EU SOLARIS

The European Research Infrastructure for Concentrated Solar Power

The EU-SOLARIS Project is co-funded
by the 7th Framework Programme
of the European Union

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CTAER - Advanced Technology Centre for Renewable Energies

"Because of its dispatchability and other numerous advantages, Concentrating Solar Thermal (CST) technologies are expected to play an increasing pivotal role in the necessary transition away from fossil fuels and towards renewable energies. A transition that must take place at an unprecedented rate and scale if we are to avoid environmental damages to our planet so catastrophic they have the potential to threaten our survival as a species.

The European Distributed Large Scale Research Infrastructure for CST technologies, EU-SOLARIS, is being created to support European researchers and industry in their efforts to develop the next generations of CST technologies. In so doing, EU-SOLARIS will play an essential role in consolidating Europe's lead on these strategic energy technologies".

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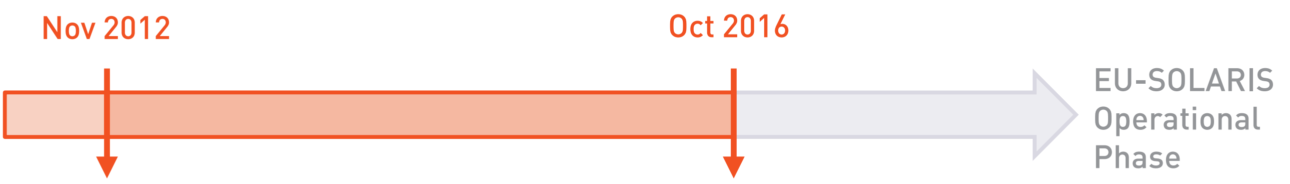
EU-SOLARIS Preparatory Phase Project

EU-SOLARIS Preparatory Phase is a project, co-funded by the 7th Framework Programme of the European Union that aims to carry out the preparatory work needed for the creation of a large distributed **Research Infrastructure** (RI) of European character and global reach. The main purpose of this distributed RI is to foster, contribute to, and promote the scientific and technological development of **Concentrating Solar Thermal** (CST) and solar chemistry technologies. EU-SOLARIS primary objective is to provide scientists and industry with the needed RIs capabilities for advancing the state of the art of these technologies and reinforcing Europe's leadership in this field. EU-SOLARIS aims to create a **new legal entity** to explore and implement new and improved rules and procedures for distributed RI for CST and solar chemistry technologies, in order to optimize RI development and Research and Development (R&D) coordination. This entity is expected to be the first of its kind, where industrial needs and private funding will play a significant role.

The EU-SOLARIS project is under the umbrella of the **ESFRI** (European Strategy Forum on Research Infrastructures). The ESFRI has been set up by the EU Council of Research Ministers in 2002 and it aims at supporting the development of a European policy for RI and discusses a long term vision at European level.



EU-SOLARIS Preparatory Phase

Duration

- 48 months, starting 1st November 2012
- Coordinated by CTAER

Budget

- Total: 6 M€
- European Commission contribution: 4,45 M€

Composition

15 partners from 9 countries:

- 13 key Scientific Centres
- The Spanish Ministry of Economy and Competitiveness
- The European Solar Thermal Electricity Industry Association (ESTELA)

Involved Key Actors

- Industry
- Key professionals
- Scientific communities
- Policy makers
- General public
- Students

EU-SOLARIS Vision

- Become a unique distributed RI for CST technologies
- Optimize RI development and R&D coordination in Europe by creating a new legal entity to explore and implement new and improved rules and procedures for RI for CST technologies
- Provide the most complete, high quality scientific infrastructure portfolio at international level
- Facilitate researchers' access to highly specialised RI through a single access point by linking scientific communities, industry and universities involved in the CST sector
- Ensure the alignment of the RI activities with the industry's needs
- Maintain Europe at the forefront of CST technologies development

Concentrating Solar Thermal technologies

CST technologies use mirrors or lenses to concentrate sunlight onto a small area receiver where sunlight is transformed into thermal energy. According to how sunlight is concentrated CST technologies are classified into line focusing and point focusing technologies. The main line focusing CST technologies are parabolic trough and linear Fresnel, whereas the main point focusing technologies are parabolic dish and central receiver.

