New online flux density and temperature measuring systems for Monitoring and optimized operation of external Tube receivers

“TubeMon”

Name of the person presenting
Organisation
Address / contact

Overview

WP1: Flux density & absorptivity measurement

WP2: Emissivity and temperature measurements

WP3: Demonstration at commercial plant

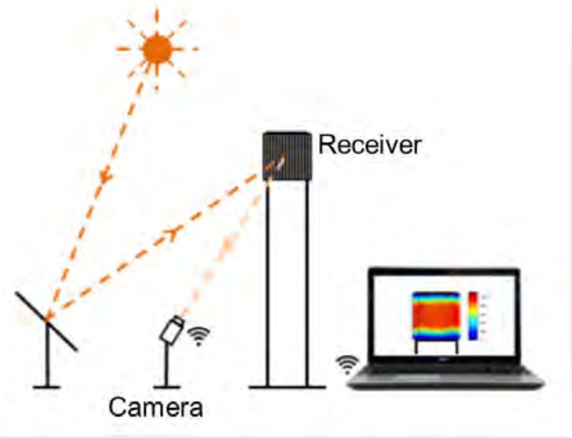
WP4: Heliostat Field Control using GPU

Flux density & absorptivity measurement

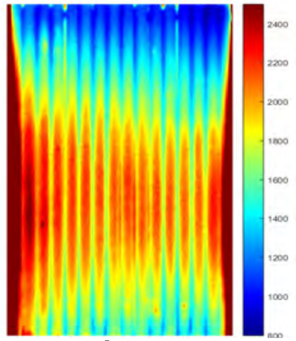
DLR, Germany

Principle of measurement

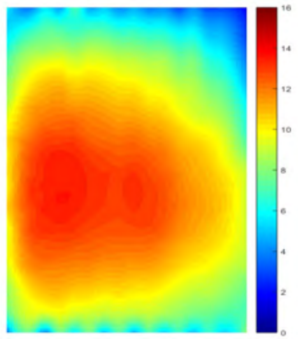
Reflection off the Absorber



Raw image



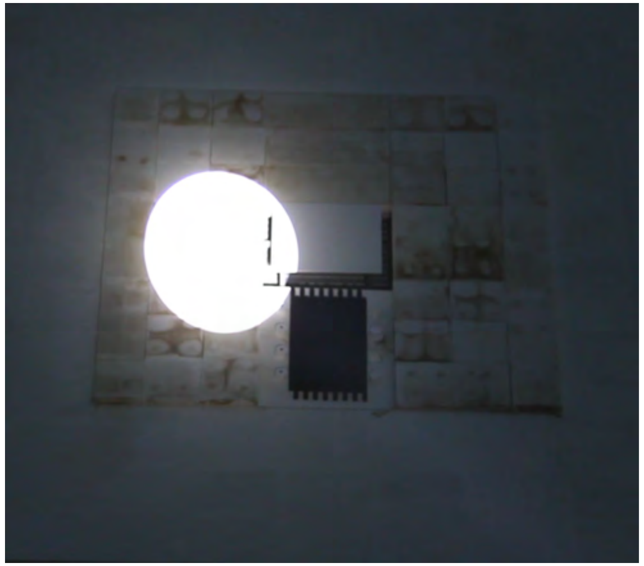
Raw image, rectified, false colors



Corrected with scan method, interpolated

Scan method

Determination of the Reflection Properties

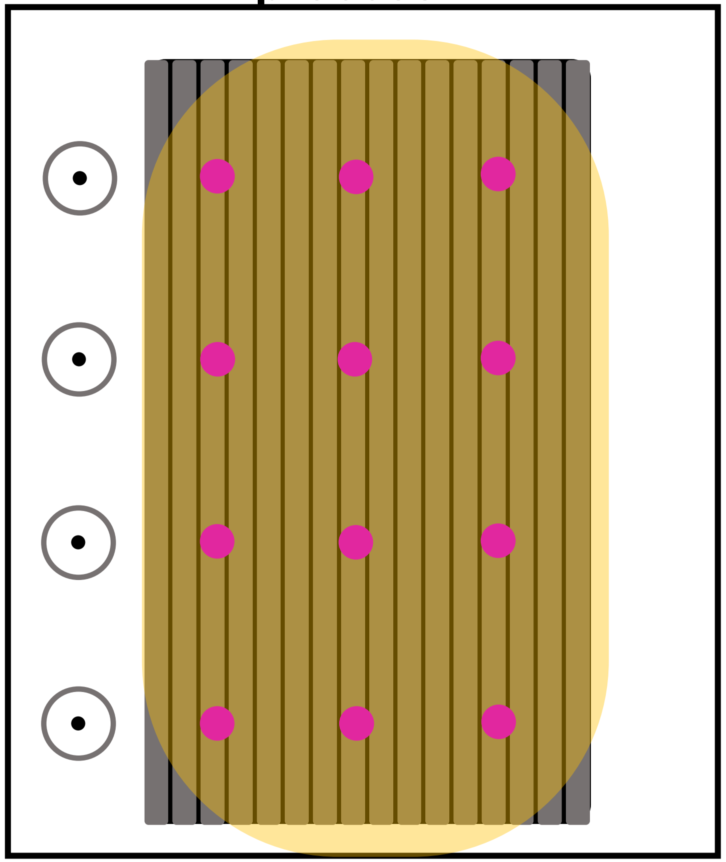


- Meander-shaped path of the light spot
- Simultaneous high-frequency series image recording
- Determination of maximum image
  ⇨ virtual image of a homogenously illuminated receiver

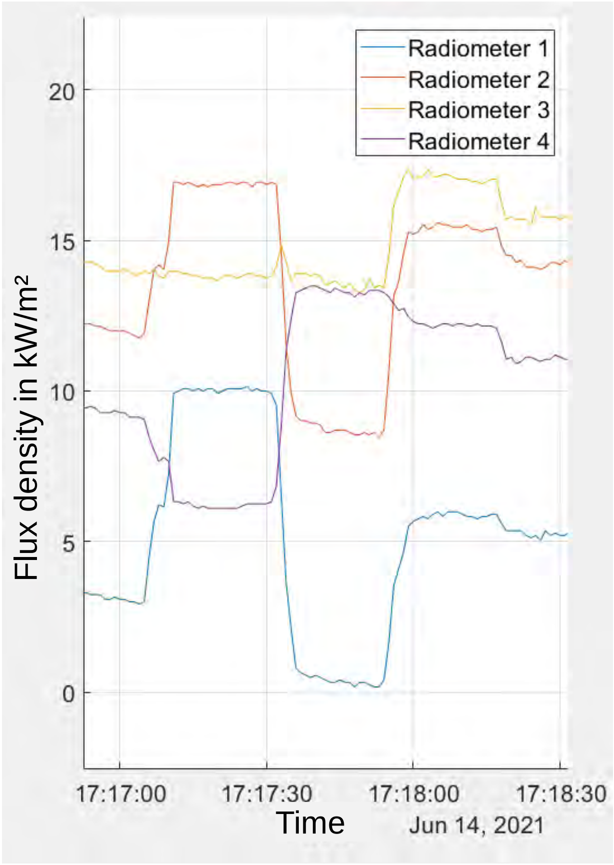
Flux density & absorptivity measurement

Radiometer method

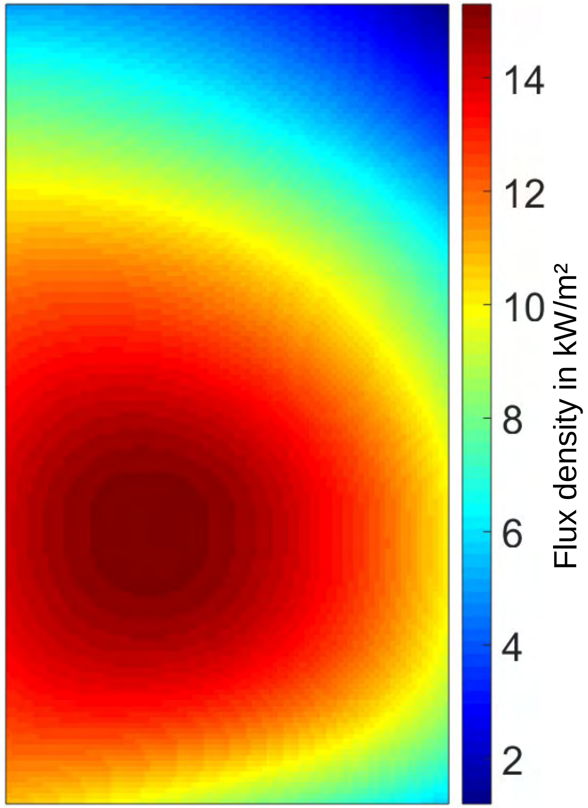
process



data of radiometers



result

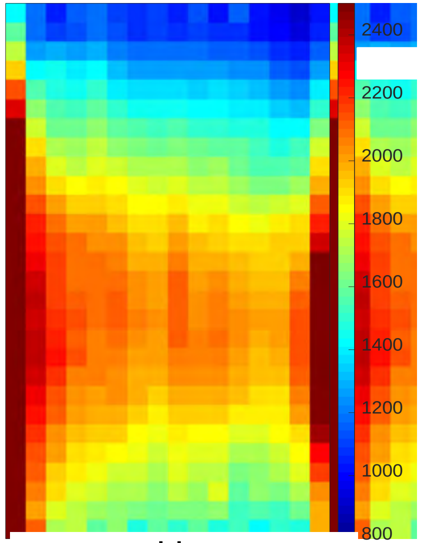


Flux density & absorptivity measurement

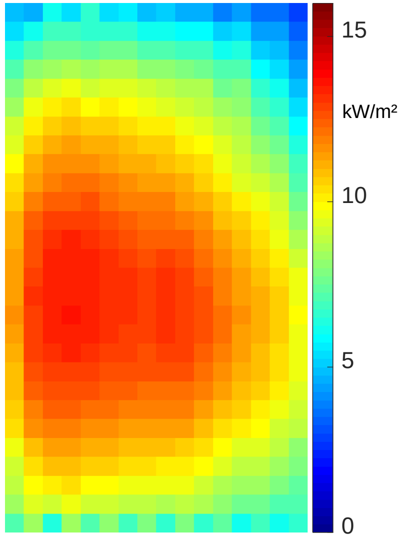
Flux maps determined by reflection off the receiver

Tests on the experimental tube receiver

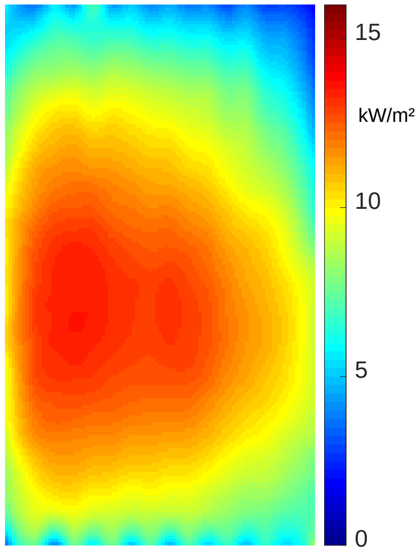
qualitatively similar images



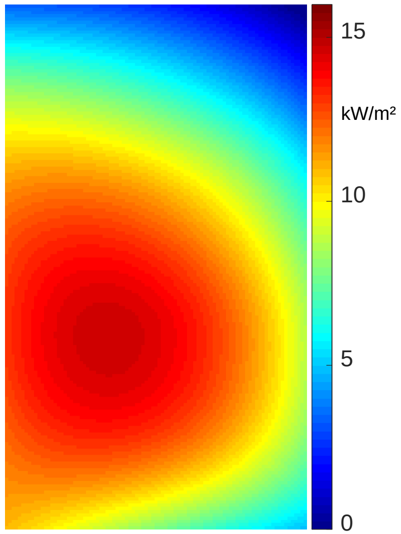
averaged image,
segment by segment



corrected image



Corrected and
interpolated image



Result with **radiometer method**

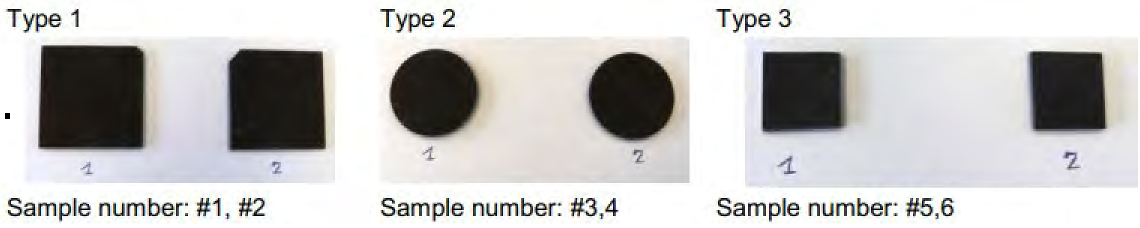
Emissivity and temperature measurements

DLR, Spain

develop a non-contact field measurement technique for the local determination of emissivity and temperature distributions on a tower receiver.

1. Adaptation to Brightsource coating
2. Set-up of the measurement system Hardware Setup
3. Programming of the software and preliminary tests

1.



2.

Figure 12: Test sequence for calibration and pre-tests

NUC (Non-Uniformity Correction)
- HDRi (High Dynamic Range Image)
- Intensity-based image registration (ratio)
- Radiometric calibration
- Model-based atmospheric correction
- Temperature - Emissivity Separation

3.

