CENER | CENTRO NACIONAL DE ENERGÍAS RENOVABLES
NATIONAL RENEWABLE ENERGY CENTRE

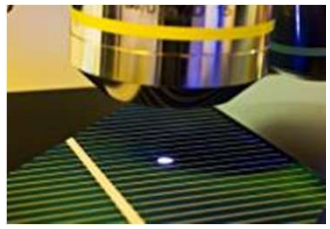
SCARABEUS

Challenges of CSP Technology in Energy Transition

Network Session 20th April 2022





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01

CENER SOLAR ENERGY TECHNOLOGIES & STORAGE DEP. OVERVIEW

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NATIONAL RENEWABLE ENERGY CENTRE

VISION & MISION

VISION

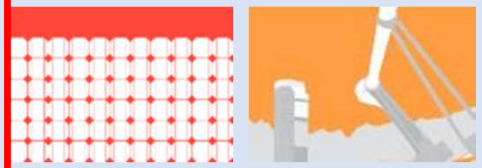
To be a research centre of excellence in the renewable energies field with international outreach.

MISSION

To generate knowledge in the renewable energy field and to transfer it to the industry in order to boost sustainable energy development.

RESEARCH AREAS

Wind Energy



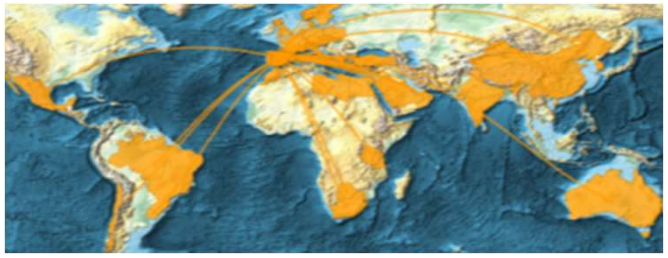
Solar Energy Technologies & Storage

Biomass

Energy in Buildings

Grid Integration of Renewable Energy

TEAM & TRACK RECORD



HIGHLY SKILLED MULTIDISCIPLINARY TEAM OF PROFESSIONALS

The team:

- **45 researchers and engineers**
- Physicists, Chemists, Mathematicians, Industrial, Mechanical, Telecommunication and Computer Engineers.
- **Large experience in Solar Photovoltaic, Solar Thermal and Energy Storage technologies**.

Team's expertise:

- **Optical, Electrical and Thermo-fluid-dynamic simulation**
- Applied **optics, image and data processing**
- **Semiconductors, coatings** and functional materials
- **Meteorology, resource assessment** and forecasting
- **Quality Assessment,** inspection and testing

LARGE EXPERIENCE IN SOLAR AND STORAGE TECHNOLOGIES AND COMERCIAL PROJECTS

Commercial projects:

- **2.000+ projects**
- **1.000+ clients**
- **40+ countries**.
- Involved in **30+ PV plant projects** and **50+ STE plant projects**.

R&D Activity:

- **60+ public financed R&D projects**
- **230+ scientific publications**.
- **9 patents**
- **30+ alliances**
- **Main international forum and expert groups**.

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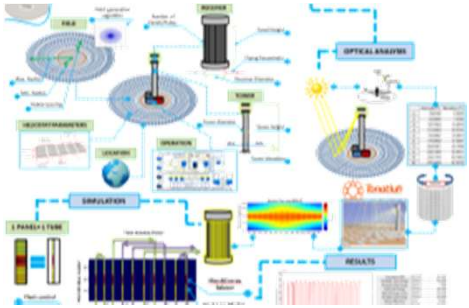
ADItech

STRUCTURED IN 4 MAIN LINES

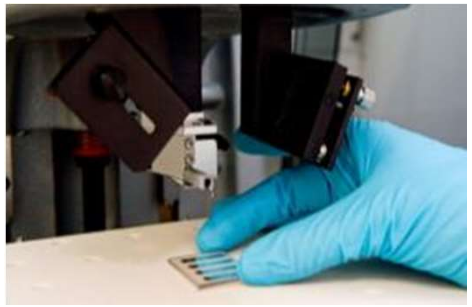
SUPPORTING THE WHOLE INDUSTRY CHAIN AND INSTITUTIONS

Systems and components design and development



- New **components for solar and storage** technologies.
- Innovative **solar systems**, **O&M** procedures and strategies
- Innovative **measuring systems**
- **Integration of PV** in devices/products
- Advanced **materials and coatings** for energy applications
- **Design and simulation software**

Systems and components testing and characterization in laboratory



- PV **modules and BoS** (trackers, inverters, cleaning devices…)
- ST Receiver **tubes**, **heliostats** and **mirrors**
- **HTF and getters** analysis
- Thermal **collectors and systems**.
- **Calibration** of radiation sensors.
- **PV Cells, solar/optical materials and coatings, climatic chambers…**

Systems and components testing and characterization on-site

O&M Services for PV installations

- Drone based **Electro Luminescence**
- In-situ **Inverter performance**
- **Mobile PV lab** (EL, I-V, etc.)