Parabolic trough, PSA

Parabolic Trough

Parabolic trough technology consists of rows or loops of parabolic trough-shaped mirror reflectors that are used to collect the solar radiation and concentrate it onto a thermally efficient receiver tube placed in the trough's focal line. The fluid is heated up to approximately 400°C by the sun's concentrated rays and then pumped through a series of heat exchangers to produce electricity. This fluid can also be used to heat a storage system consisting of two tanks of molten salt.

Linear Fresnel, Cyl

Linear Fresnel

An array of nearly flat reflectors concentrates solar radiation onto elevated inverted linear receivers. The heat transfer fluid flows through the receivers and is converted into steam. This system is linear-concentrating, similar to a parabolic trough, with the advantages of low costs for structural support and reflectors, fixed fluid joints, a receiver separated from the reflector system, and long focal lengths which allows the use of flat mirrors. The technology is seen as a potentially lower-cost alternative to trough technology for the production of solar process heat and steam.

Parabolic Dish, PSA

Parabolic Dish

The parabolic dish concentrating solar mechanism is composed of the parabolic reflective surface (mirror), the metal structure, the tracking mechanism, the receiver and the thermal engine. The mirrors track the sun in two axes in order to concentrate the solar irradiation onto the receiver located at the focal point. The receiver converts the concentrated irradiation to useful heat. The produced heat from the parabolic dish can be used for electricity generation by driving an engine connected to an electrical power generator and for thermochemistry by driving a reactor.

Central receiver, CNRS

Central Receiver

An array of heliostats (large mirrors with sun-tracking motion) concentrates sunlight on to a central receiver mounted at the top of a tower. A heat transfer medium in this central receiver absorbs the highly concentrated radiation reflected by the heliostats and converts it into thermal energy (up to 1000ºC) that is used for electricity production.

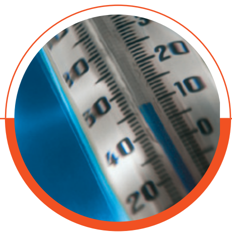
CST Applications

The main applications of the CST technologies are power generation, process heat, cooling, desalination and solar chemistry. Commercially, the most widely used application is power generation, known as Solar Thermal Electricity (STE) or Concentrated Solar Power (CSP).

Power Generation

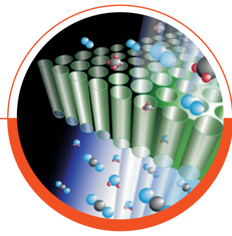
Process Heat

Cooling



Desalination

Solar Chemistry



Current environment and future potentialities of CST technologies

Nowadays, the vast majority of the commercial CST systems are used for power generation. Within the last ten years, STE has expanded rapidly from a non-mature technology to become a reliable, **power generation** solution. By the end of 2015, 4.9 GW of STE projects were operational worldwide. The projects under construction at the time of writing will add at least another 300 MW over the next two years. These projects are located mostly in South Africa, India, the Middle East and Morocco.

The cost per unit of generated power for commercial CST has been continuously declining as industry move through the learning curve and more plants are built and operated, but further substantial cost reductions are possible. The primary factor affecting the cost of CST technologies is market volume. Just as with any other energy technology, costs come down along a solid deployment programme based on a political decision to establish a technology. Such a political decision, leads to a positive investment climate with preferential financing conditions and/or tax and investment incentives. This is expected to also create the conditions for progressively bringing to market innovative solutions that will, in turn, further **reduce costs and increase business opportunities** beyond the electricity sector in countries that decide to launch such programmes.

A strong STE deployment programme, ensuring a STE market volume of around 30 GW per year, could avoid the need for new fossil fuel power plants and replace decommissioned fossil fuel power plants. In this way, STE technologies would strongly contribute to the reduction of global CO_2 emissions. The dispatchability capabilities of STE power plants would also enable a further reduction in emissions by allowing increased penetration of intermittent renewable energy technologies in a reliable and affordable way. Once consolidated, the STE market will facilitate the establishment of a larger CST market, in which CST technologies will provide solutions beyond power generation.