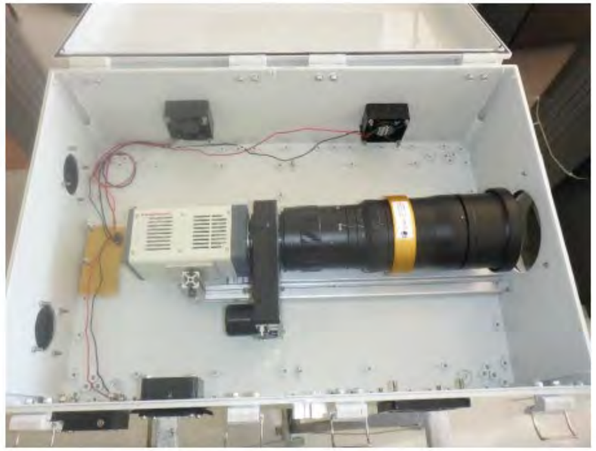


Figure 11: Structure of the infrared camera system in the protective housing

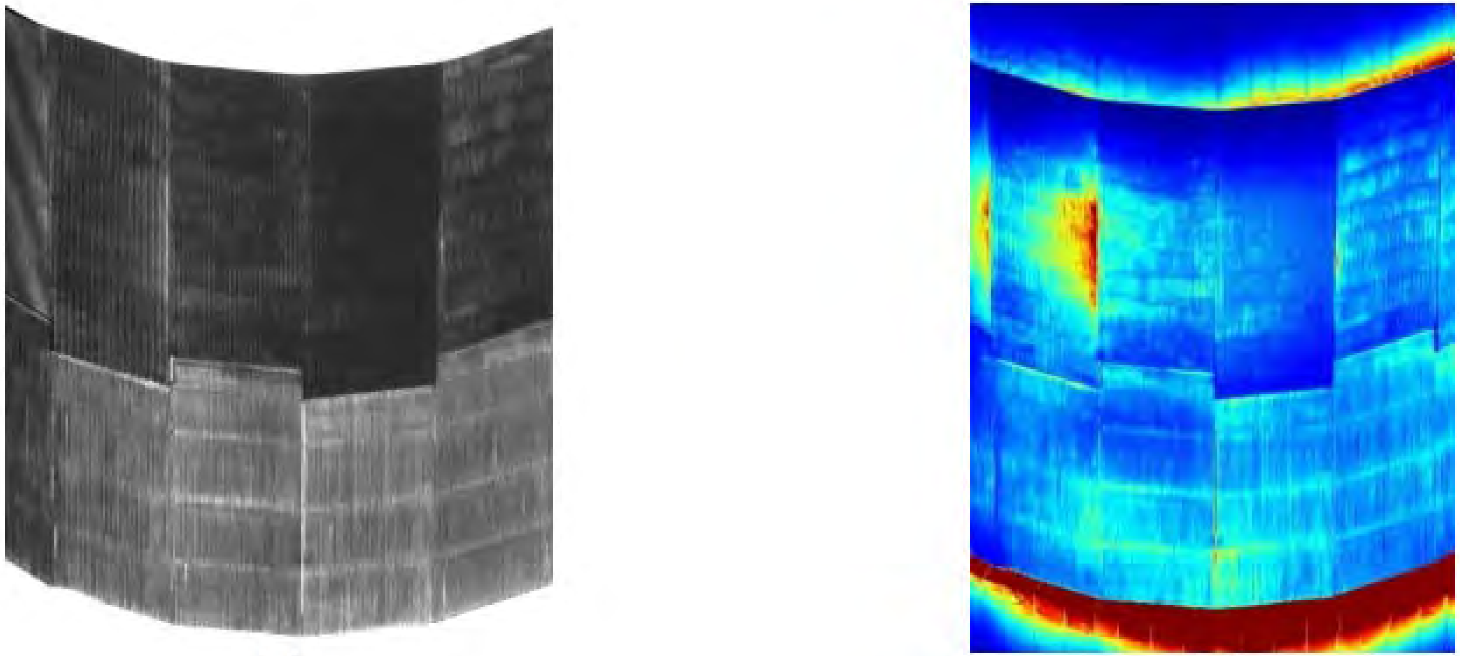
- e-SWIR camera module (Hamamatsu, C16090-03)
- Control software (Hamamatsu, HC Image DIA)
- motorised filter wheel (LUDL 96A351, 6 filter positions)
- Controller (LUDL, MAC6000) for controlling the filter wheel
- Narrowband filters (supplier: Spectrogon)
- Infrared teleoptics (OPTEC, OB-SWIR 300)

Patent Application Number /License:212069DE Rü/STM/ol
Vorrichtung und Verfahren zur Ermittlung einer Temperatur und eines spektralen Emissionsgrads einer mit Solarstrahlung bestrahlten Fläche
Simon Caron (DLR)

Demonstration at commercial plant

DLR, Germany; CSPS, Spain

(a) T
came
tube



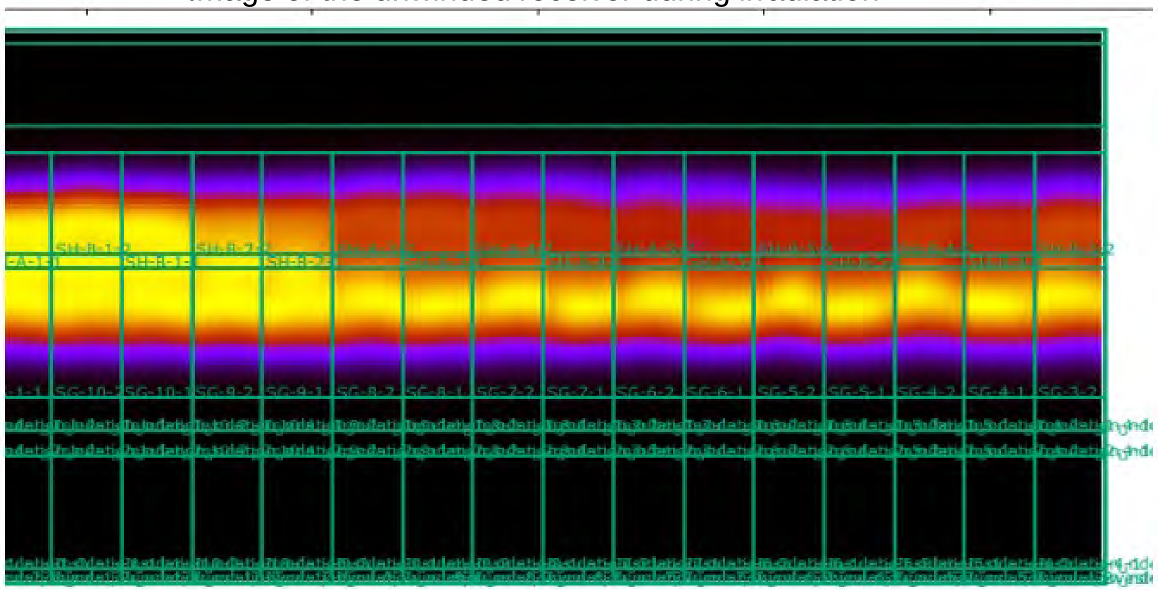
(a) (b)

Figure 1: (a)scan result (maximum image) of the tube receiver, (b) false color image of the irradiated tube receiver

Heliostat Field Control using GPU

Brighsource Energy, Israel

Image of the unwinded receiver during irradiation



The Y axis of the grid represents the height axis, and the X axis represents the peripheral dimension on the receiver, where x=0 is the north

The objective of this task was to develop **GPU-tailored software** and to integrate it into the heliostat field control system. Using GPUs in the **aiming control procedure** has the potential to significantly shorten its running time which is especially precious during cloudy or transient situations.

- using GPU for calculation of projection on the flux map
- each thread deals with a small number of pixels
- several thread configurations have been tested to achieve the best result

Threads per block	Avg Runtime, 100X180 [msec]	Gpu time [msec]	Avg runtime 1000X1800 [msec]	Gpu time [msec]
64	3.113	299.345	8.553	5.654,09
256	3.070	340.961	8.564	5.618,82
512	3.331	428.812	9.379	6.381
1024	3.310	433.553	10.073	7.055,77

optimal runtime using **256 threads** per block – for **high flux map resolution** (1800X1000) and 64 threads per block for the normal resolution

Results

- A camera based system was developed to **measure the flux density** on tube receivers
- A camera based **emissivity and temperature measurement system** was developed
- A **Heliostatfield optimisation** was developed by means of a GPU based simulation tool
- A **measurement campaign** was performed at the MEGALIM Solar Tower Plant

- Delays in another project forced us to build and set up a test receiver on own expenses.
- Due to the Covid-pandemia several constraints and delays were experinced
  - Emissivity and temperature measurement system could not be sent to Israel due to long lead time
- A request for a cost-neutral extension of the project was unfortunately not answered

Contents – What to Present about your Transnational Project

- Scientific, technical, commercial challenge(s) addressed
- Key outcomes, results and benefits
- Experiences gained in transnational set-up
- Critical factors and lessons learned for future successful transnational R&I projects

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- Speak up to **10 minutes maximum**
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- Be specific about the challenges and outcomes (not too general nor too detailed)
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- Present up to 8 slides maximum
- Send your presentation (ppt) to era-energia@aei.gob.es by 20 September the latest

Nano4CSP

Nanomaterials for reduced maintenance costs in CSP plants

Konstantinos Giannakopoulos (Coordinator)

Institute of Nanoscience and Nanotechnology

National Centre for Scientific Research "Demokritos"

Greece

Overall Objective:
To reduce the O&M costs and water consumption while increasing the efficiency of a CSP solar collector field

Specific Objective:
Tuning the properties of **self-cleaning surfaces** to the specifications of CSP applications:

maintaining high mirror reflectivity

reduce the plant water consumption

(1% reflectivity loss → 1% increase of cleaning cost)

Tasks:
Tuning of scalable processes in order to:

Minimize diffuse reflectance

Keep very high optical transmittance in the 250-2500 nm range

Keep stability to UV, humidity, dust/wind abrasion,

high temperatures, thermal cycles, etc

Durability - lifetime similar to that of the heliostat: 20-30 years

Testing in real operational environment

Market study

Partners – Roles

Coating Materials:

National Centre for Scientific Research “Demokritos” (NCSRD) - *Greece*

- Electron Microscopy and Nanomaterials
- Nanotechnology Processes For Solar Energy Conversion and Environmental Protection
- Plasma Enabled Nanofabrication and Applications

Montanuniversitaet Leoben (MUL) – *Austria*

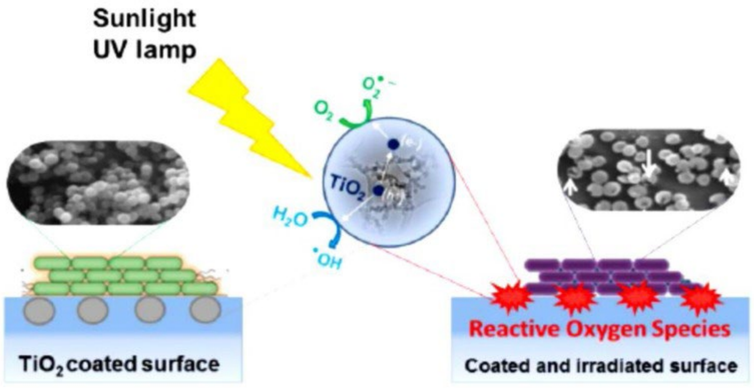
BFP Hellas (BFP) - *Greece*

CSP evaluation:

Cyprus Institute (CYI) - *Cyprus*

Coating Material	Function	Method	On existing mirrors	Thickness scale	Partner
Undoped TiO_2	Superhydrophilic	Magnetron Sputtering	Yes	10	NCSRD
Undoped TiO_2	Superhydrophilic	Hydrosol – Dip Coating	No	40 nm	NCSRD
Doped TiO_2 & Nanoparticles of TiO_2	Superhydrophilic	Magnetron Sputtering	No	10-100 nm	Leoben
Polymers (COC etc)	Superhydrophobic	Surface nano-texturing and plasma treatment	Yes	μm	NCSRD
SolarSkin & Thorasil	Hydrophobic	Spraying	Yes (application also on site)	• μm	BFP

Self-Cleaning Mechanism (A)

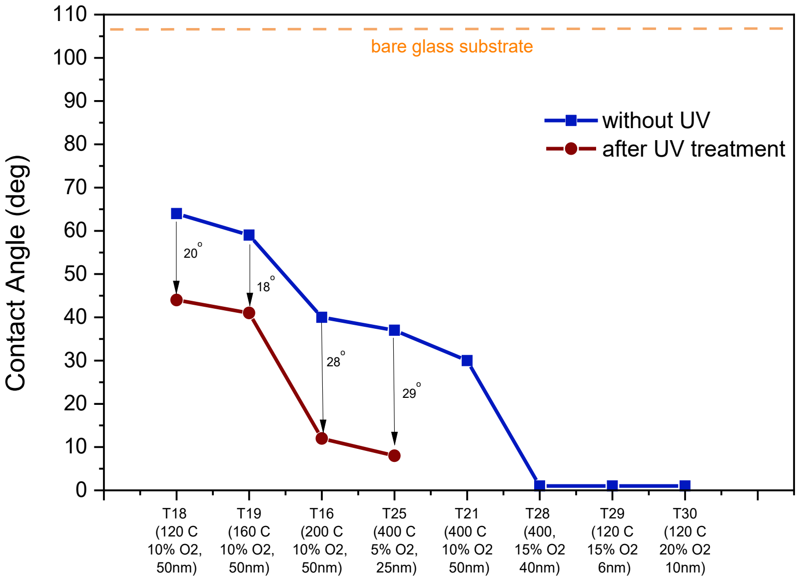


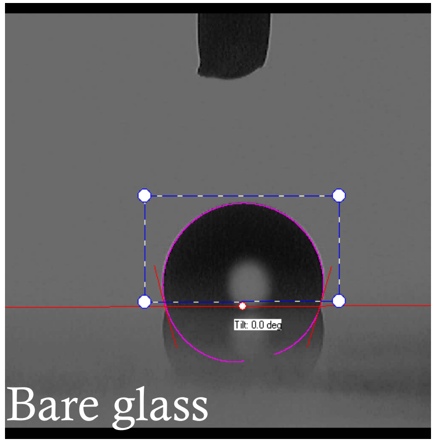
An example of work (Sputtered TiO_2)

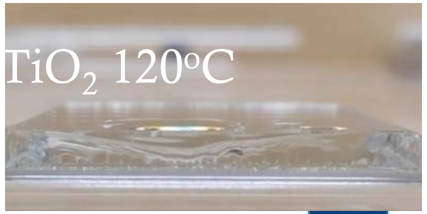
Transparency: Ultra-thin
Low cost: Low Temp (on existing mirror)

Contact Angle Measurements

- Bottom: TiO_2 coated at 120°C: <1°

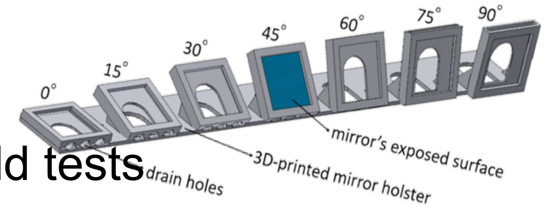


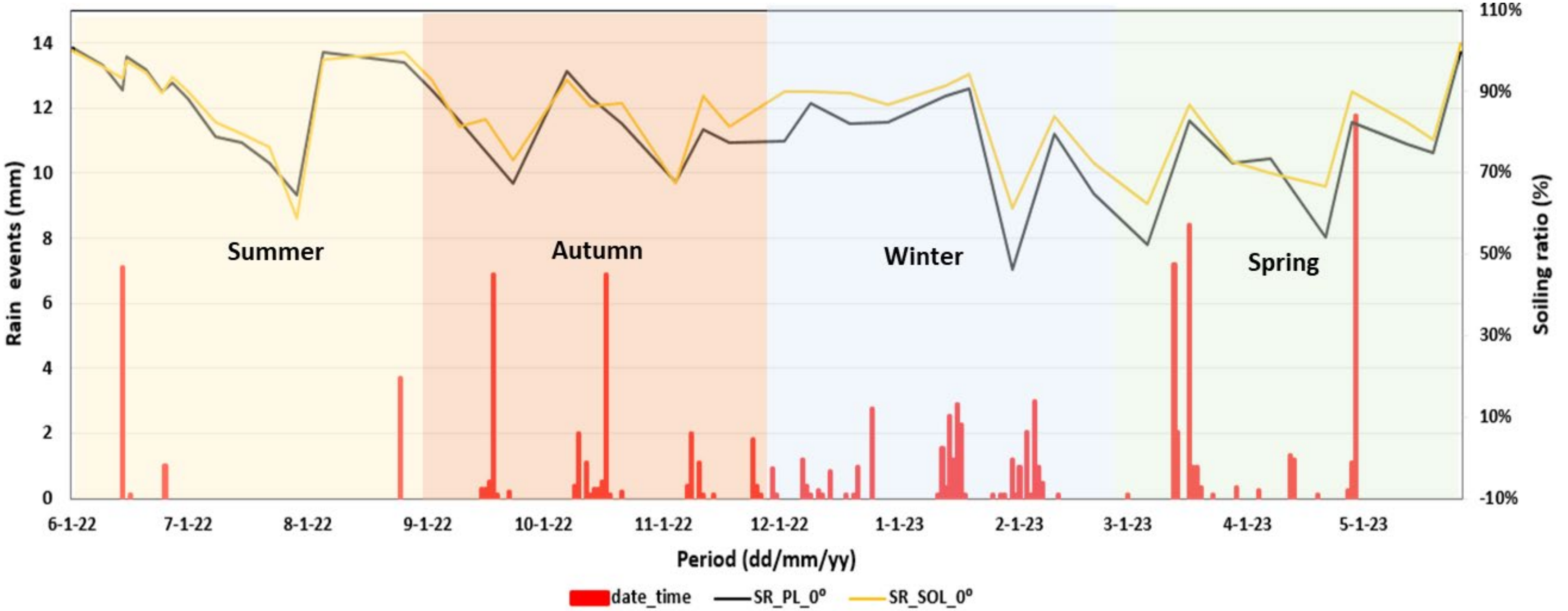




Field Testing (CYI)