O&M Services for ST installations

- Drone based **receiver tubes and mirrors** inspection
- Advanced **HTF sampling (incl. H2)**
- In-situ solar **collectors certification**

Technical Assistance

- **Solar Resource Assessment** and **Techno-economic studies** for feasibility and bankability analysis.
- **Technical Advisory** and **Due Diligence**.
- **Technical specifications, tendering, RFP** and others.
- Training, knowledge transfer, technology road mapping and others

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DESIGN TOOLS

OPTICAL MODELLING

- ✓ Tonatiuh Ray Tracer
- ✓ Simplified models based on optical geometric
- ✓ Optimize algorithm and aim point strategies tools for solar fields

THERMAL MODELLING

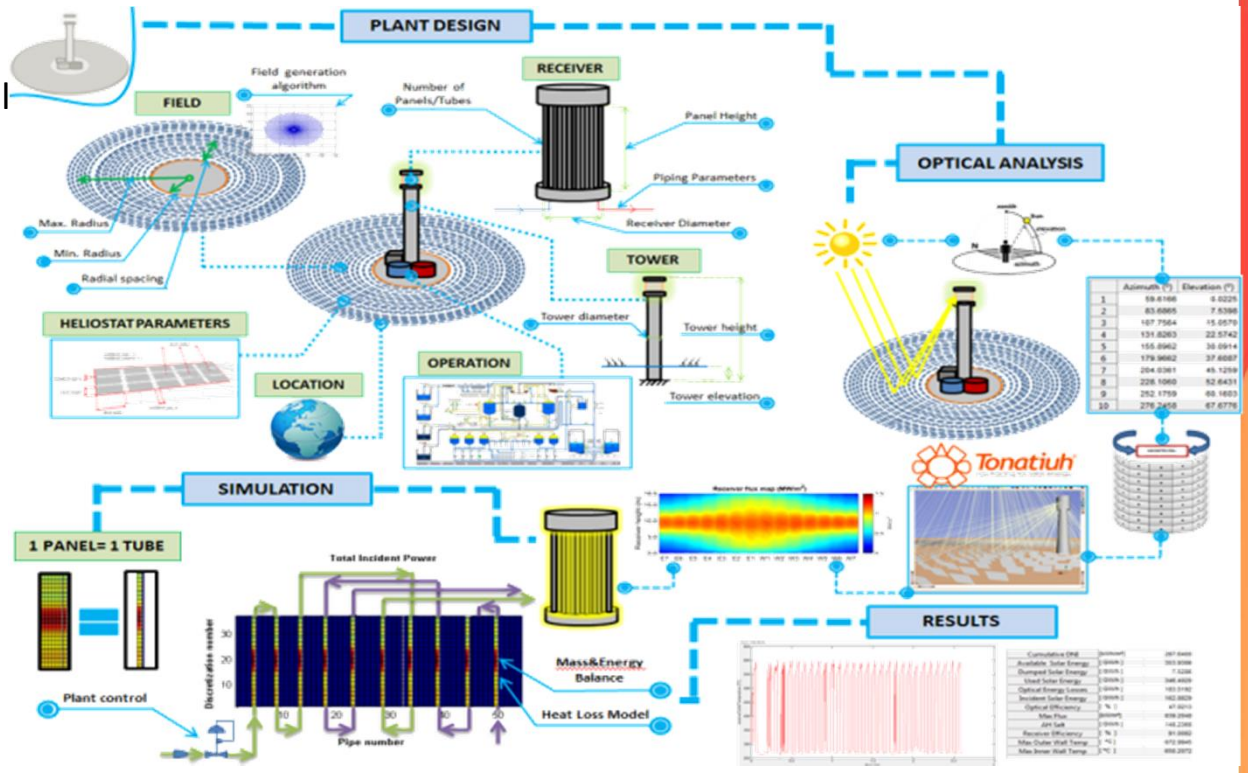
- ✓ Dymola (Own CSTLibrary-Modellica)
- ✓ TRNSYS
- ✓ IPSEpro (Power Cycles)

HEAT TRANSFER

- ✓ ANSYS-Fluent (CFD)