In this framework, CST technologies are suitable for industrial **process heat** applications, by suppling thermal energy from low-medium to high temperature ranges, such as steam supply and drying. Potential applications can be found in several sectors: chemicals, food and beverages, pulp and paper, etc. Currently, process heat represents more than two-thirds of industry energy consumption and more than 80% of this energy consumption is being covered by fossil fuels. The deployment of Solar Heat for Industrial Processes (SHIP) systems could respond to a third of such needs, representing a significant potential market for CST technologies.

For **solar chemistry** technologies, existing options are numerous, such as the implementation of the available solar fuels technologies in CST facilities - which has still key-challenges to overcome - and the further development of thermochemical processes that are based on non-carbonaceous sources.

Finally, CST technologies present great potential for **solar cooling** and **desalination** applications, especially in Mediterranean countries.

EU-SOLARIS Preparatory Phase outcomes

At the preparatory phase of EU-SOLARIS a series of main cornerstones have been accomplished. Among these are the identification of the potential technical services portfolio of EU-SOLARIS and the legal and governance structure to be adopted by the future EU-SOLARIS entity. The legal structure proposed by the consortium of the EU-SOLARIS Preparatory Phase project is the European Research Infrastructure Consortium (ERIC).The proposed governance structure is a simple collegiate structure composed of the General Assembly, the Managing Director, and several consultative bodies, such as a Financial Committee, a Technical Committee and a Board of National Nodes Directors.

In addition, training courses have been identified and scheduled for the implementation phase of the project, to promote the creation of a new generation of young 'solar' researchers. All public outcomes of the project are being made accessible as they are being generated in the project website (www.eusolaris.eu).

EU-SOLARIS available facilities and laboratories

One of the main technological assets of EU-SOLARIS is the comprehensive set of RIs owned by the Partners, covering the range from a few kW to several MW thermal power. These RIs are composed of both outdoor test facilities and indoor laboratories.

Parabolic Trough facilities

At present, EU-SOLARIS partners have eight test facilities with parabolic trough collectors. The next table provides their main technical parameters. These facilities are used for many different purposes: testing of components (receiver tubes, mirrors, solar tracking systems and local controls), new working fluids (water/steam, compressed gases, thermal oils and molten salts) and complete new collector prototypes (small and large size prototypes). Most of the new parabolic trough designs and components installed in modern CST plants have been previously qualified in these facilities.

Table 1: Summary of the EU-SOLARIS partners' parabolic troughs' parameters

Name	Partner/ Country	Capacity (kWt)	Length (m)	Max. Temp. (°C)	HTF
DISS	PSA/Spain	2 600	700	400	Water
HTF		500	75	420	Oil
Innovative Fluids Test Loop		350	50	515	CO_2
CAPSOL		3	NA	230	Water
KONTAS		NA	20	400	NA
CNRS	CNRS Odeillo/ France	180	36	350	Oil
Sopran	DLR/Germany	140	13.8	200	Water
ENEA	ENEA/Italy	400	100	550	Molten salt

Linear Fresnel facilities

There are presently two Linear Fresnel facilities owned by the EU-SOLARIS partners. The first is the FRESDEMO plant operated by PSA which is composed of a North-South oriented linear Fresnel concentrator of 100 m length and 22 m width, provided with a single-tube receiver using water as working fluid and a maximum working temperature of 400°C. The second one is the LIFE (Linear Fresnel for the built Environment) facility at the CyI premises in Athalassa, Cyprus. It has a thermal power of 70 kW, comprises of 72 mirror rows and uses oil as heat transfer fluid at a temperature of 170°C, with plans to increase it in the future.

Parabolic Dish facilities

Concerning parabolic dishes, there are seven units in operation at PSA (six units) and CNRS-Odeillo (one unit), with thermal powers ranging for 40 to 52 kW, and solar concentration factors from 10 000 to 16 000. Besides the evaluation of new Stirling engines, these facilities are excellent test benches for accelerated-ageing studies of STE plant components working under high solar flux conditions (e.g., central receivers).