Field tests





Sol-Gel - 0 deg

Result Summary

Dependance on the coating /substrate used - All technologies showed positive aspects

Simulations show (based on our measurements):

Annual reflectance efficiency increase:	1-3% / 5-8%
Mirror cleaning cost decrease:	3-8%
Reduction in water consumption:	3-8%
Weighted average levelized cost of electricity (LCOE) decrease:	0.8% - 1.5%

Cost of coating: 2- 5 €/m^2

Durability

Best results came from the less durable samples
Need to collaborate with mirror manufacturers

Experience gained in transnational set-up

- Importance to **cross scientific disciplines**: one's weakness is someone else's strength
- Importance to **cross borders:** Good partners are not necessarily near you
- There is a wild variation of **bureaucracy** in Europe: from minimal to maximal

Critical factors and lessons learned for future successful transnational R&I projects

- There is a need for precise planning of the **funding flow**
- Such projects provide a great opportunity to **harmonise** the various national funding rules across the EU

Thank you!

National Centre for Scientific Research “Demokritos”
Konstantinos Giannakopoulos
Evagelos Goggolides
Polycarpos Falaras
Andreas Kaidatzis
Michail Arfanis
Angleos Zeniou
George Papadimitropoulos
Nafsica Mouti (also at MUL)
Dafni Papadopoulou
Christos Kouzios

Cyprus Institute
Kypros Milidonis
Manuel Jesus Blanco
Aristides Bonanos
Andreas Eliades

BFP Hellas
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CSP ERA-NET has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

EuroPaTMoS
European Parabolic Trough with Molten Salt

Presented by
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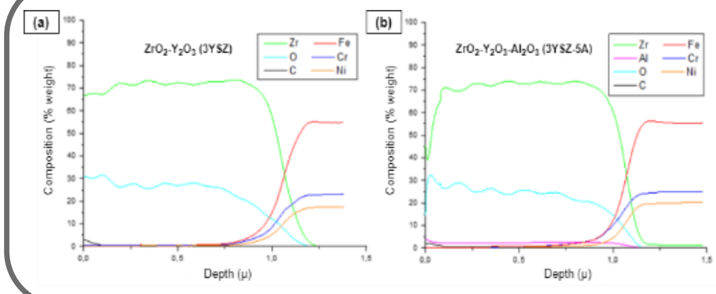
"Exchange od Experiences" Webinar – 28 September 2023

CSP ERA-NET has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

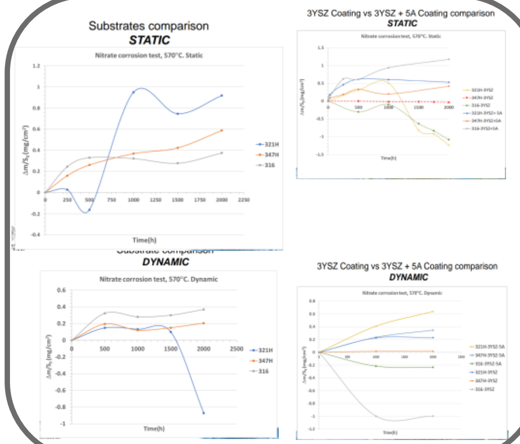
Exchange of experiences Webinar 230928

WP1/2 Corrosion (UCM/Uex/DL)

Characterisation test on coatings



Corrosion test on coatings

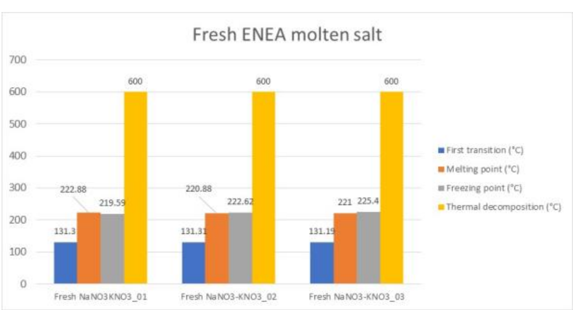


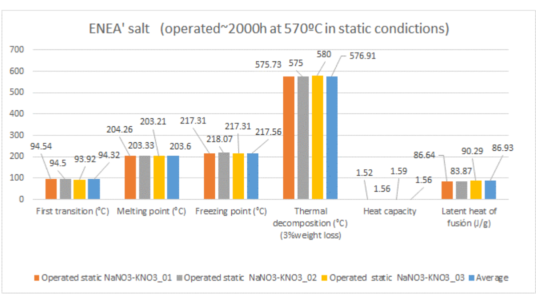
Extensive corrosion tests, including dynamic test methods, were carried out at UCM, along with in-depth characterisation processes by UEX and UCM.

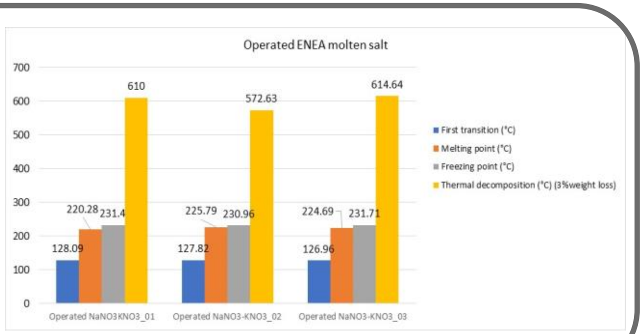
The results, together with a compilation of existing knowledge on molten salt corrosion, were compiled as a best practice guide for component suppliers and plant developers.

In addition, extensive chemical and thermophysical analyses of the molten salts before and after operation were carried out at UCM in order to assess degradation problems in both composition and thermal properties.

Thermophysical analyses of the molten salts







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Exchange of experiences Webinar 230928

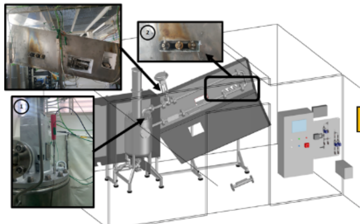
WP1/2 Corrosion (UCM/Uex/DL)

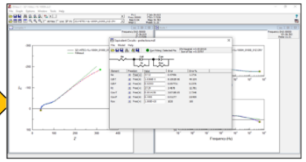
WP 2.4 Plant monitoring system (Ductolux, UCM)

2. Concept test. Corrosion. Lab.

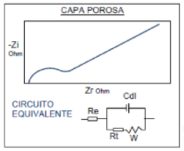
Digital Architecture

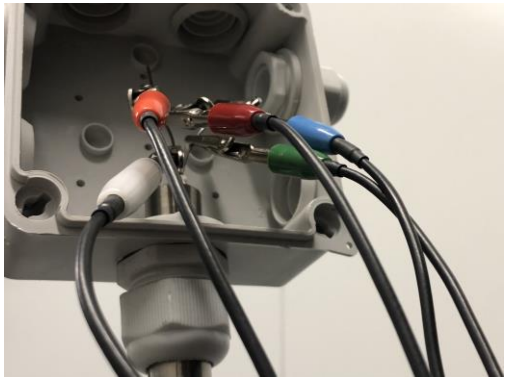
Fase	Necesidades
Ingesta	• Sensores en tiempo real
Limpieza	• Procesamiento y preparación de datos para su posterior análisis • Cálculo de datos derivados
Almacenamiento	• Distribuido, tolerante a fallos y elástico • Acceso a históricos con baja latencia
Análisis	• Detección de anomalías
Visualización	• Exploración visual de los datos en un cuadro de mando
Explotación	• Uso de los datos para planificar acciones de mantenimiento





Electrochemical Impedance data collection in the lab.

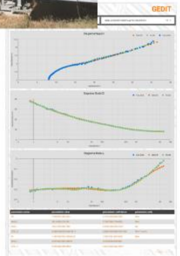




Online corrosión monitoring system onto the molten salt tank

WP 2.5 Real-time long-term tracking of molten salt (UCM, UEvora, Ductolux)

- The static sensor was successfully installed in the drainage tank at EMSP
- The cabling up to the data acquisition equipment is been structuring by Ductolux and UCM during Oct.



DUCTOLUX, UCM, UEX and DLR

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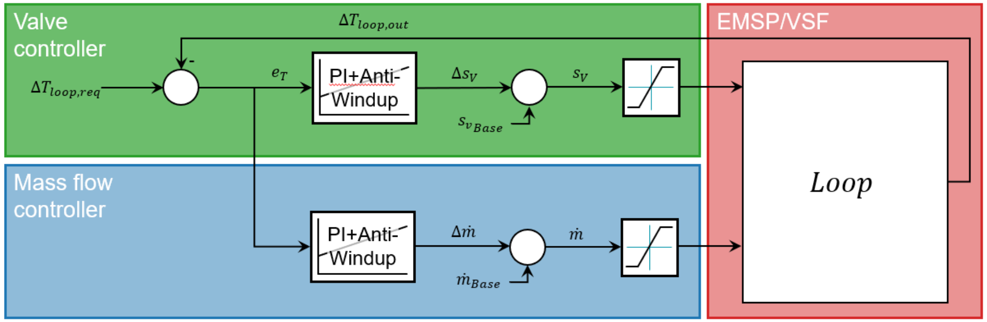
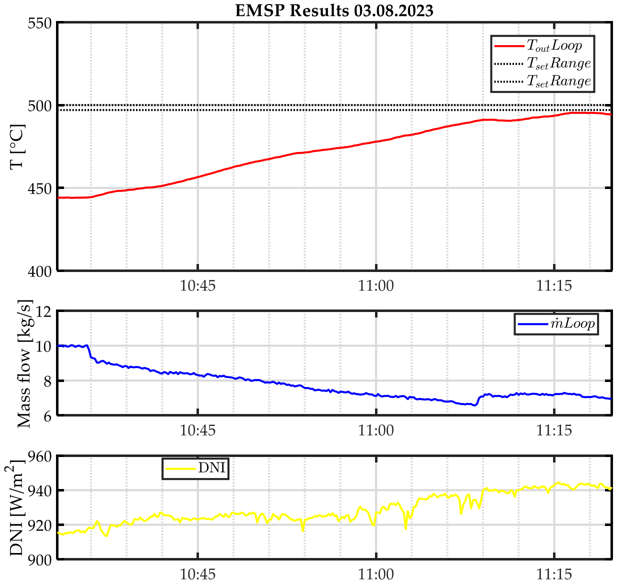
WP2 Control-System for Parabolic Trough with Molten Salt

- Reference solar field with molten salt implemented.
- Spatially resolved irradiation maps generated for simulation of dynamic effects.
- Control concepts for start-up and night mode developed
  - 1st concept: Homogeneous distribution of mass flow in each loop
  - 2nd concept: use of control valves at the inlet of each loop
- Control concepts tested with Virtual Solar Field (VSF) and on Évora Molten Salt Platform (EMSP)

Figure below: Representation of control concept with control valves for a loop.
Figure right: Test of startup from 440°C to 500°C on the EMSP.





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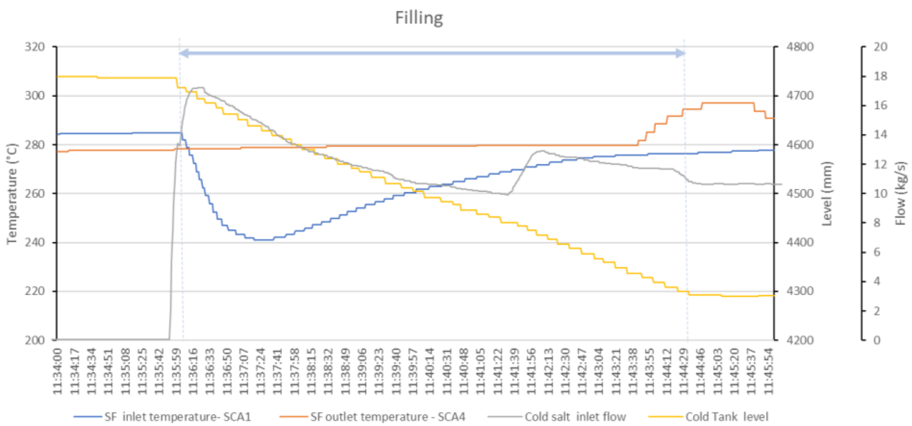
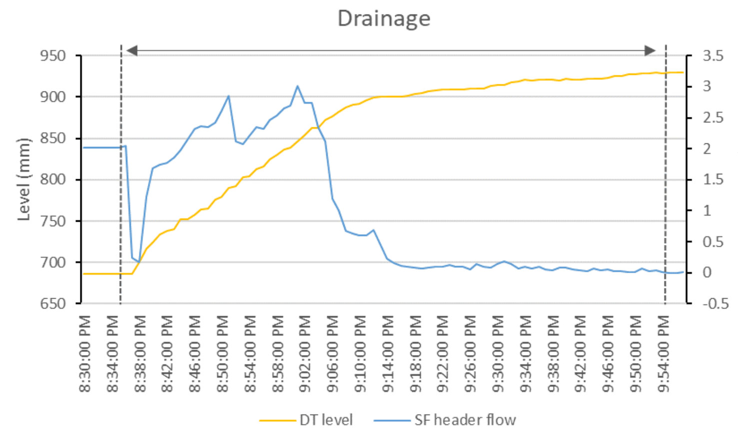
EuroPaTMoS - European Parabolic Trough with Molten Salt

WP1/3 Component tests/O&M processes (FLG/ENEA/UEvora)

Demonstration of molten salt-specific operations at EMSP: Solar Field filling and drainage with Yara Most Molten Salt (Uevora)