MECHANICAL

- ✓ ANSYS-Mechanical



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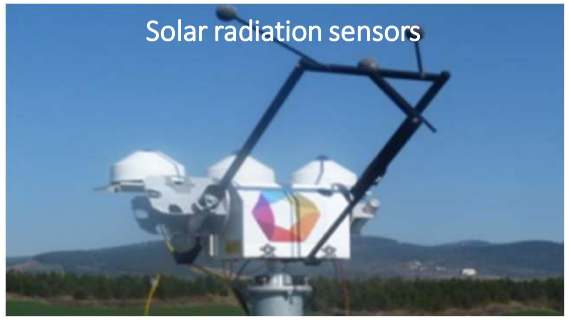
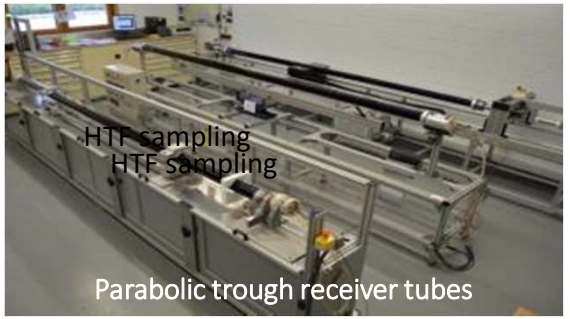
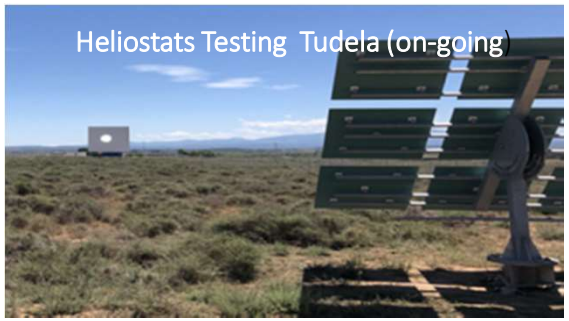
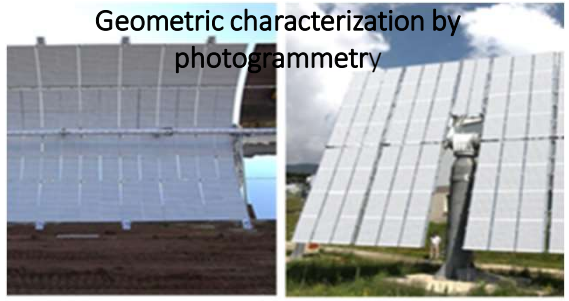
TESTING INFRASTRUCTURES









02

CHALLENGES OF CSP IN ENERGY TRANSITION

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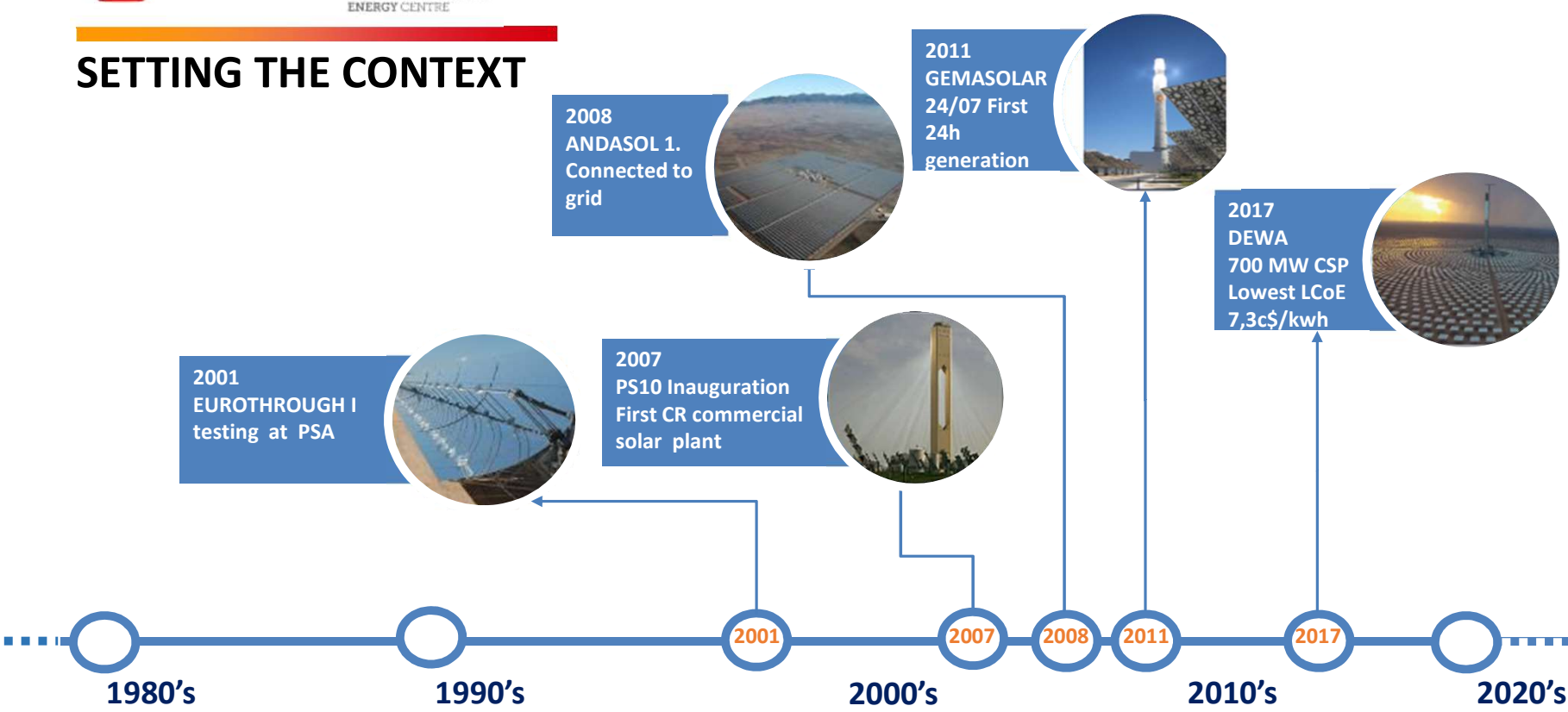
SETTING THE CONTEXT