Geographical distribution of EU-SOLARIS Research Infrastructures in the Preparatory Phase

Central Receivers facilities

EU-SOLARIS partners operate seven experimental central receivers, the main technical parameters of which are listed in Table 2. These facilities are used not only for testing of components (central receivers, heliostats, secondary concentrators, etc.) but also for control systems and operation strategies. Most of these facilities are provided with several test platforms installed at different levels in the tower.

Table 2: Summary of the Central receivers' parameters

Name	Partner/Country	Thermal power (kWt)	Height (m) / Reflective area (m^2)	Sun Concentration	Power/Reflective area Ratio (kW/m^2)
SSPS CRS	PSA/Spain	2 000	40 / 3 600	2 500	0.556
CESA-1		5 000	80 / 12 000	2 700	0.417
Thémis	CNRS/France	4 200	115 / 5 778	2 000	0.727
Jülich	DLR/Germany	10 900	60 / 18 000	900	0.606
SRFU	Weizmann/Israel	1 000	60 / 3 584	4 000	0.279
CTAER	CTAER/Spain	850	58 / 1 560	NA	0.544
PROTEAS	CyI/Cyprus	150	15 / 253	1 000	0.593

Solar furnaces and solar simulators facilities

Solar furnaces and solar simulators are very flexible and user friendly facilities because they allow many different types of tests with high solar radiation fluxes, which make experiments at very high temperatures possible. EU-SOLARIS partners are operating 17 solar furnaces with unit thermal powers ranging from 0.125 kW up to 1 000 kW, reflecting surfaces from less than 1m^2 up to 1 830 m^2 and concentration factors between 2 500 and 16 000. Twelve solar furnaces, including the current biggest one, are operated by CNRS at Odeillo (France), while three are operated by PSA in Spain, one is operated by DLR in Germany and another one is operated by LNEG in Portugal.

Concerning solar simulators, EU-SOLARIS partners are operating one 20 kW simulator at Greece (by APTL), one 18 kW simulator at Germany (by DLR) and one 4 kW simulator in Spain (by PSA). More powerful simulators are expected to be available by 2017.

Solar furnace, DLR

Solar simulator, APTL

Laboratories

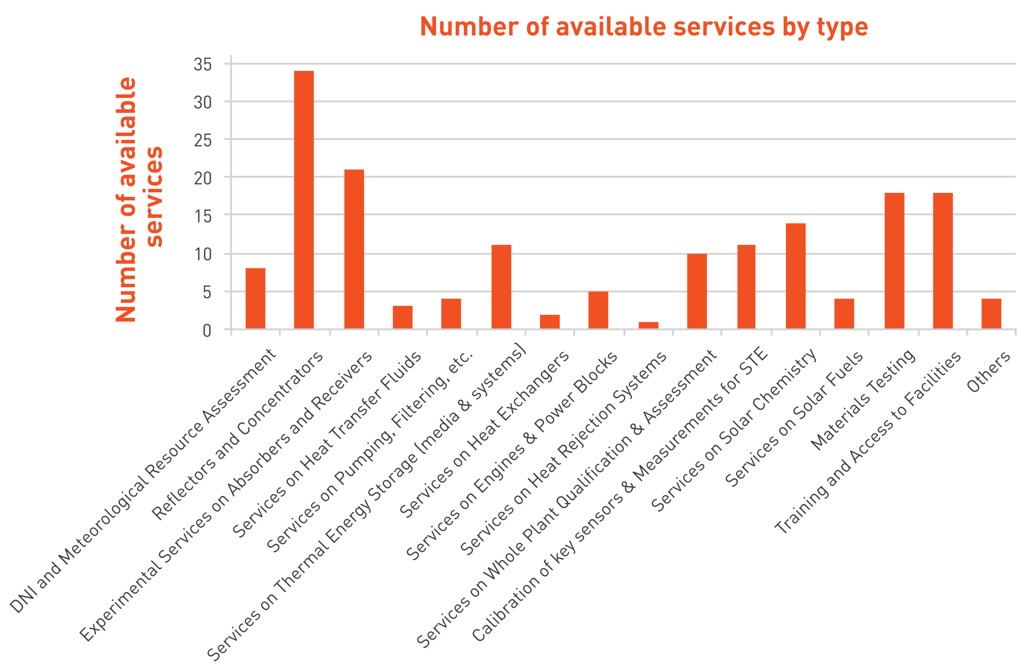
The EU-SOLARIS partners' experimental facilities are complemented by a large number of laboratories. The types of laboratories available and their owners are shown in the following table according to their specialization.