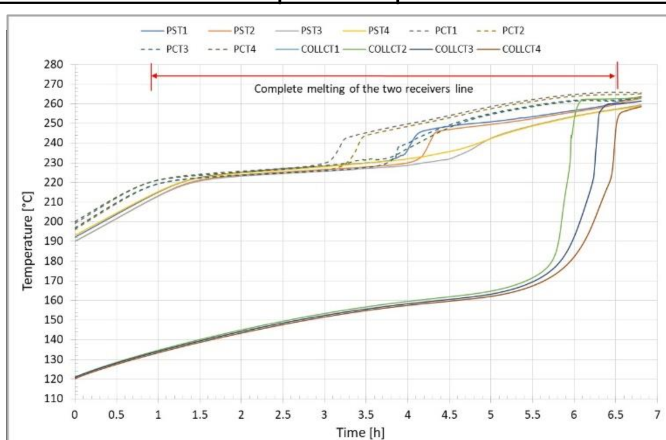
Typical filling graph



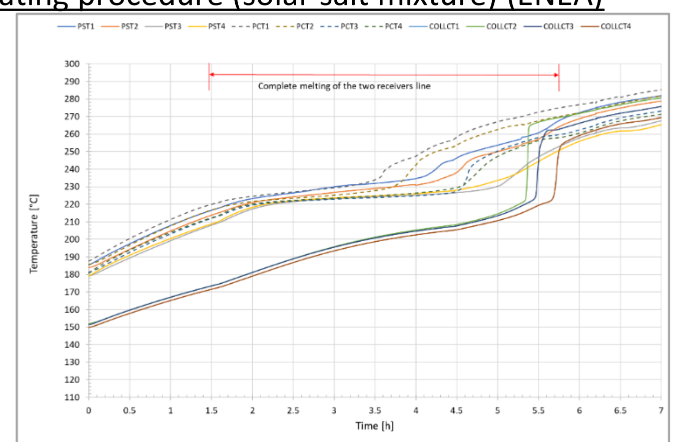
Typical drainage graph

Demonstration of molten salt specific operations ENEA melting procedure inside of receiver tubes (solar salt mixture) (ENEA)

Demonstration of molten salt specific operations ENEA PCS plant preheating procedure (solar salt mixture) (ENEA)



Temperature inside the not - evacuated receivers during the melting process



Temperature inside the evacuated receivers during the melting process

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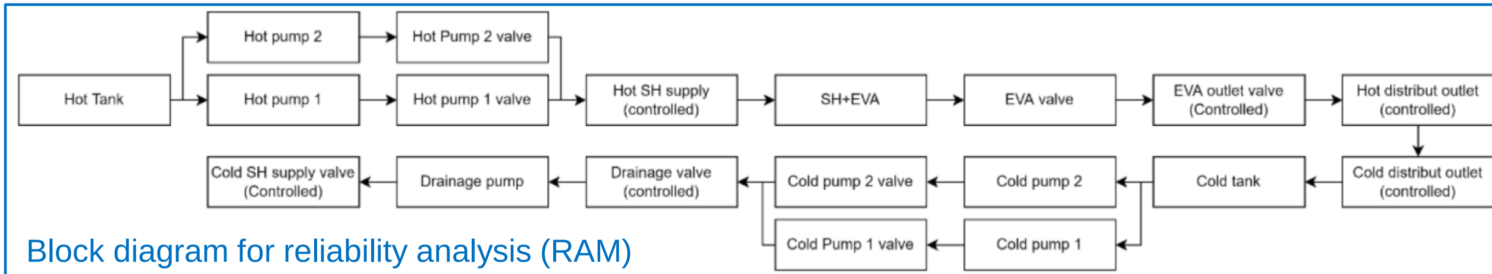
WP4 Systematic risk assessment for molten salt line focusing systems

- Example: Reliability, availability and maintainability analysis of MS plant subsystems



Block diagram for reliability analysis (RAM)

- Example: Failure Mode Effects and Criticality Analysis of MS plants

Structural Analysis (Step 2)			Failure Analysis (Step 4)			Risk Analysis (Step 5)				Optimization (Step 6)				
1. System	2. System Element	3. Component	1. Failure Effects (FE)	2. Failure Mode (FM)	3. Failure Cause (FC)	Severity (S)	Occurrence (O)	Detection (D)	DFMEA AP	Proposed Mitigation Action	Severity (S)	Occurrence (O)	Detection (D)	DFMEA AP
Heat Transfer Fluid	Molten Salt	Salt Mixture	Different chemical composition and properties	Deviations from expected chemical behaviour	Mixing the salt components in a non-predefined mix ratio	5	4	8	M	Countercheck before mixing salt; Taking and analysing control samples after mixing	5	2	3	L
Heat Transfer Fluid	Molten Salt	Ingredients	reduced heat transfer; cavitation risk at pumps	air/water in HTF	leakage from water-steam circuit	4	6	7	M	Regular performance monitoring and check of apparatus, HTF analysis	4	5	4	L
Heat Transfer Fluid	Molten Salt	Temperature	increased HTF degradation, fire	HTF overheating	wrong control of tracking/defocusing	3	8	6	M	Regular performance monitoring and application of correct operation procedure, maintenance of control	3	4	4	L

- Other tasks: -> Life Cycle Analysis of MS plants
  -> Proposal of improved materials and components

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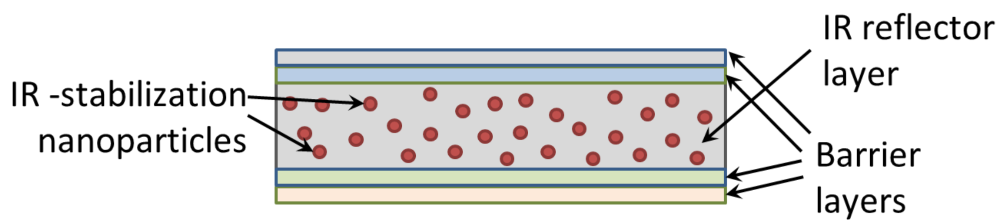
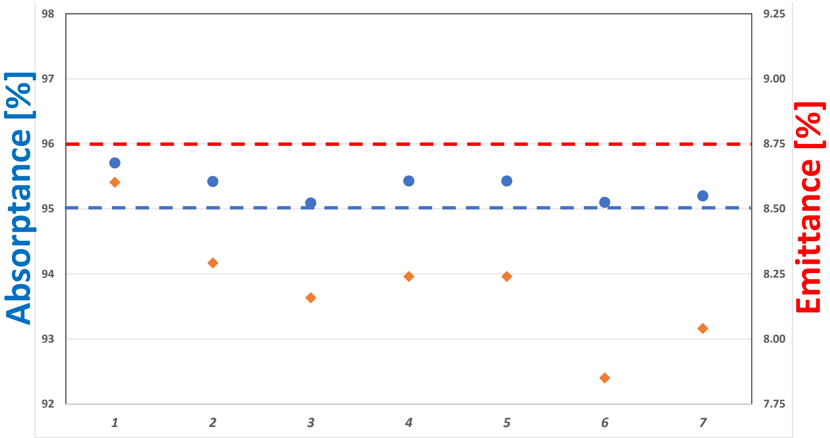
Advanced receiver tube with reduced thermal losses (Rioglass)

Objective:

Develop a receiver suitable for high temperature applications maintaining and even improving performance figures





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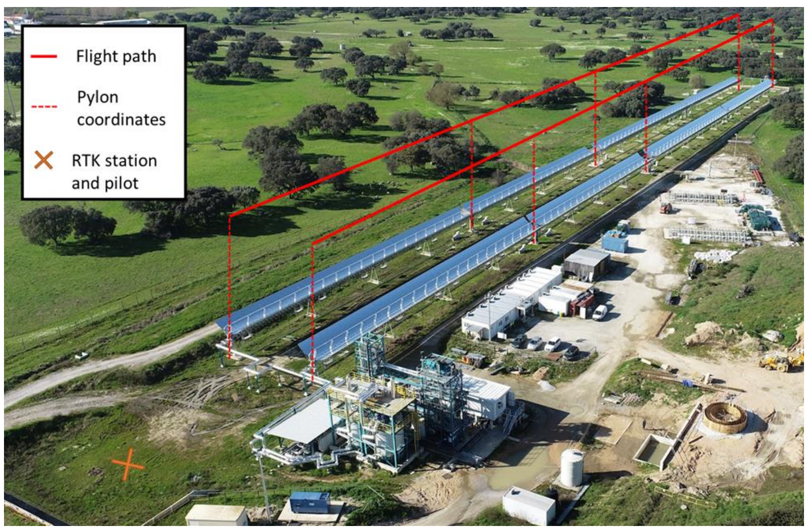
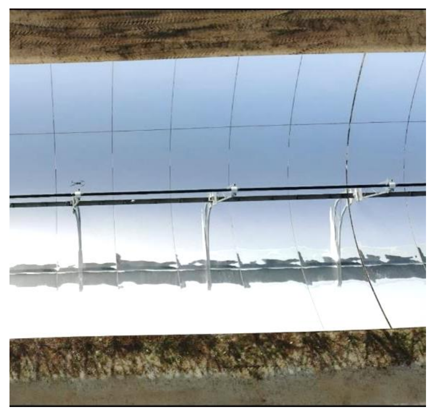
WP5 Development of advanced quality control methods

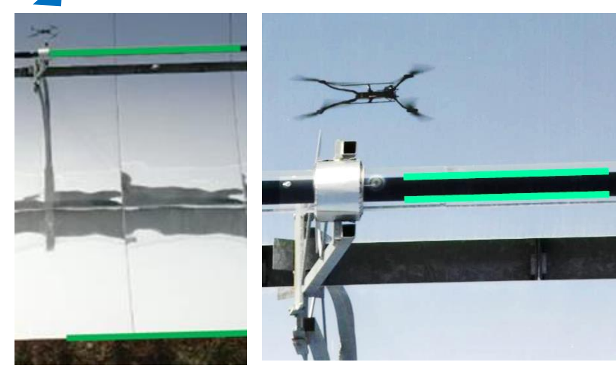
- Analysis of measurement techniques for solar field installation
- Control of receiver / module alignment accuracy
- Development, test and optimization of MS-specific pre-commissioning services



Flight path above EVORA collector loop



Drone measurement picture



Line fitting to assess
module and receicer alignments

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Conclusion:

- Evaluated critical plant components regarding reliability (review of consortium joint knowledge, laboratory testing, operation in realistic environment) (WP1)
- Developed a process control concept based on a virtual solar field, to be validated on a full size collector loop enabling hardware-in-the-loop simulation of a full solar field. (WP2)
- Developed and demonstrated O&M procedures for exceptional molten salt operations (e.g. filling, draining, repair of leakages, re-vitalizing frozen parts) (WP3)
- Carried out and document systematic risk assessment including mitigation measures. (WP4)
- Developed high performance receiver tube and validate in relevant environment. (WP5)
- Provided methods and equipment for advanced QA and monitoring during construction and operation of PTC-MS solar fields (WP5)

Thank you!!

Presented by Michael Wittmann (DLR, Germany)

CSP ERA-NET has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

CSP ERA-NET has received funding from the European Union’s Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

NEWCLINE: Advanced thermocline concepts for thermal energy storage for CSP

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www.newcline.eu

“Exchange od Experiences” Webinar – 28 September 2023

CSP ERA-NET has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

Project objectives and transnational factors

- Development of **new thermocline concepts** that can be applicable to different CSP plants (PTC and CR)
- Two concepts related to materials are proposed:
  - Use of innovative **structured ceramic filler refractories**
  - Combination of the solid filler material with specially selected encapsulated PCM located at strategic regions of the tank (**multi-layered TCF**)
- **Official project coordination started in May 2021**. However, and due to the National Agencies administrative/evaluation process, some partners started in **November 2020**, while others in **May 2021**. This issue is affecting a possible project extension.
- **It is suggested for future transnational R&I projects** to synchronize the participation of all the partners as much as possible.

CSP ERA-NET has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

Consortium and experiences gained

Empresarios Agrupados Internacional S.A. (EAI), Madrid, Spain	Kraftblock (KB), Saarbrücken, Germany	Universitat Politècnica de Catalunya-BarcelonaTech (UPC), Spain	German Aerospace Center (DLR), Cologne and Köln, Germany	Institute for Solar Technology (SPF), Rapperswil, Switzerland

- **Strong interaction between the partners**. From May 2021: 5 biannual meetings, 25 progress meetings, and more than 65 bilateral meetings
- **Complementary background among partners**: advanced numerical simulation (UPC); experimental studies on thermocline systems (DLR); material development (KB); material compatibility (DLR); design from an engineering point of view / up-scaling (EAI); development of system simulation framework and thermo-economic analysis (SPF)

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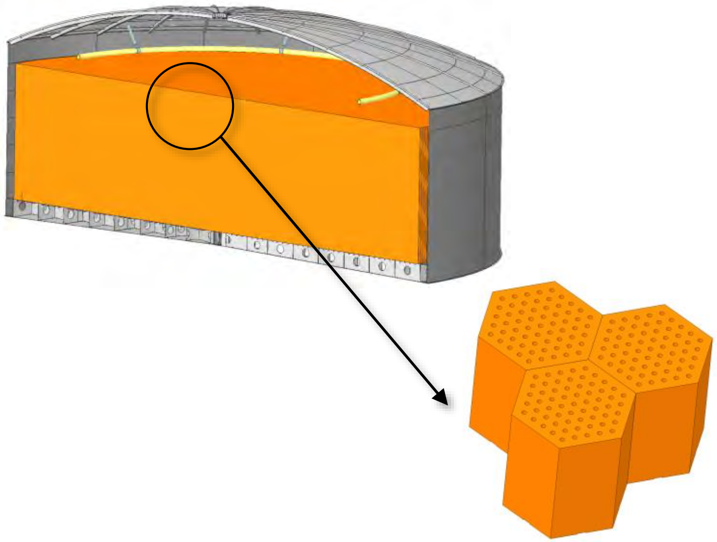
Key outcomes, results and benefits

- Novel analysis of **structured thermocline fill**er (TCF) without and with encapsulated PCM (EPCM) material using different simulation levels
- **Material development** based on waste ceramic products, and material compatibility of the solar salt and the filler material
- **Experimental studies** of the structured filler material and the multilayered EPCM
- TCF conceptual design from an engineering point of view; **up-scaling design** of the TCF tank concepts
- **Integration of the TCF concepts in the whole CSP plant** through transient dynamic simulations
- **Significant LCOE reduction** compared to two-tank solution