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SETTING THE CONTEXT

- PV (utility scale) and Wind are cost-competitive with convectional technologies
- PV (utility scale) is cost competitive with carbon and nuclear technologies, even considering marginal costs only of conventional plants (and very close to GCC, 28$ vs 24$/MWh)
- CSP Tower technology cost is close to Carbon cost (upper limit) and Nuclear and Gas Peaking cost (lower limits).
- The scale factor, financial conditions and DNI has a high impact in CSP cost (73$/MWh DEWA Dubai, 700 MW, 35 PPA)

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SETTING THE CONTEXT

Challenges of energy transition: **secure, affordable and sustainable energy**.

Decarbonisation of energy system, reducing dependence of fossil fuels, and increasing RREE penetration.

- ✓ We have achieved the **maturity and competiveness of RREE**.
- ✓ **Renewable energies** (solar PV and Wind) are today **cheaper than conventional fossil** fuel-based energies, but are not dispatch-able.
- ✓ It is time to talk about the true **value** of EERR from the citizen's point of view, and not only about energy generation **cost,** LCoE.
- ✓ A **wise implementation of RREE requires storage** systems that improve their capacity factor: **CSP with massive energy storage is key.**

REVISING THE RENEWABLE ENERGY DIRECTIVE

Renewables in the EU energy mix

19.7% Current renewables share (in 2019)

32% Current EU 2030 target

40% New EU 2030 target

Stepping up the ambition for renewables in **key sectors**:

- Annual binding increase of **1.1 percentage point** renewables in **heating and cooling at national level**
- Indicative target of **2.1 percentage points** renewable energy and waste heat and cold in **district heating and cooling**
- New **13%** greenhouse gas intensity target in **transport**
- New indicative target of a **1.1 percentage point** annual increase in renewable energy use in **industry**
- New benchmark to reach at least **49%** renewable share in the energy used in **buildings**

Boosting the **deployment of and investment** in renewable energy:

- Measures to **boost electrification**, including a credit mechanism for transport
- Sub-targets and certification for **renewable hydrogen**
- Measures to facilitate renewable **Power Purchase Agreements** (PPAs)
- **Accelerated permitting** for renewable energy projects
- **Promoting cross-border cooperation**, including through the renewable energy financing mechanism

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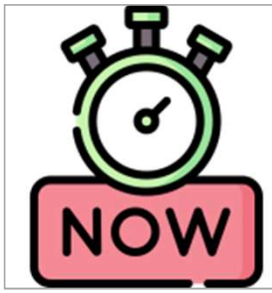
Challenges of CSP



- ✓ Take advantage of the singularity of CSP technology, to provide **thermal energy in the industrial sector and in district heating applications**

SHORT TERM

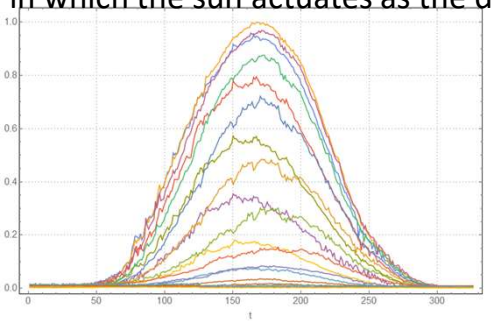
- ✓ **O&M Improvement** to increase **efficiency** and **reliability** of plants
  - Monitoring at site: HTF degradation, PT solar tubes and mirrors inspection, CR incident solar flux,…
  - Heliostats automatic calibration
  - New methodologies to characterize heliostats quality
- ✓ Increase RREE penetration by means of **Power to Thermal Energy to Power** solutions, integrated in CSP plants. Retrofit of carbon and other fossil fuel power cycles, to be decommissioned.