Table 3: Summary of the EU-SOLARIS partners' laboratories

Partner/ Country	Meteorology monitoring	System Modelling	Energy Efficiency	Equipment Testing & Calibration	Chemistry & Material testing	Optics	Radiometry
PSA/Spain	Y	Y	Y	Y	Y	Y	Y
DLR/Germany	Y	Y	Y	Y	Y	Y	Y
ENEA/Italy	Y	Y	Y	Y	Y	Y	Y
LNEG/Portugal	Y	Y	Y	Y	Y	Y	Y
APTL/Greece	Y	Y	Y				
CRES/Greece	Y	Y	Y	Y		Y	
CNRS/France	Y	Y	Y	Y	Y	Y	Y
UEVORA/ Portugal	Y	Y	Y	Y		Y	
CTAER/Spain	Y	Y	Y				
METU/Turkey	Y	Y					
SELCUK/Turkey	Y		Y		Y		

EU-SOLARIS partners' services

The large number and different types of experimental facilities and laboratories owned and operated by the EU-SOLARIS Preparatory Phase project partners offer to the industry a wide range of services and capacities related to CST technologies and their applications, as summarized in the following figure.



Benefits and ways to join/collaborate with EU-SOLARIS

RIs are becoming a key instrument to achieve scientific and technological excellence. They offer a single contact point where facilities, resources and research services are effectively offered to users from different countries, contributing to increase the sector competitiveness through the collaboration between industry and the scientific community.

Benefit for EU-SOLARIS users:

EU-SOLARIS will offer to the world a unique distributed research infrastructure in CST and Solar Chemistry technologies. In so doing, it will optimize the use of the associated national research facilities, improve their management, expand and upgrade their services, streamline and enhance the user experience, and leverage synergies among them. EU-SOLARIS will:

- Offer a single access point for all legal aspects, such as contracts, confidentiality, and intellectual property among others;
- Provide first class research services – the most qualified human resources and most advanced technologies in EU will be available to EU-SOLARIS users;
- Integrate all the national research facilities under a common framework (i.e., common protocols, standards and contractual terms), which will reinforce the international cooperation among EU countries;
- Develop common procurement procedures to decrease costs and achieve significant impact in access to services;
- Foster the participation of SMEs in research projects where the company size is a barrier, thereby, contributing to increase the innovation in the sector.

Main services provided by EU-SOLARIS to the scientific community and industry:

- Research Infrastructures: Access and services;
- Dissemination: Training courses and communication;
- Services: R&D services and consultancy services;

Moreover, EU-SOLARIS will not only be a service provider but it will be available for any kind of collaboration enabling the fulfilment of the objectives for which it was created.

Different modes of access to the EU-SOLARIS RIs:

- Market-based Access: this one is especially suited for the industrial sector, because it is related to activities aimed at developing a commercial product, and a more intensive use of the RIs is therefore demanded by the Applicants;
- Quality-based Access: this one is more likely to be requested by small R&D groups working on CST technologies and chemical applications when they need RIs that they do not have;
- Archival Access: this one is more oriented to on-line and remote access to data bases of information related to the RIs and their experimental results.

