity production. Thanks to modularity, the total power of the plant is theoretically unlimited and could range from kilowatts to more than 1 GW.

MOSAIC is now entering the commissioning phase. According to Fabrizio Perrotta, the project's dissemination leader, "We are targeting plant operators and industrial stakeholders in more than 25 countries. Initially intended for electricity production, MOSAIC can also be advantageously used for emission-free industrial heat production. We are currently identifying applications." So, expect soon to see shiny mosaics of tiny spherical concentrators decorating landscapes and contributing to cleaner energy for an increasingly green world!

PROJECT
MOSAIC – MOdular high concentration SolAr Configuration

COORDINATED BY
Tekniker Research and Technology Center, Spain

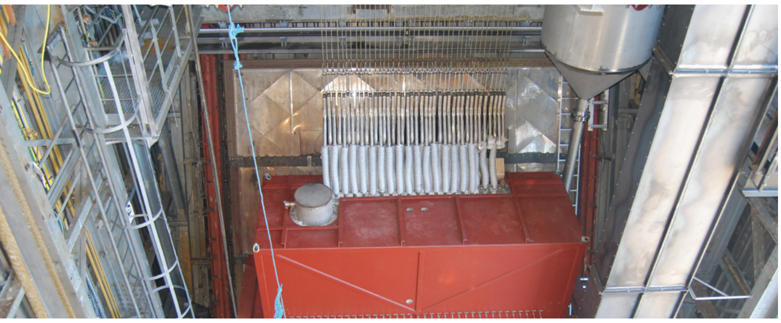
FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/727402

PROJECT WEBSITE
mosaic-h2020.eu/

Fluidised particles turn up the heat in a novel solar power design

Clean solar energy with storage can help Europe reduce emissions and deliver a secure and cost-effective electricity supply. EU-funded research suggests that fluidised crystal particles trump molten salts as the heat transfer and storage medium.



© Gilles Flamant

Current state-of-the-art concentrated solar power (CSP) plants use central receivers with several options for heat transfer fluids (HTFs) and storage mediums. Usually, these materials and processes are considered separately, each with their specific restraints. Occasionally, molten salts have been used as both the HTF and the thermal energy storage medium. The chemical stability of the salts puts an upper limit on the working temperature of 565 °C, limiting the efficiency of heat-to-electricity conversion to about 42 %. The NEXT-CSP project is using fluidised refractory particles (resistant to heat decomposition) as both the HTF and storage medium. They boost the operating temperature up to 750 °C and should significantly increase CSP plant efficiency.

Towering above the rest

NEXT-CSP chose olivine (the source of peridot), a natural silicate of magnesium and one of the most common minerals on earth, to make the particles for the HTF. Making good use of the particles required significant innovation on the technical side as well, including developing suitable solar receiver technology and a new heat exchanger composed of 1 300 tubes in which the compressed air from the gas turbine compressor flows, and an advanced combined cycle.

The technology is integrated in a tower CSP system consisting of the solar receiver, the hot store, the heat exchanger, the gas turbine and the cold store. Project coordinator Gilles Flamant of the French National Centre for Scientific Research (CNRS), explains: “High atop the tower, the HTF in the cold store is heated by sunlight reflected onto the newly designed multi-tube receiver. It goes to the hot tank, where it can be stored until you want to use it. At that point, it goes through the heat exchanger, where heat is transferred from the particles to the compressed air to power the turbine.” Overcoming challenges related to space and weight limitations at the top of the tower, all the components were installed and validated at the top of the THEMIS 5-MW solar power tower in France.

We expect the nominal plant efficiency of the fluidised-particle solar power plant to be about 20 % greater than current state-of-the-art molten salt towers. The design should also decrease electricity costs by about 25 % and significantly reduce the cost of the storage medium.

Adding towers, increasing power in the planned commercial plant

For the commercial-scale power plant (150 MW), scientists have adopted a multi-tower concept aiming to boost the overall cycle efficiency of typical solar power plants from 42 % to 48.8 %. It can be operated as a solar ‘peaker’ plant as well, storing the heat absorbed during the day to be delivered during the evening hours of peak electricity demand, when the electricity cost is also the highest.

Flamant concludes: "Under these conditions, we expect the nominal plant efficiency of the fluidised-particle solar power plant to be about 20 % greater than current state-of-the-art molten salt towers. The design should also decrease electricity costs by about 25 % and significantly reduce the cost of the storage medium. We have successfully demonstrated that solid particles can be an important and cost-effective alternative to liquids for collection and storage of solar energy in solar thermal power plants."

NEXT-CSP's innovative technology has been awarded a global patent. Commercialisation should begin within the decade, bringing clean and secure solar electricity to consumers, greener thermal energy storage for the environment than electrochemical batteries, and a competitive edge to the CSP industry.