Challenges of CSP

O&M improvements for Heliostats Field

Heliochart +

- Innovative system for the optical characterization of heliostats based on light detectors and cameras vertically distributed (Patent CENER U. Zaragoza)
- Scanner-based measurement system in which the sun actuates as the driver mechanism whilst the heliostats remains static



"Validation of a Heliostat Characterization System Based on Cameras and Light Detectors to Measure the Heliostat's Beam and its Surface Error" Solar paces 2021. Iñigo Les

Short

- Automatic calibration system based on artificial vision equipped on the heliostats
- Low-cost camera rigidly mounted on the facet structure
- Artificial lights (targets) distributed through the solar field with known positions
- Patent (CENER Tekniker)

"Validation of a Low-cost Camera for Scalable HeliOstat calibRation sysTem (SHORT)" Solar Paces 2021 Iñigo Les

Challenges of CSP

MEDIUM / LARGE TERM

- ✓ Components and sub-systems design improvement to increase **efficiency** and **feasibility** of plants:
  - **Materials breakthrough**: new HTF fluids, coatings with better optical properties for receivers, anti-soiling coatings for mirrors,..
  - Cost effective **high temperature receivers**
  - New cycles and schemes: **supercritical cycles, hybridization**
- ✓ Increase RREE penetration, **integrating innovative CSP with innovative thermal storage systems**:
  - New generation of molten salts with **higher operation temperature** and **lower freezing point**
  - **Thermocline packed-bed** storage systems
  - **Thermo-Chemical** storage systems
  - Latent Thermal storage systems **PCM**
  - High Temperature Volumetric Air Receivers to **Hybridize CSP and CAES** (Comprised Air Energy Storage) systems
  - **Hybridize CSP with PTES** (Pumped Thermal Electricity Storage)

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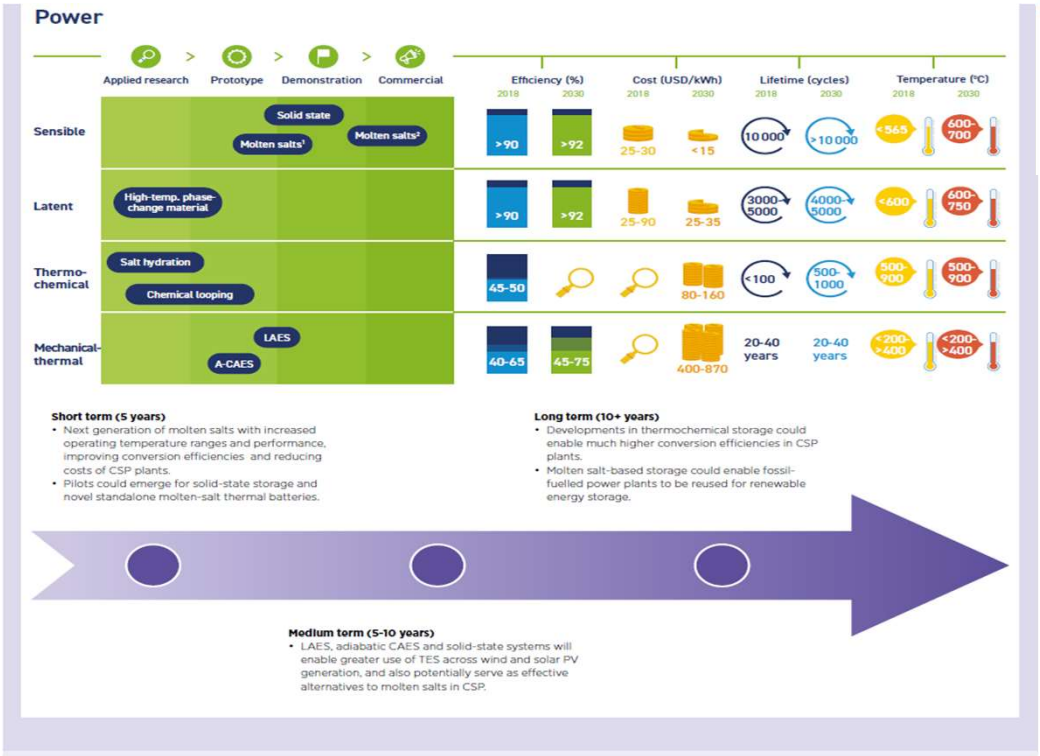
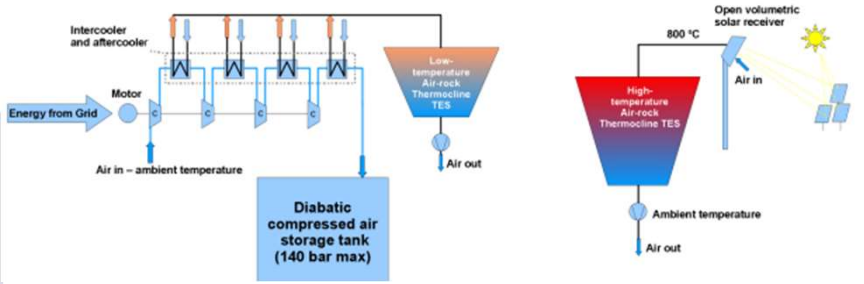
Challenges of CSP