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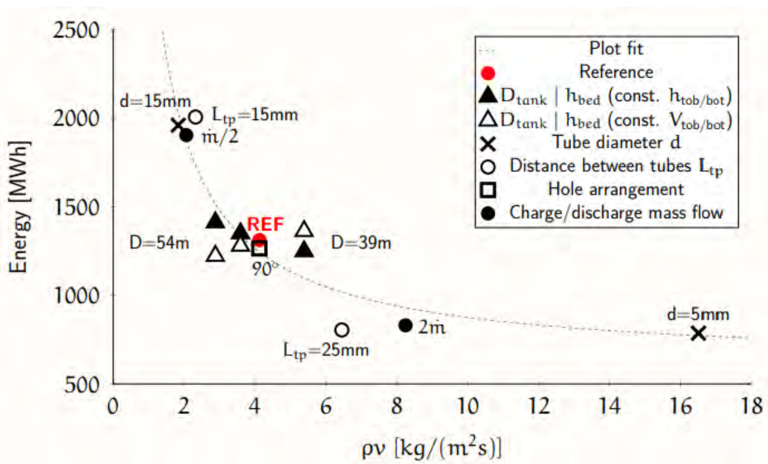
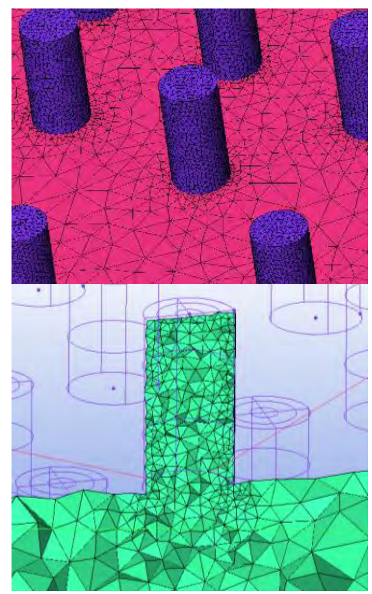
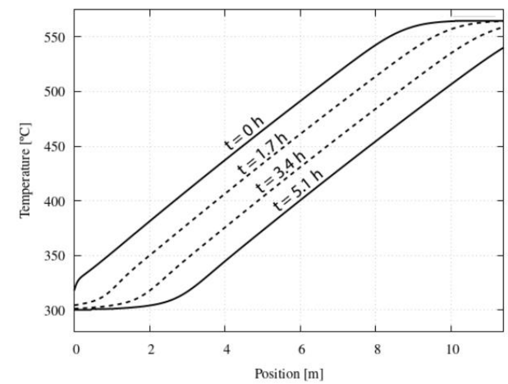
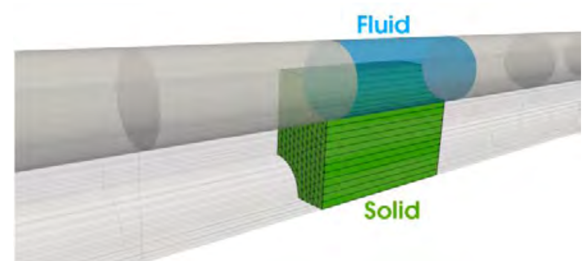
Simulation tools for structured thermocline

- **Three levels of analysis** fluid/structure: 1D/1D, 1D/3D, 3D/3D. Filler material **without and with EPCM** in strategic parts of the tank









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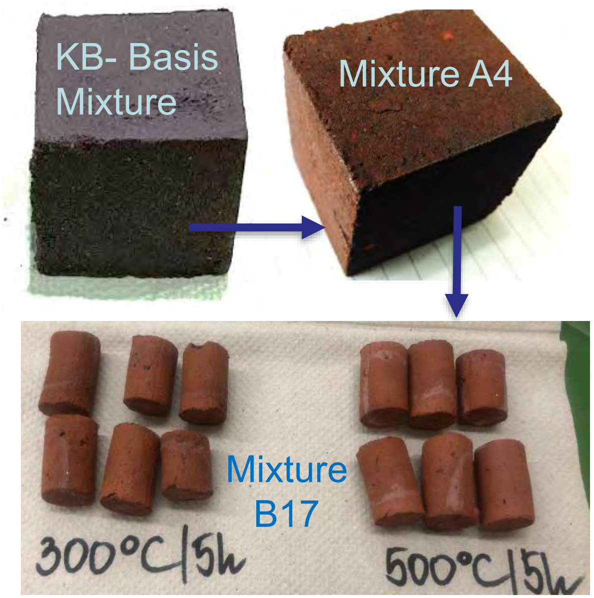
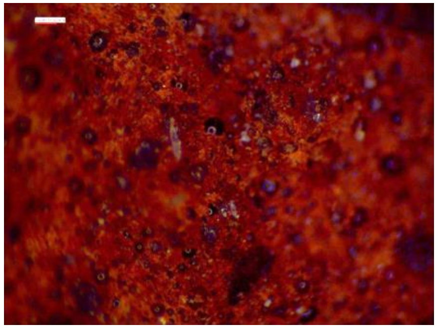
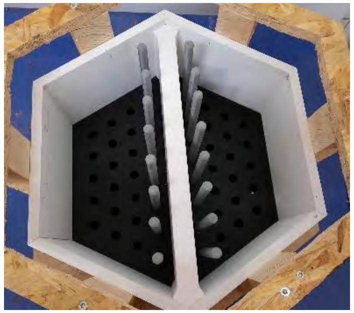
Material development and material compatibility

- Screening of different **recycled materials** and **compatibility tests** with the inorganic binding agent and with molten solar salt; design the **press mould** and filler **checkers production**







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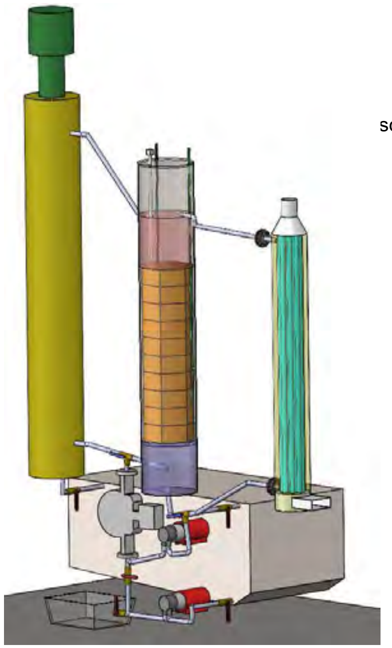
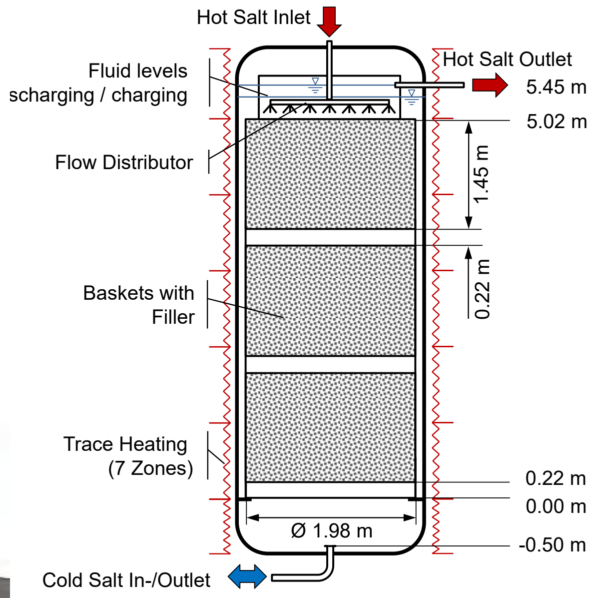
Experimental studies: lab-scale and pilot-scale setups

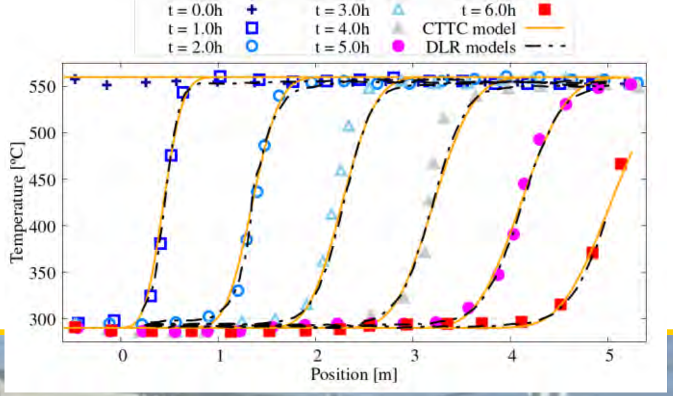
- **Lab-scale** (Barcelona) and **pilot-scale** (TESIS:store facility, 4MWh, Cologne) setups. Test of the **TCF concepts**; mathematical models **validation**



Lab-scale setup



Pilot-scale setup



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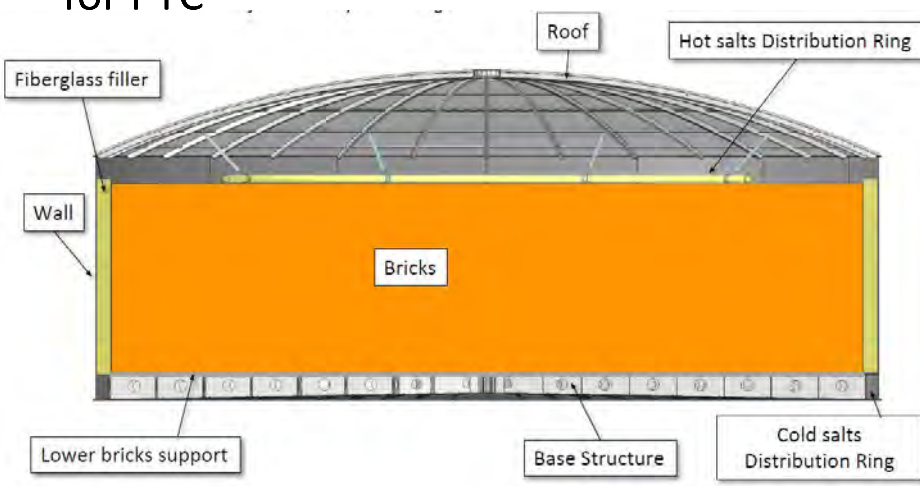
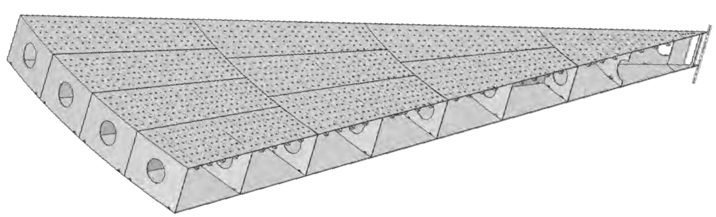
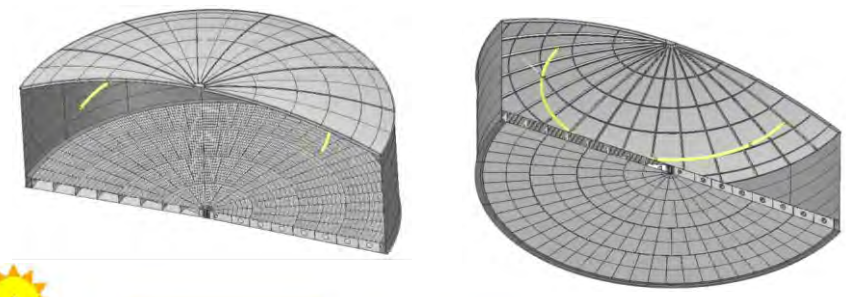
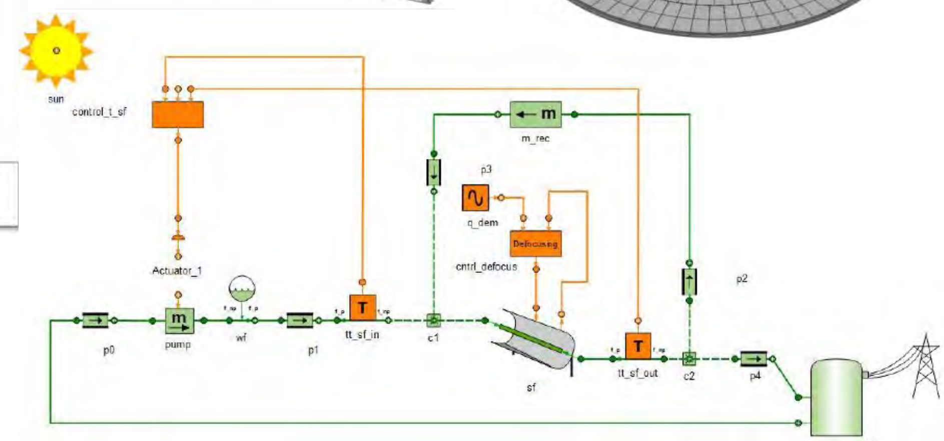
Engineering design of the tank and up-scaling

- **Mechanical design** (tank structure), **civil foundation**, model simulation in **ECOSIMPRO** for PTC









tt_sf_out c2
sf
nh

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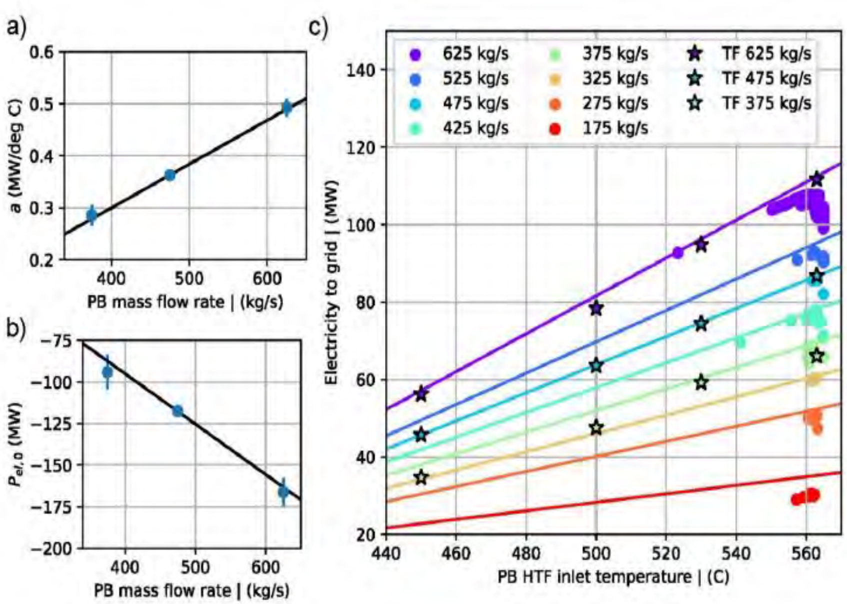
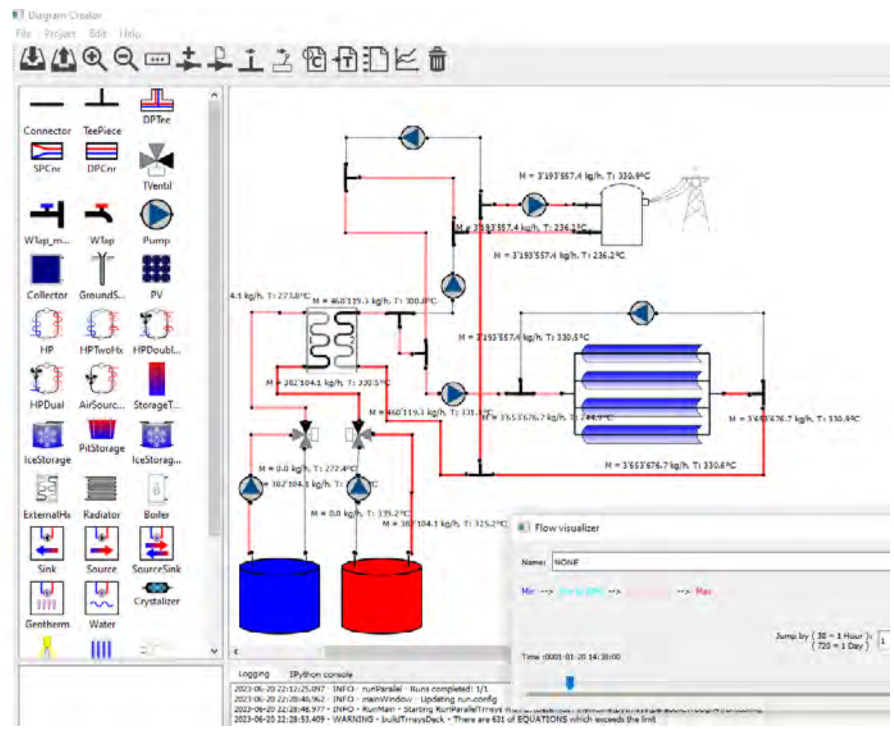
Integration of the TCF concepts in the whole CSP plant

- Open source **Python-based framework** for setting-up, running, and processing TRNSYS simulations; **transfer functions** for the PB





Thank you!!