PROJECT
NEXT-CSP - High Temparature concentrated solar thermal power plan with particle receiver and direct thermal storage

COORDINATED BY
National Centre for Scientific Research (CNRS), France

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/727762

PROJECT WEBSITE
next-csp.eu/

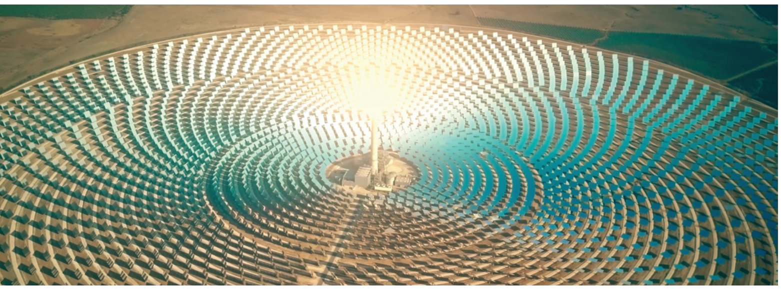
Energy potential of concentrated solar power for Europe

In light of the EU 2030 climate & energy framework, MUSTEC (Market uptake of solar thermal electricity through cooperation) aims to explore and propose concrete solutions to overcome the barriers that hinder the deployment of concentrated solar power (CSP) cooperation projects.

CSP has a high potential in supplying renewable electricity on demand not only to the southern, but also to central and northern European countries. As Yolanda Lechón of the Spanish Research Centre for Energy, Environment and Technology (CIEMAT) and MUSTEC project coordinator says: "Our key objective is to identify and overcome the barriers that limit CSP's expansion in Europe. At the same time, we are exploring potential drivers that can boost cooperation, as intra-European CSP trade can play an important role for the decarbonisation, stabilisation and integration of the European power system."

CSP competitive in the decarbonised energy market

To gauge the factors that affect the competitiveness of CSP in the European electricity market, MUSTEC researchers looked at the market environment and the future development of techno-economic parameters of CSP projects. In particular, this covered carbon pricing and to what extent the levelised cost of energy (LCOE) of CSP can be reduced in the future.



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"Based on LCOE, CSP technologies can be competitive by providing an alternative option compared to other decarbonised generation technologies (PV or wind onshore plants), especially if we take into account its high storage potential. The technology may provide over 4 hours of storage," Lechón points out.

Besides targeted R&D efforts, a major lever to lower the LCOE of CSP is to decrease investment costs. MUSTEC is aware that there is a need for financing packages for CSP projects as well as an investment framework that lowers the associated risks.

"The main competitive advantage of CSP is the dispatchability of the generated electricity," emphasises Lechón. Flexibility is the keyword here and MUSTEC has worked towards appropriate pricing and ambitious energy and climate policies that reflect the value of CSP manageability.

MUSTEC strategy reflects on success in Spain

Spanish project partners have advised the government by providing scientific support for CSP expansion policies in Spain. Specifically, CIEMAT has provided advice on construction of the energy planning tool TIMES-SINERGIA used in the elaboration of the National Energy and Climate Plans (NECPs) and the inclusion of CSP technology. Moreover, MUSTEC partner CSIC was required by the government to advise on the design of renewable electricity auctions, including specific considerations for dispatchable sources, such as CSP.

Significantly, geopolitical and security considerations have been brought to the fore by MUSTEC partner RIE ELCANO. These include the role of oil and gas in Spanish national strategies through in-depth exchanges with policymakers. Close contacts with the Spanish Ministry for Ecological Transition from the European Solar Thermal Electricity Association, ESTELA member Protermosolar have reinforced the interest in the technology. Regarding technological advances, Spanish partner COBRA is also coordinating some EU research initiatives such as HYSOL to develop suitable CSP hybrid configurations.

Consequently, the Spanish government has included CSP technology in its NECP. There will be an additional 5 GW of CSP in 2030, up from 2.3 GW in 2020, along with support mechanisms that could consider the system value of the technology.

Implications of the changing geopolitical and economic landscape in the wake of COVID-19

Besides being fully consistent with the spirit of the objectives of the European Green Deal, supporting CSP cooperation mechanisms will have the beneficial redistributive effects of promoting high-value-added and sustainable economic activity in southern Member States (MS).

Our key objectives are to identify and overcome the barriers holding CSP back and limiting its expansion in Europe.

"The coronavirus crisis has changed the EU's internal geopolitical landscape, and energy is no exception," Lechon points out. Increasing the integration of CSP and renewables' exchange and cooperation mechanisms will have substantial geopolitical and economic benefits for Europe that are particularly valuable in the current crisis.

Ramping up energy security and facilitating the integration of renewable energies for example, will provide opportunities for southern EU MS that have so far suffered most in the recent recession. These countries have the solar resources and the technological, industrial and engineering background to profit from the construction and exploitation of CSP generation and storage facilities.