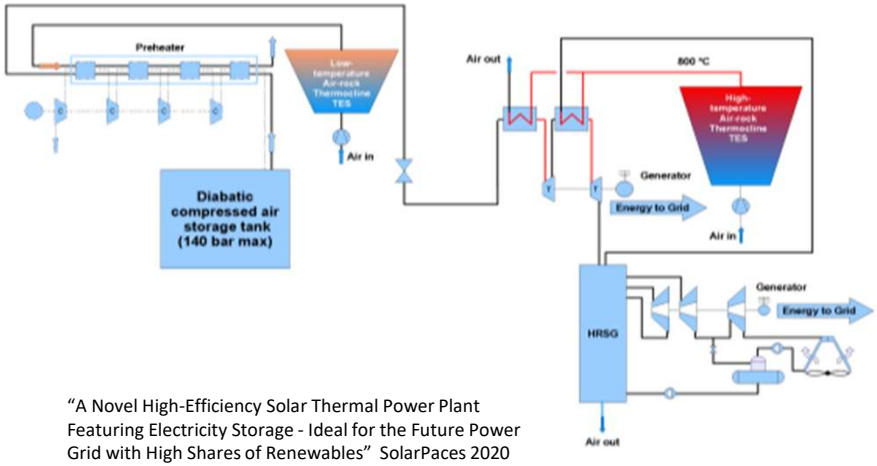


Source Irena "Thermal Storage" Innovation outlook. 2020

CAES-CSP CHARGING



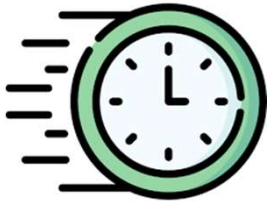
CAES-CSP DISCHARGING



"A Novel High-Efficiency Solar Thermal Power Plant Featuring Electricity Storage - Ideal for the Future Power Grid with High Shares of Renewables" SolarPaces 2020 Fritz Zaversky

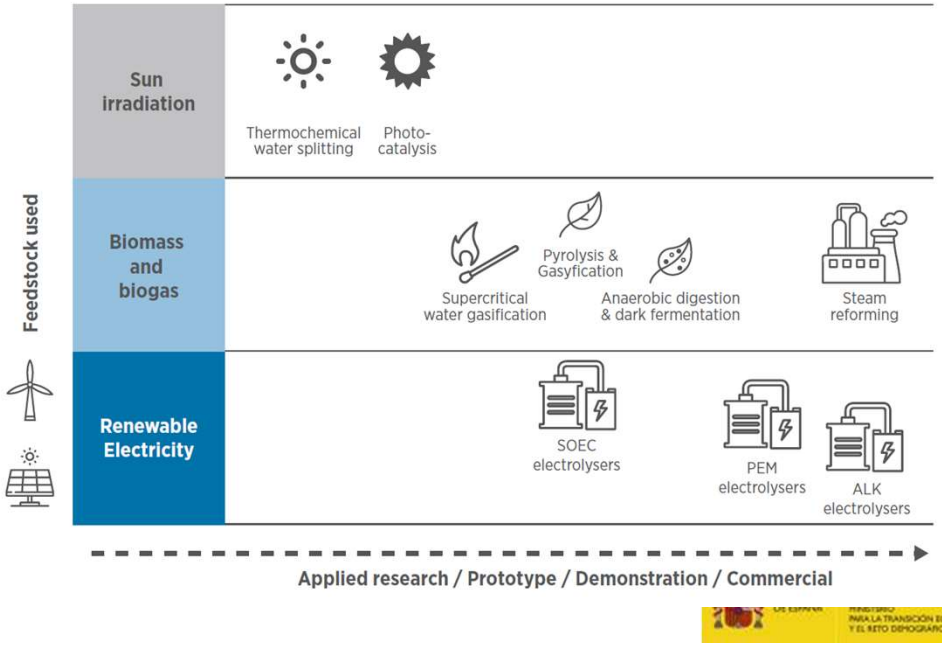
Challenges of CSP

LARGE - TERM



- ✓ Fossil fuels diversification by using Hydrogen and other synthetic solar fuels. **High Temperature Receivers,** to supply energy to SOEC (Solid Oxide Electrolyzes Cells), and other thermochemical reactions.

Source Irena "Hydrogen for Renewable power "



03

MAIN R&D PROJECTS

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NATIONAL RENEWABLE ENERGY CENTRE

RESTORE

ONGOING

RESTORE - Renewable Energy based seasonal Storage Technology in Order to Raise Economic and Environmental sustainability of DHC

OBJECTIVES OF THE PROJECT

Main objective:

To develop a technical solution able to overcome the current technological barriers that limit the penetration of RES in the DHC sector.