EU-SOLARIS access point:

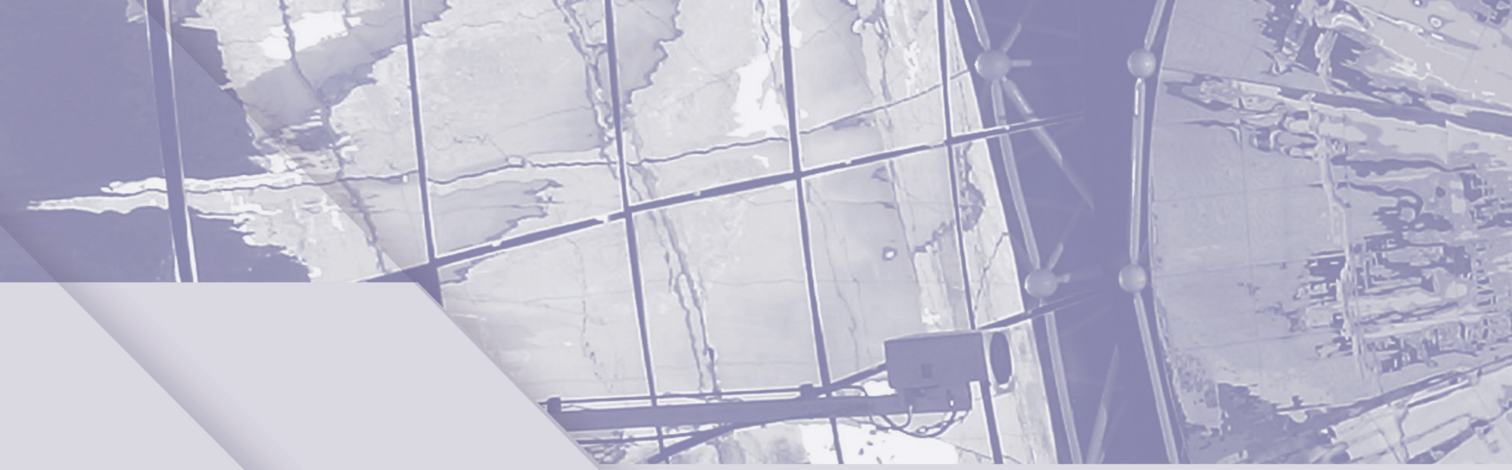
The single contact-point for any entity or person interested in the services of EU-SOLARIS or for any other type of collaboration will be the EU-SOLARIS Desk, which will be also accessed via internet and it will gather not only the applications submitted by potential users, but also the requests-for-support submitted by entities trying to find the appropriate RI or research service to meet their needs.

Project Consortium

- **CTAER:** Advanced Technology Centre for Renewable Energies (Spain) - Project Coordinator
- **CIEMAT-PSA:** Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas-Plataforma Solar de Almería (Spain)
- **MINECO:** Ministerio de Economia y Competitividad (Spain)
- **CyI:** The Cyprus Institute (Cyprus)
- **ESTELA:** European Solar Thermal Electricity Association
- **CNRS - PROMES:** National Center for Scientific Research - Processes, Materials and Solar Energy laboratory (France)
- **DLR:** German Aerospace Center (Germany)
- **APTL-CERTH:** Centre for Research and Technology Hellas (Greece)
- **CRES:** Centre for Renewable Energy Sources and Saving (Greece)
- **ENEA:** Agenzia Nazionale per le Nuove Tecnologie, L'energia e lo Sviluppo Economico Sostenibile (Italy)
- **WEIZMANN:** Weizmann Institute of Science (Israel)
- **LNEG:** Laboratório Nacional de Energia e Geologia, I.P. (Portugal)
- **U.EVORA:** Universidade de Evora (Portugal)
- **GÜNAM:** Center for Solar Energy Research and Application, Middle East Technical University (Turkey)
- **SELCUK U:** Selcuk University, Advanced Technology Research and Application Center (Turkey)

Abbreviations

CSP: Concentrated Solar Power
CST: Concentrating Solar Thermal
ERIC: European Research Infrastructure Consortium
ESFRI: European Strategy Forum on Research Infrastructures
EU: European Union
HTF: Heat Transfer Fluid
R&D: Research and Development
RES: Renewable Energy Sources
RI: Research Infrastructure
SHIP: Solar Heat for Industrial Processes
SMEs: Small and medium-sized enterprises
STE: Solar Thermal Electricity



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