Lechón concludes: "The MUSTEC project proposes the mainstreaming and fast-tracking of CSP cooperation mechanisms as a consistent internal EU geopolitical response to the COVID-19 crisis."

PROJECT
MUSTEC – Market uptake of Solar Thermal Electricity through Cooperation

COORDINATED BY
Research Centre for Energy, Environment and Technology (CIEMAT), Spain

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/764626

PROJECT WEBSITE
mustec.eu/

Super-cool temperature for industrial processes with solar heat

EU-funded project HyCool is advancing the use of solar heat in industrial processes. Flexible and efficient, the technology developed can be adapted to supply industry's both cooling and heating needs.

Concentrated solar power CSP systems literally concentrate sunlight onto a receiver where the power collected from the sun is converted into heat. Among all the CSP technologies, HyCool is developing its concept based on the cheap and easy-to-install linear Fresnel system. Consisting of a large number of simple mirrors in parallel rows, these mimic a large Fresnel lens to maximise energy collection.

A hybrid – the pump with synergy

The prime mission of the HyCool project is to increase the use of solar heat in industrial processes. "We have developed a new Fresnel CSP solar thermal collectors (FCSP) system with specially tailored hybrid heat pumps (HHPs)," says Silvia Jané, HyCool's project coordinator.

"The 'two-in-one' combination of adsorption- and compressor-based heat pumps results in a wider output temperature range, enabling both industrial heating and cooling powered by the sun," Jané explains. By increasing flexibility, the objective is to extend the range of application of solar heat in industrial processes with temperatures ranging from 5 °C to 240 °C.

"Incorporating a wide range of design and operational configurations, we have increased the number of use scenarios for solar heat in industrial environments," Jané emphasises. The proposed system improves the adsorption technologies for cold generation – coupled with increased compactness and plug and play features. This also provides seamless integration with other conventional sources such as electrical energy, resulting in a higher deployability of solar heat in industrial processes (SHIP).

Moreover, when the HHPs developed in HyCool are driven by solar or waste heat and embedded in real industrial thermal processes, they can achieve twice the coefficient of performance of conventional heat pumps and further improve the overall process efficiency.

Component optimisation and final design of the full-scale modular solar HHP and its manufacture and commissioning have been completed. A characterisation protocol for the properties of different adsorber materials such as thermal diffusivity, heat capacity, adsorption behaviour, vapour transport properties and heat of adsorption at different temperatures and pressures has also been developed and will lead to an extensive material testing campaign to select the best candidate for real case applications.

Energy winners in industry and food sectors

"The biggest challenge facing the HyCool project was to obtain a valid configuration for the two pilots based on the first design of the modular heat pump and the hydraulic schematic as well as the specifications for each demonstration site," Jané comments. This key step has now been achieved, and fieldwork has enabled a full display of energy profiles.

At the Spanish production site of consortium partner Givaudan, a flavours and fragrances company, the HyCool concept has been applied to several processes with either heating or cooling needs. Givaudan's current cold installation makes use of a glycolic water chiller to keep the water entering the liquid ring of the vacuum pumps at 7 °C, with a thermal demand of 125.5kW. "For the use cases considered, the electrical consumption of the compression chiller will be reduced by 29 % (spring) and 44 % (summer), respectively, by using HyCool technology," says Jané This efficiency gain is even higher if compared to common refrigeration systems.

For the use cases considered, the electrical consumption of the compression chiller will be reduced by 29 % (spring) and 44 % (summer), respectively, by using HyCool technology.

Another prototype applies the HyCool concept to specialised small food industries with cooling needs in their processes and will be tested at Bo de Debò SL in Spain. Here, the industrial cold installation is necessary for the preparation of pre-cooked fresh dishes and is used in different configurations: the food production area at 6-8 °C, whereas the delivery area is to be maintained at 10-12 °C.

HyCool is poised to make a big difference in solar heat use in European industry, and so will the EU-funded SHIP2FAIR project, essentially HyCool's 'twin' project that is due to finish in March 2022. Their developments focus in particular on the heating needs of the food and agro industry and are being demonstrated and validated in a variety of processes including spirits distillation (Martini & Rossi), meat transformation (Larnaudie), sugar boiling (RAR group) and wine fermentation and stabilisation (RODA). The objective is to supply 40 % of the heat demand through solar power.

PROJECT
HyCool – Industrial Cooling through Hybrid system based on Solar Heat

COORDINATED BY
Veolia Serveis Catalunya Sociedad Anonima Unipersonal, Spain

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Editorial coordination
Georgios TASIOPOULOS, Silvia FEKETOVÁ

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Hydrogen's growing role in sustainable energy systems

Hydrogen is a real contender for being the world's next big solution to ensuring more sustainable energy and transport systems and in this edition of Research*eu, we meet seven EU-funded projects that are demonstrating how hydrogen's time to shine may finally have dawned.

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