Solution based on the combined use disruptive technologies:

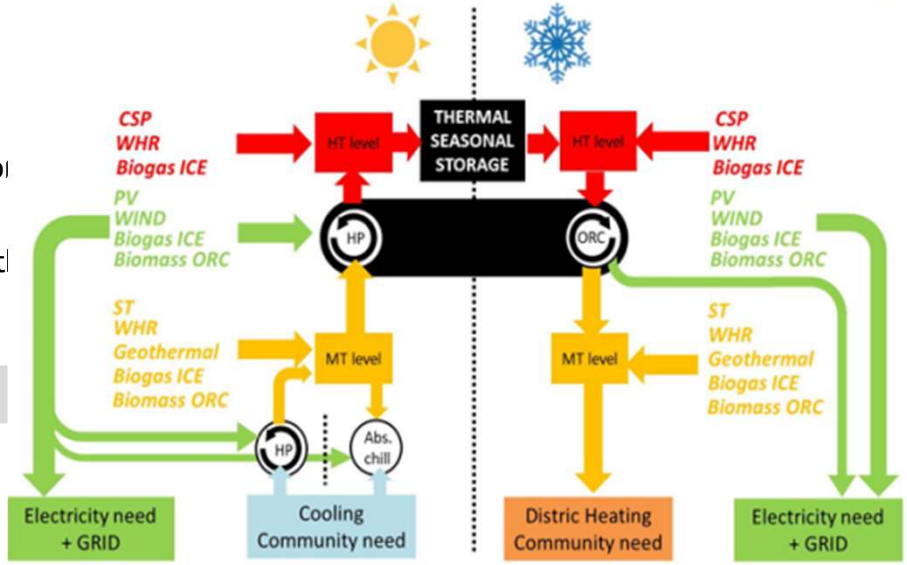
- Thermochemical energy storage fo storage of energy
- ORC/HP technology for maximize t integration of RES.

MORE INFORMATION

https://www.restore-dhc.eu/

CENER´S MAIN ACTIVITIES

- Project management and coordination (WP8).
- WP1 requirements definition and responsible for the concept specifications definition .
- Strong contribution in modelling and simulation, in special, in WP5 (EU-wide replication in virtual



BUDGET

- Total: 5.667.736,25€

DATES

October 2021 – October 2025

PARTNERS

CENER ADItech · TU WIEN Technische Universität Wien · Politecnico Milano 1863 · SimTech · enerbasque · Steinbeis · ANDRITZ · Aalborg CSP · prospex · clean energy ahead TURBODEN · Universitatea Babeș-Bolyai

Horizon 2020 European Union Funding for Research & Innovation

This project has received funding from European Commission, Research and Innovation Program, under Grant Agreement number 101036766.

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COMPLETED

MOSAIC - MOdular high concentration SolAr Configuration

MOSAIC MODULAR HIGH CONCENTRATION

OBJECTIVES OF THE PROJECT

Main objective:

To design, manufacturing and validation in a "relevant environment" of an innovative CSP concept based on a **fixed hemispheric semi-Fresnel solar field and a high temperature mobile receiver** with low implementation and O&M costs at the highest plant efficiencies, thus reducing the LCOE.

CENER´S MAIN ACTIVITIES

- **Technical coordinator of the project. Promoter of the original** idea
- Conceptual design of the prototype (WP2)
- Design, assembly and verification of the optical quality of the solar field (WP3) and the risk management of the project(WP8), as well as in the operation and performance of the prototype validation tests (WP7).
- Conceptual design at the plant level by defining the CSP plant to achieve by using modules based on the

BUDGET

- Total: 5.077.733,75 €

DATES

December 2016 – November 2021

MORE INFORMATION

www.mosaic-h2020.eu

PARTNERS

CENER · ADItech · Tekniker · RIOGLASS · senior FLEXONICS · cobra · sirea group · POLITECNICO DI TORINO · AALBORG CSP - Changing Energy · AMIRES

Horizon 2020 European Union Funding for Research & Innovation

This project has received funding from European Commission, Research and Innovation Program, under Grant Agreement number 727402.

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COMPLETED

CAPTURE - Competitive SolAr Power Towers

OBJECTIVES OF THE PROJECT

Main objective:

To increase plant efficiencies and reduce LCOE by developing all relevant components for implementing an innovative plant configuration based on a **multi-tower decoupled advanced solar combined cycle.**

This design avoids frequent transients and inefficient partial loads, thus maximizing overall efficiency, reliability as well as dispatchability.

CENER´S MAIN ACTIVITIES

- **Project management and coordination. Promoter of the original** idea
- DSCC – Modular multi-tower decoupled solar combined cycle concept (WP1).
- Solar receiver (WP2), Regenerative heat exchange system (WP3), Solar-driven Brayton cycle (WP4), Solar field (WP5).
- System integration and testing in the relevant environment (WP6)
- Risk analysis (WP7), Dissemination and communication (WP8), Exploitation of results (WP9)

BUDGET

- Total: 6.104.033,00 €

DATES

May 2015 – July 2020

MORE INFORMATION

www.capture-solar-energy.eu

PARTNERS

CENER, Bluebox Energy, CEZ, EDF, EUREC, FCT Ingenieurkeramik GmbH, Fraunhofer, IK4 TEKNIKER, QuerDenkFabrik AG, TSK FLAGSOL, SAMSON

Horizon 2020 European Union Funding for Research & Innovation

This project has received funding from European Commission, Research and Innovation Program, under Grant Agreement number 640905.