Presented by Carlos D. Pérez Segarra, Heat and Mass Transfer Technological Centre (CTTC-UPC), Spain

www.newcline.eu

CSP ERA-NET has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

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InnoSolPower

INNOvative SOLar micro-TES with high-POWER density

Sinan Akmandor,
Pars Makina

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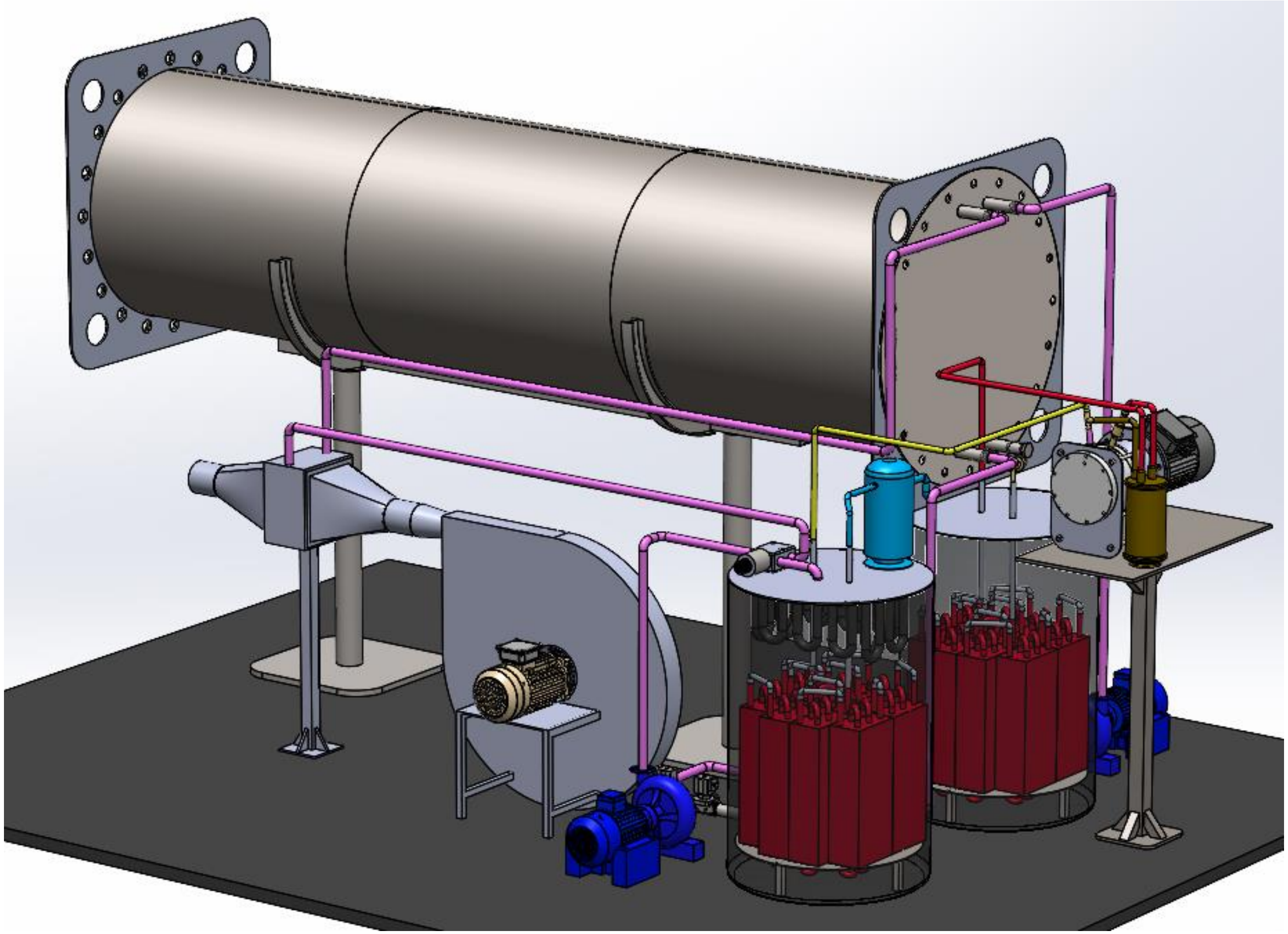
"Exchange od Experiences" Webinar – 28 September 2023

Rosie Christodoulaki, Vassiliki Drosou, (CRES)
Özgür Bayer, Ilker Tari, Seyedmohsen Baghaei Oskouei, (METU)
Guido Francesco Frate, Lorenzo Ferrari, Umberto Desideri (UNIPI)

InnoSolPower is novel

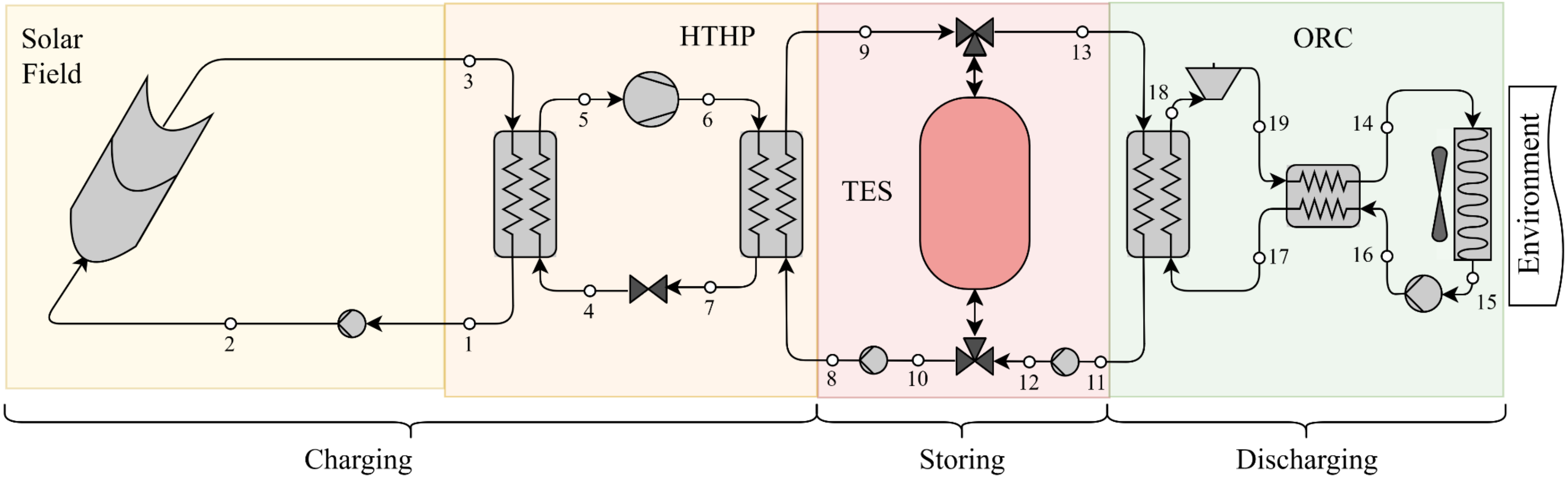
- Safe and environmentally friendly phase change material (PCM salt) **homes, schools and small enterprises**,
- **TES is not pressurized**, PCM salt fully static and encapsulated
- High temperature (>130°C) TES (100°C from local μCSP tracker),
- Novel HTHP with a **high coefficient of performance (COP>10)**
- Plug and run system (manufactured in factory, minimal installation cost),
- **Solar heat is locally produced, stored and consumed**
- 20 year trouble-free operation (minimal maintenance cost)



System model

Parameter	Value
mdot [kg/s]	0.14
p_{in} [bar]	12.40
p_{out} [bar]	19.55
pressure ratio [-]	1.58
T_{in} [°C]	110.00
T_{out} [°C]*	132.50
$W_{el,in}$ [kW]*,**	1.73

- Steady state modelling
- Final layout
  - Components in series
  - Micro-TES connected with intermediated oil loops



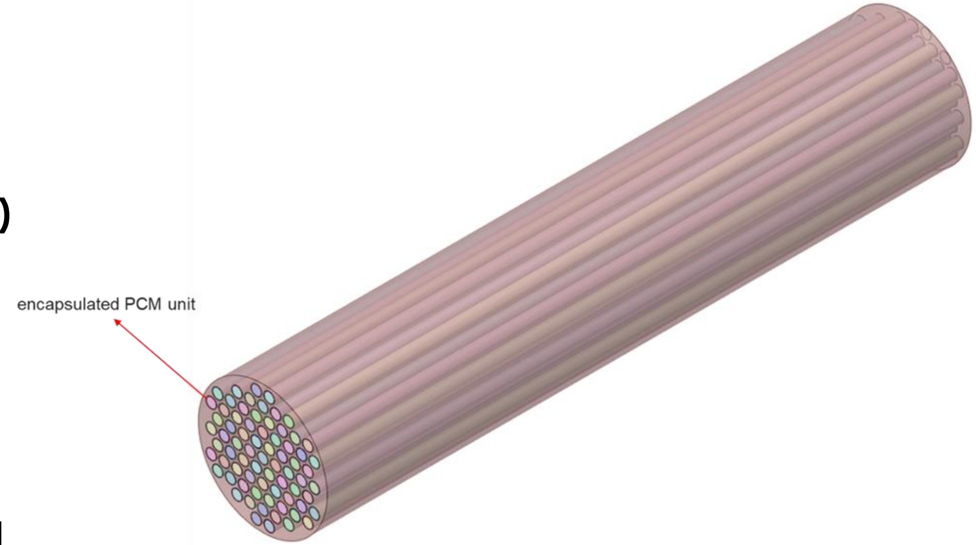
PCM materials & performance

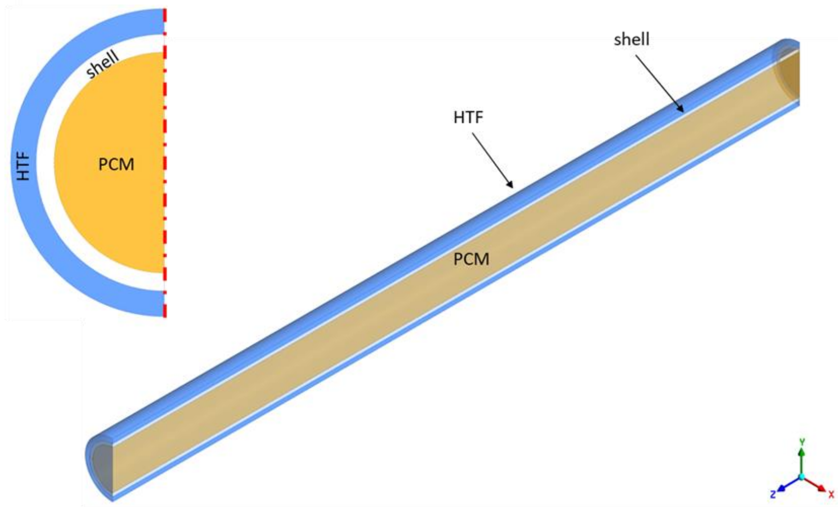
Selected Materials

- Heat storage material: S117 **($MgCl_2 \cdot 6H_2O$)**
- Tank: Steel 306 (Prototype SS304)
- Insulation: Rockwool 70mm
- Heat transfer fluid: Renotherm 320

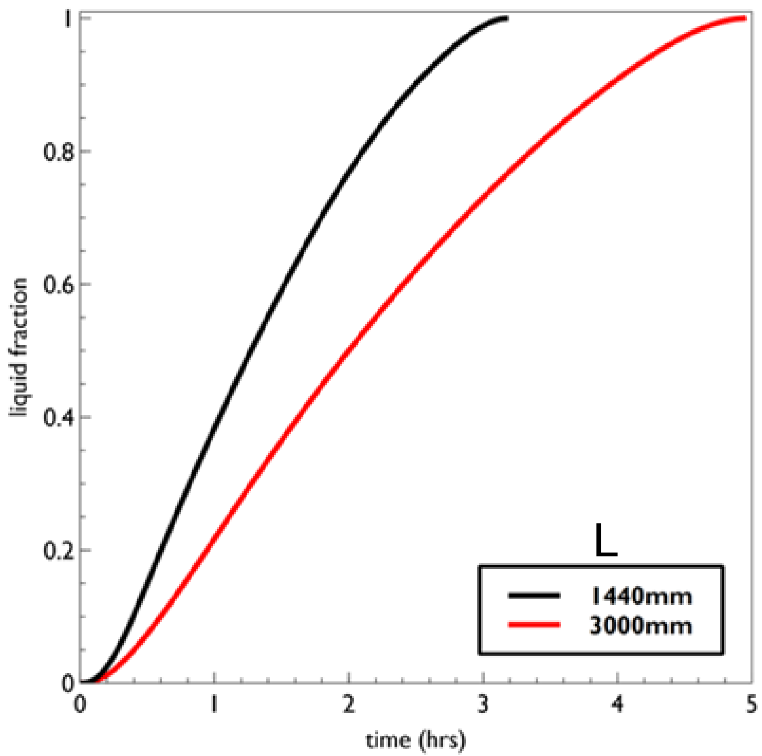
Energy & Power Calculations

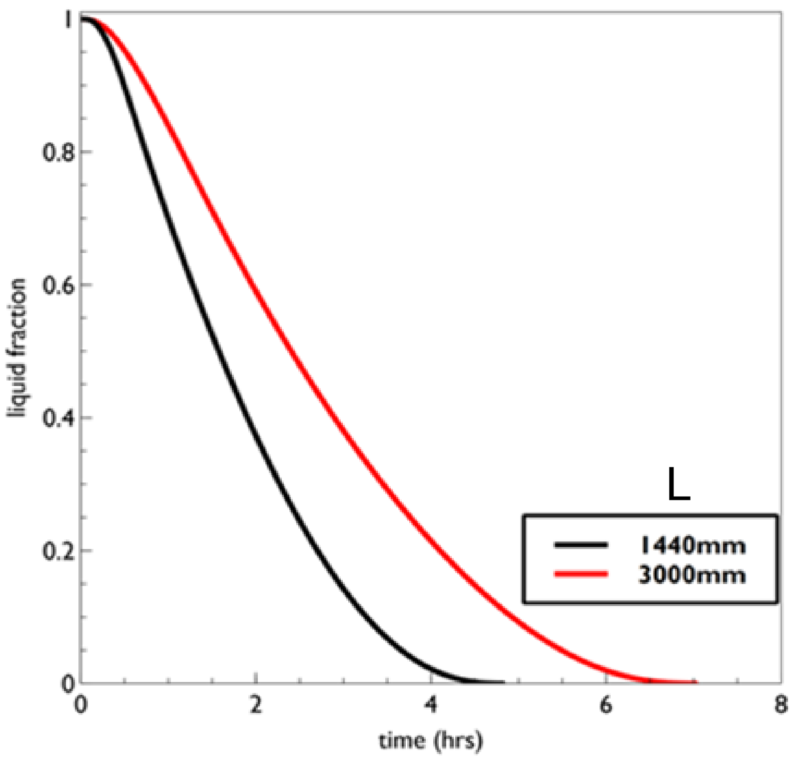
- Charging power 27 kW [prototype: 6 kW]
- Discharging power 48 kW [prototype: 10 kW]
- Total heat strorage capacity 159.8 kWh [prototype: 25 kWh]