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RESLAG - Turning waste from Steel Industry into valuable low cost feedstock for energy intensive industry

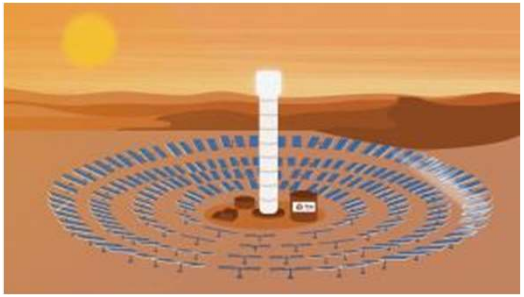
REslag
Turning waste into value

COMPLETED

OBJECTIVES OF THE PROJECT

Main objective:

To valorize the steel slag that is currently not being recycled and reuse it as a raw material for 4 innovative applications that contribute to a circular economy in the steel sector with an additional cross-sectorial approach.

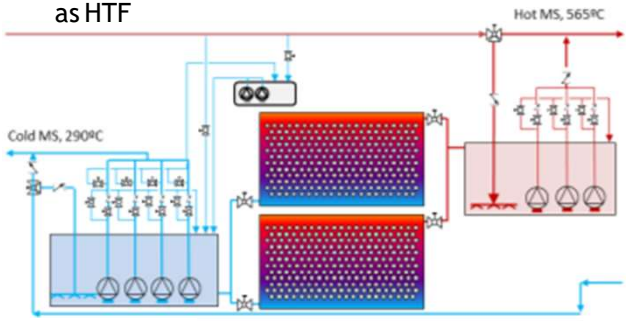


MORE INFORMATION

http://www.reslag.eu/

CENER´S MAIN ACTIVITIES

- **Performance up-scaling and benchmarking of slag Thermal Energy Storage (TES) feedstock for CSP application**: Development of a **specific air and molten salts thermocline storage thermo-economic model** for the coupling to an annual plant performance model, and benchmarking versus current technology based on figures of merit such as energy production and cost of electricity.
- **Feasibility and pre-engineering study of a full-scale TES system** based on slag TES feedstock for CSP application **using air and molten** salts as HTF



BUDGET

- Total: 9.540.695,24€

DATES

September 2015 – July 2019

PARTNERS

CIC energiGUNE, CENER, ADItech, DLR, ArcelorMittal, Imperial College London, NOVARGI, Renotech Oy, IK4 AZTERLAN, hasten ventures, cea, FAU, GE, ENEA, ETH, VTT, masen, Fraunhofer ISC, LIFE CYCLE ENGINEERING, OPTIMUMCEMENT

Horizon 2020 European Union Funding for Research & Innovation

This project has received funding from European Commission, Research and Innovation Program, under Grant Agreement number 642067.

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R&D

More relevant R&D projects

COMPLETED

COSMIC

INNOVATIVE SOLAR COLLECTOR FOR PROCESS HEAT APPLICATIONS WITH SELECTIVE COATING AS COMPETITIVE EDGE

The **main objective** of this research project was the **development of an innovative solar collector for industrial process heat** applications that require thermal energy at temperatures between **180ºC and 250ºC**

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ain Asociación de la Industria Navarra

Nafarroako Gobernua Gobierno de Navarra ADItech

This project has received funding from Gobierno de Navarra/Renewable Energies.

ONGOING

MASS STORAGE

DEVELOPMENT OF LOW-COST MASSIVE THERMAL ENERGY STORAGE SYSTEMS FOR POWER-TO-HEAT-POWER AND CSP FOR POWER-TO-HEAT-POWER AND CSP APPLICATIONS IN NAVARRA REGION

The **main objective** of this R&D project is the alignment of Navarra's research centers around a research area which is **Massive Energy Storage** (MES), needed at grid scale to integrate renewable energies on a large scale.

CENER

ain Asociación de la Industria Navarra upna

Nafarroako Gobernua Gobierno de Navarra ADItech

This project has received funding from Gobierno de Navarra/Renewable Energies.

COMPLETED

HT - STORAGE

MEDIUM AND HIGH TEMPERATURE THERMAL ENERGY STORAGE

The **main objective** of this project was to develop **innovative materials and low cost systems for Thermal Energy Storage** applications, as well as to provide solutions at the energy storage system level to the solar thermal sector and to industries that massively consume heat at high and medium temperatures.

CENER ADItech NAITEC Lurederra centro tecnológico upna

Nafarroako Gobernua Gobierno de Navarra ADItech

This project has received funding from Gobierno de Navarra/Renewable Energies.

ONGOING

TERMOCONVERTER

DESIGN, DEVELOPMENT AND TECHNICAL FEASIBILITY DEMONSTRATION OF AN ENERGY STORAGE AND THERMO-CONVERTER SOLUTION

The **main objective** is to develop an energy storage system that enables de-carbonization and facilitates the energy transition of the industrial sector towards an emission-free and environmentally friendly model.

CENER

GREENDUR INTELIGENCIA VERDE

Nafarroako Gobernua Gobierno de Navarra

This company has received a grant co-financed 50% by the European Regional Development Fund through 2014 - 2020 FEDER Operational Program for Navarra.

CONTACT

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