Initial TES Design



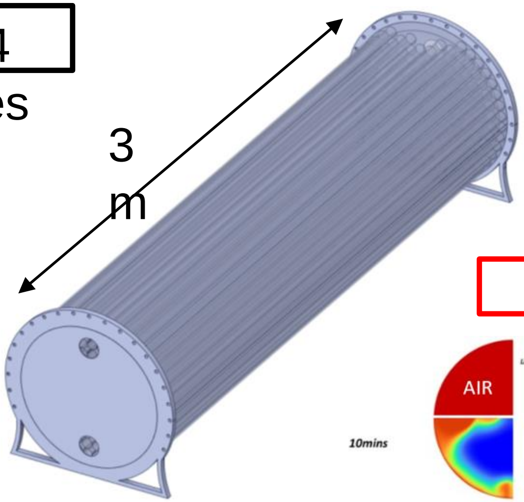


- Stored energy per tube of ***3m*** length: **0.3 kWh**
- Number of tubes: **73** [prototype: 164 tubes]
- **In reality, half of the tubes were filled with PCM**

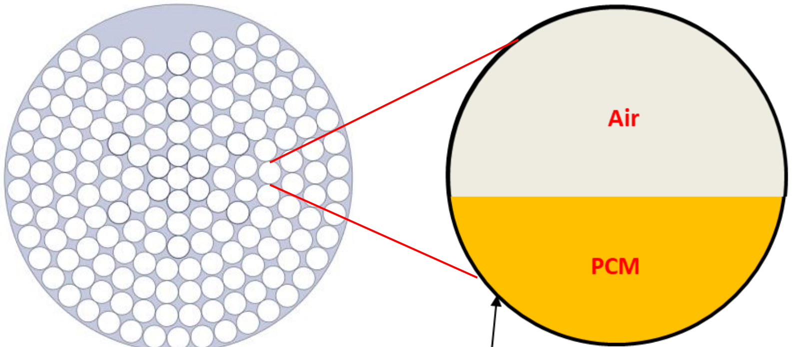
Final TES Design

164
tubes

3 m



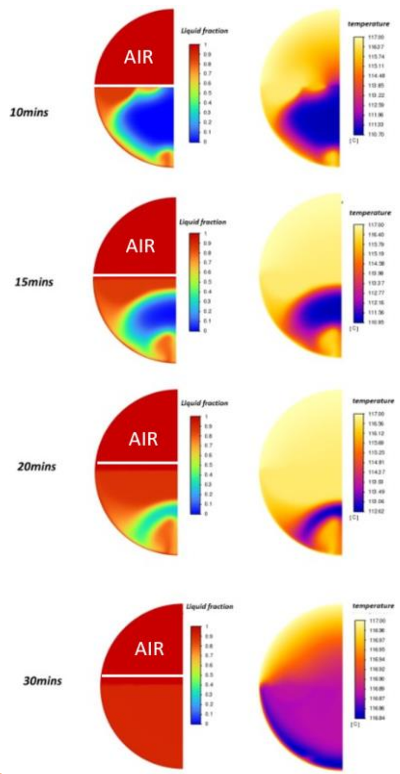
0.78 m



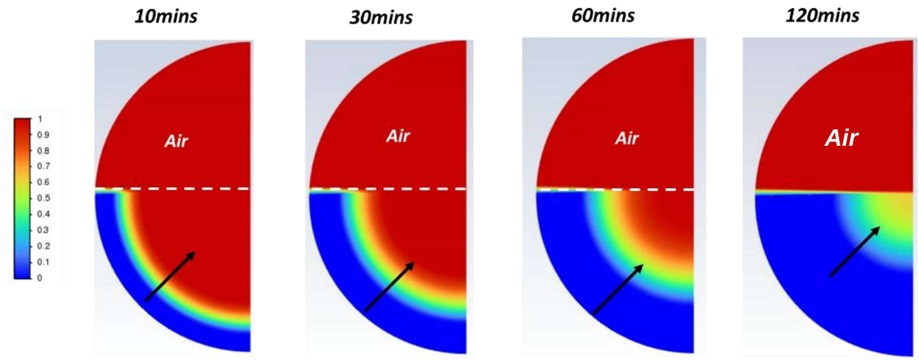
47.7mm

Constant temperature

Melting



Solidification

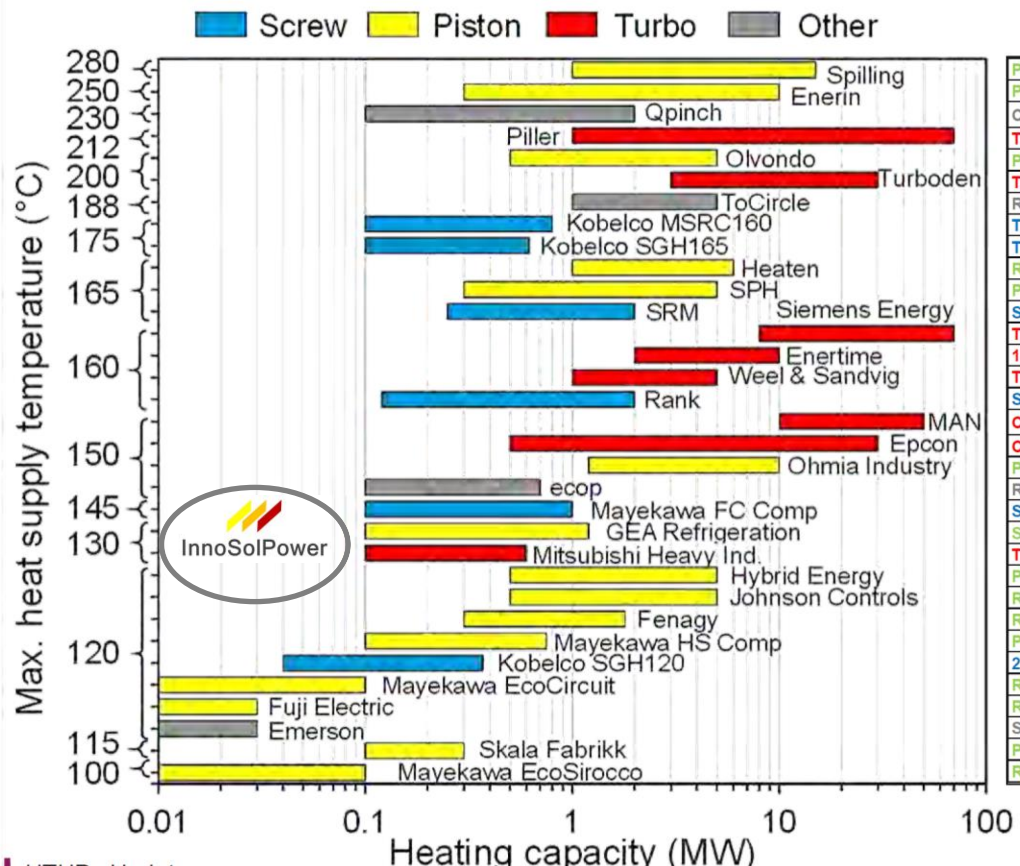


CFD modeling

Enthalpy porosity method
+ volume of fluid

New Developments and Products for Supply Temperatures above 100 °C

Max. supply temperature vs. heating capacity of various HTHPs



Piston (MVR)	R718 (water)
Piston	R704 (helium)
Chemical heat transformer	R718, H_3PO_4 and derivatives
Turbo (MVR)	R718
Piston (double acting)	R704
Turbo	Application specific
Rotary vane	R717 (ammonia), R718
Twin -screw (MVR)	R718
Twin-screw (MVR)	R245fa/R134a (mixture), R718
Reciprocating, custom design	HFOs (hydrofluorolefins)
Piston	HFOs (hydrofluorolefins)
Screw (MVR)	R718
Turbo (geared or single-shaft)	R1233zd(E), R1234ze(E)
1- or 2-stage centrifugal	R1336mzz(Z), R1224yd(Z), R1233zd(E)
Turbo (MVR)	R718
Screw	R245fa, R1336mzz(Z), R1233zd(E)
Centrifugal turbo with expander	R744 (CO_2)
Centrifugal fan / Blower	R718
Piston, Centrifugal fan (MVR)	R717, R718
Rotational heat pump	ecop fluid 1 (He, Kr, Ar)
Screw	R601 (n-pentane)
Semi-hermetic piston	R744
Two-stage centrifugal	R134a
Piston/screw	R717/R718 mixture
Reciprocating	R717, R600 (n-butane) (cascade)
Reciprocating	R744
Piston	R600 (n-butane)
2-stage twin-screw	R245fa
Reciprocating	R1234ze(Z)
Reciprocating	R245fa
Scroll and EVI scroll	R245fa, R410a, R718
Piston (semihermetic)	R290 (propane), R600 (cascade)
Reciprocating	R744 (CO2)

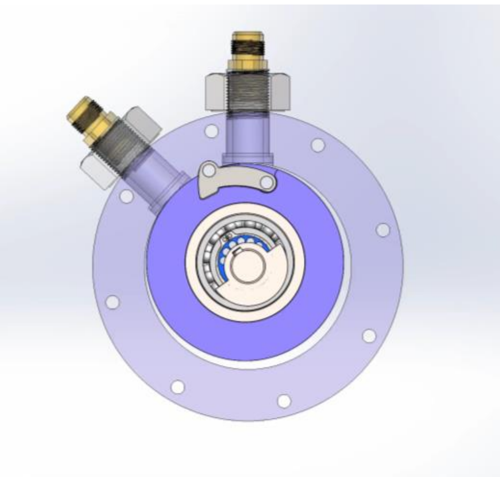
Based on data from IEA HPT Annex 58
https://heatpumpingtechnologies.org/annex58/task1

9 HTHPs Update
22 Feb 2023

cordin.arpagaus@ost.ch

OST

Reference: High-Temperature Heat Pumps for Industrial Applications –New Developments and Products for Supply Temperatures above 100 °C, Webinar: 2023 High-TemperatureHeat Pumps Update, 22 February2023, Institute forEnergy Systems IES, Dr. Cordin Arpagaus



Thank you!!

Presented by Sinan Akmandor, Dr. (Pars Makina, 2023, Turkiye)

CSP ERA-NET has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

CSP ERA-NET has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

SI-CO: High performance parabolic trough collector and innovative silicone fluid for CSP power plants

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mcasanovamolina@acciona.com

"Exchange od Experiences" Webinar – 28 September 2023

CSP ERA-NET has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

SI-CO Project

SI-CO
High performance parabolic trough collector and innovative silicone fluid for CSP power plants

Objectives:

Si-CO will develop innovations in order to achieve the following objectives:

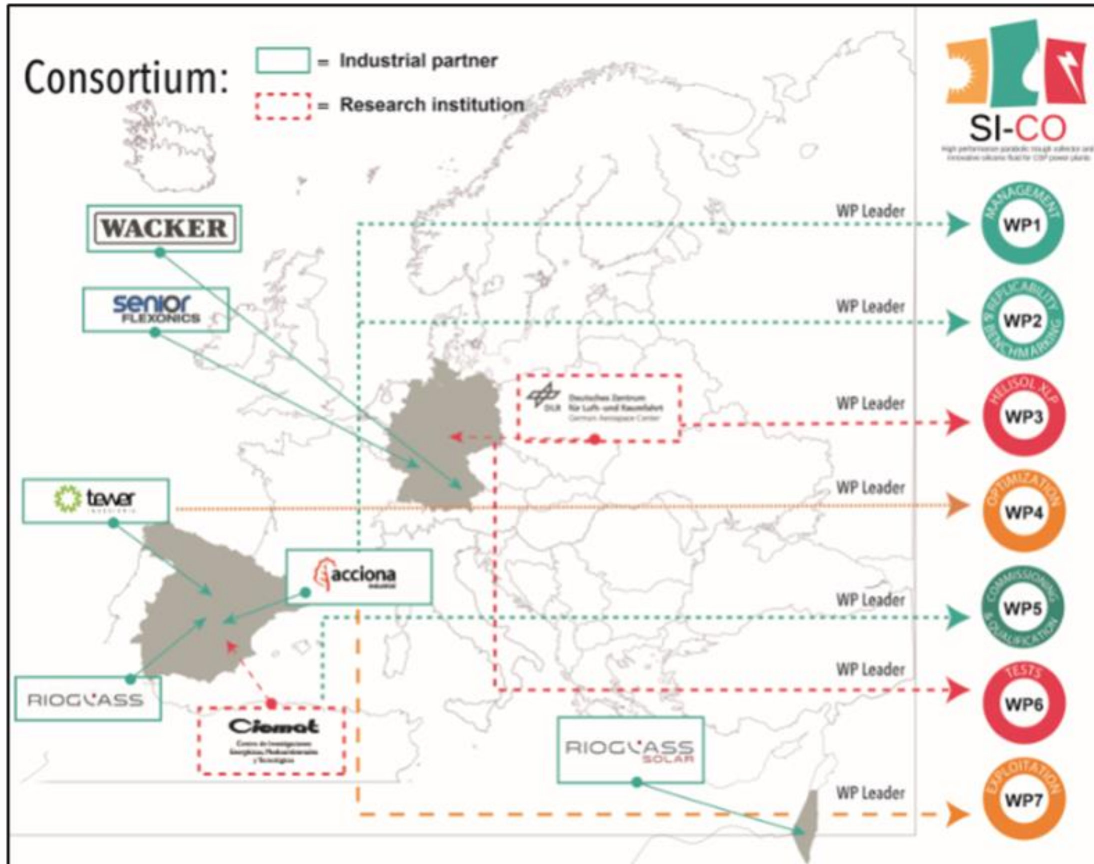
- Increase the operation temperature of PTC plants to 430°C by using silicone fluid
- Validate and demonstrate the Si-CO collector performance using a new silicone fluid
- Remove the existing technical and industrial barriers to optimize parabolic trough designs to reduce CAPEX
- Develop and demonstrate new HCEs with H2 barriers and larger length and improved PTC's components for 430°C.
- Substitute existing BP/DPO (biphenyl/diphenyl oxide) HTF used in state of the art (SOA) PTC power plants, with a new silicone fluid.

CSP ERA-NET has received funding from the European Union’s Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

SI-CO Project

The Consortium:

1. Acciona Industrial
2. TEWER
3. Rioglass Solar (Spain & Israel)
4. CIEMAT-PSA
5. DLR
6. Senior Flexonics
7. WACKER Chemie



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Outcomes:

SI-CO
High performance parabolic trough collector and innovative silicone fluid for CSP power plants

Si-CO project is an innovative solution that aims directly at **cost reduction of PTC with silicone fluid technology**.

- Enhancement of the reliability and the operation temperature of CSP PTC applications using HELISOL® XLP at 430°C
- New Si-PTC with optimized geometry and reduced costs, demonstration to work with HELISOL® XLP at 430 °C
- Validation of the Si-PTC performance using HELISOL®XLP at 430°C
- HCEs and REPA demonstration with selective coating optimized to work with HELISOL® XLP at 430 °C
- Demonstration of the applicability of Si-HTF for existing PTC power plants to prove environmental and O&M advantages

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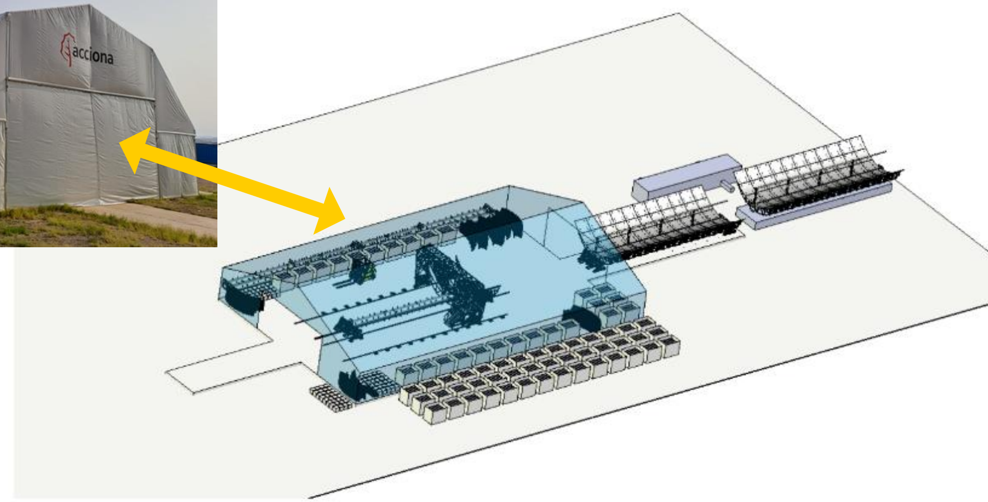
CSP CONCENTRATED SOLAR POWER

Exchange of experiences Webinar 230928

SI-CO

High performance parabolic trough collector and innovative silicone fluid for CSP power plants



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SI-CO
High performance parabolic trough collector and innovative silicone fluid for CSP power plants

Outcomes:

New Parabolic Trough Collector

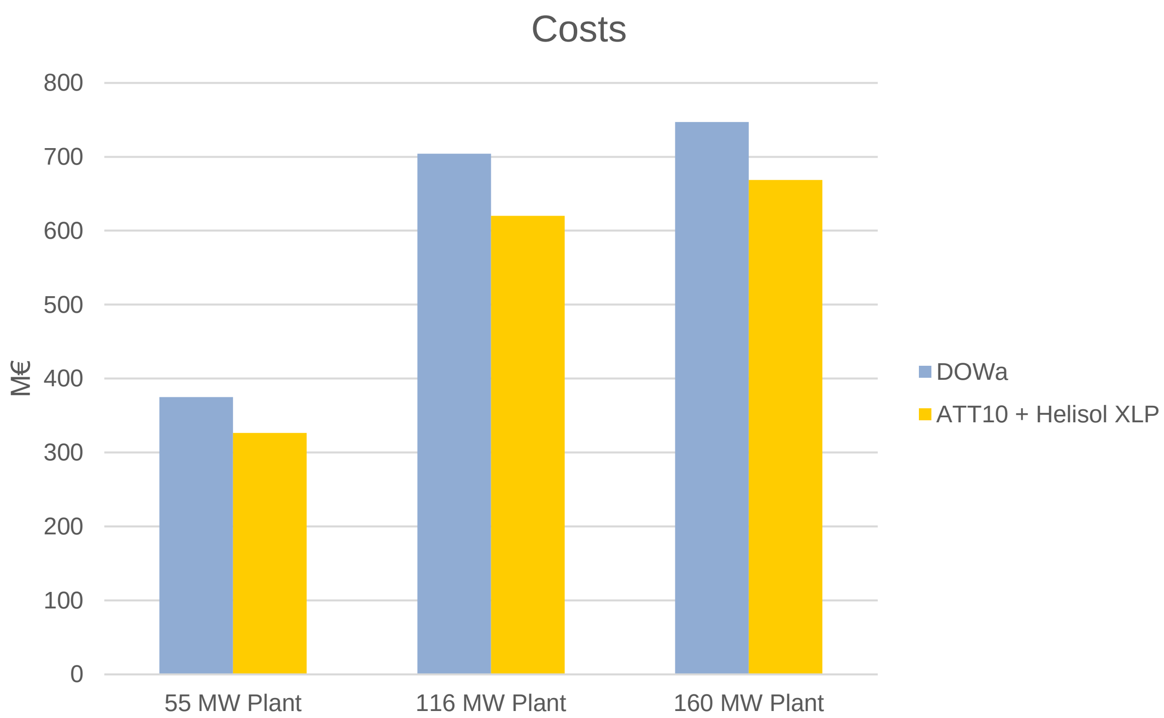
A technical-commercial evaluation of the main commercial components with influence in the geometrical definition of the collector has been performed.

1. Parabola aperture of 8 m, defined by 6 mirrors per section with 4 support points. Mirror width of 1469 mm approximately.
2. Use of absorber tube with external diameter of 90 mm and length of 4.49 mm for the optimization of the thermal gain ratio, pressure drop and solution cost.
3. SCA configuration with a total length of 181 m, thus maintaining a pressure drop in the loop similar to the reference case and current plants.

CAPEX and OPEX Reduction

1. The new PTC using HELISOL®XLP will allow to **reduce the CAPEX** in Solar Field, HTF and TES systems by **16.5%** (26.4M€ out of 160M€).
2. Reduce **OPEX costs by 14%** savings of 0.7M€/year out of 4.8M€.

CSP ERA-NET has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 838311



Storage:	9h	4,5h	3h
Reduction CAPEX:	-13%	-12%	-11%

- Experiences gained:
    - Knowledge acquired and experience in different technical areas

- Critical factors and lessons learned:
    - Funding agencies in different countries should be better coordinated in terms of timing
    - Having different grant conditions for countries makes more difficult the coordination and the participation of partners from other countries

Thank you!!

Presented by Marina Casanova (ACCIONA, 2023, Spain)
mcasanovamolina@acciona.com

CSP ERA-NET has received funding from the European Union’s Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

CSP ERA-NET has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

CSP CONCENTRATED SOLAR POWER

Thermal Energy Storage for Trigeneration (TES4Trig)

TES4Trig

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"Exchange of Experiences" Webinar – 28 September 2023

CSP ERA-NET has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No. 838311

The consortium

TES4Trig

CSP CONCENTRATED SOLAR POWER

cade engineered technologies

protarget

SOLAR & OTHER ENERGY SYSTEMS LABORATORY

MES ENERGY member of MESOGEOS group

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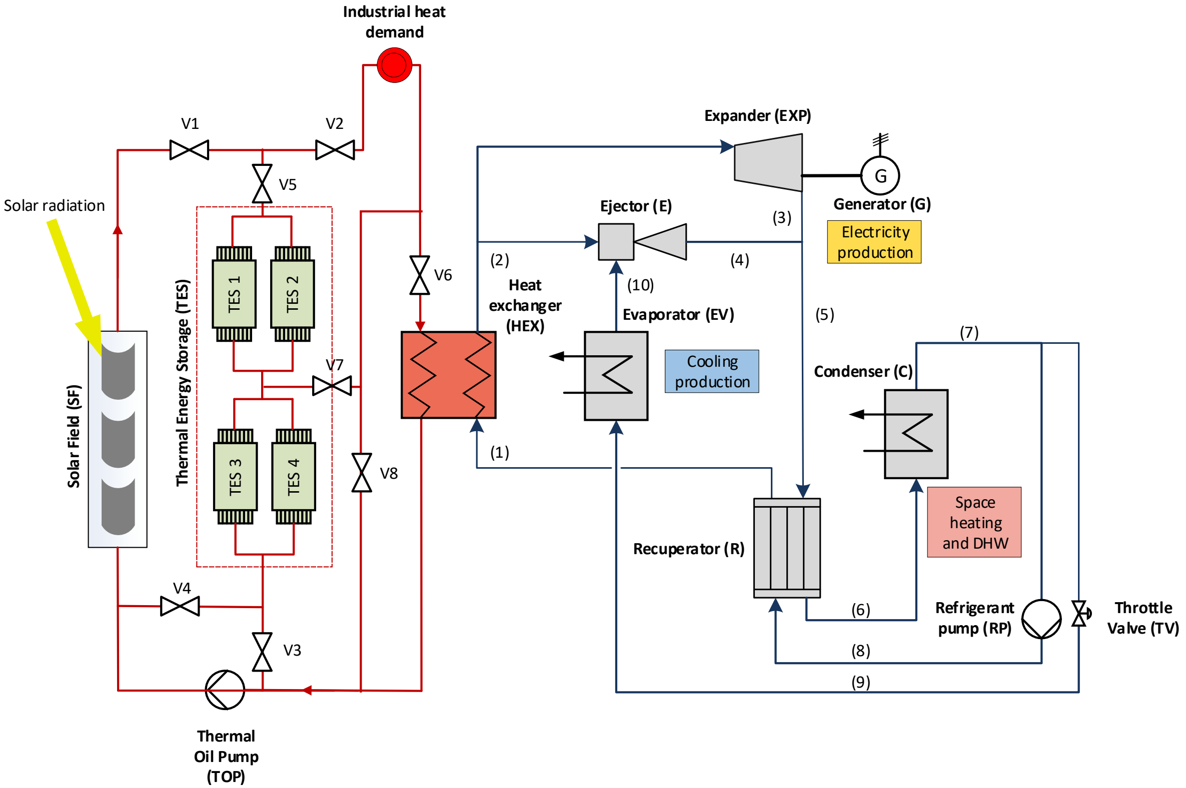
The project



Key technologies

- High-temperature (about 400°C) parabolic trough collectors
- Solid thermal energy storage system
- Organic Rankine Cycle – Ejector cooling cycle for production of electricity, heating and cooling
- What we want to do:

1) **integrate all technologies together into single demonstrator**
2) **interconnect demonstrator to consumer building to cover real heating and cooling needs**

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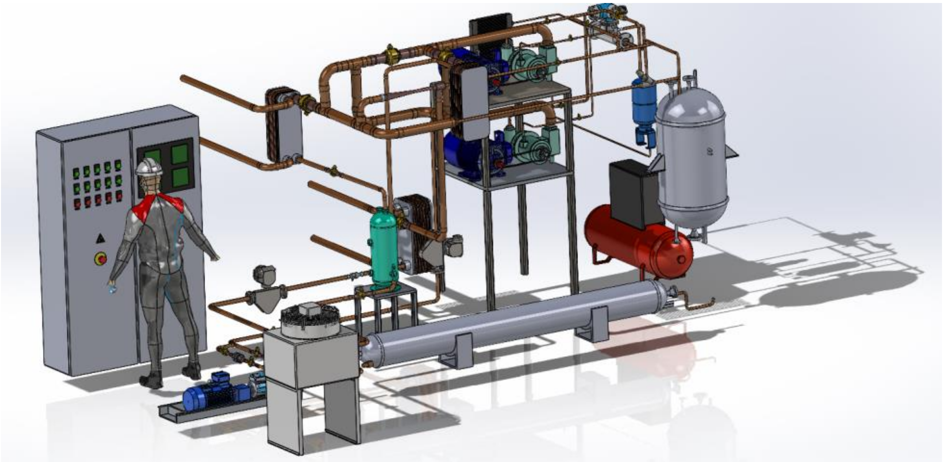
Exchange of experiences Webinar 280928

Parabolic Trough Collectors by Protarget

ORC-ECC trigeneration system by NTUA



TES4Trig

Challenges addressed

- 1st **worldwide demonstrator** of solar ORC-ECC with solid-state TES integrated into a building
- Technical feasibility (engineering and control) of integrating multiple different technologies together
- Proving the economic feasibility of the concept via a real world application for an office building
- Integrating the demonstrator **into a historical building with significant architectural and cultural value**

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Thermal Energy Storage system developed by CADE

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Consumer building: Administration Building (Serpieri Building) of Lavrio Technological and Cultural Park, NTUA (erected in 1875)

The TES4Trig demonstrator will be integrated into the heating/cooling infrastructure of the building to cover part of its heating/cooling demands and produce electricity

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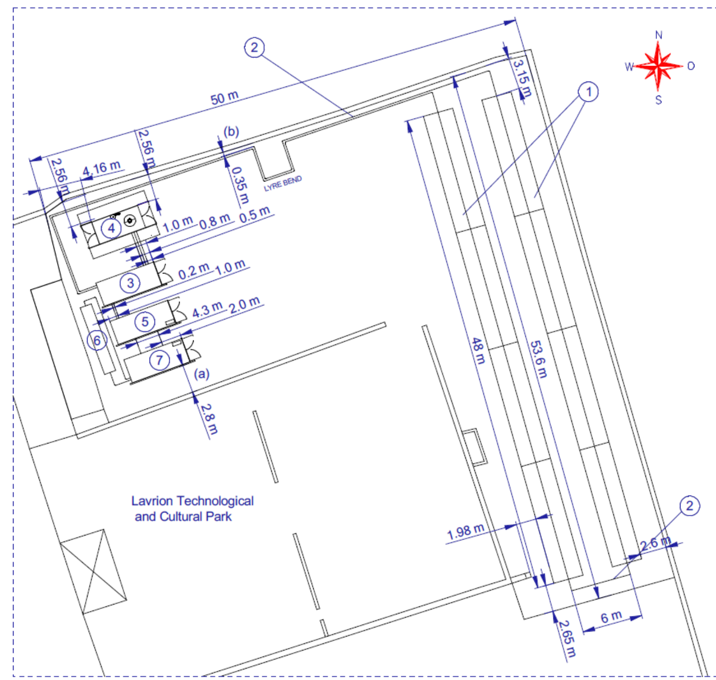
Exchange of experiences Webinar 280928

Consumer building: Administration Building (Serpieri Building) of Lavrio Technological and Cultural Park, NTUA (erected in 1875)



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Positive aspects of transnational set-up

- Opportunity to work together with pioneering industrial players in the field of CSP (Protarget, CADE) and research organizations (NTUA, SIJ, SESL)
- Improved dissemination across different countries and markets

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Critical difficulties encountered during the project

TES4Trig

- Funding period timelines: significant discrepancies between time periods of funding agencies
- Limitations on funding ceilings per country: this inherently limits the scope of work that can be undertaken by partners belonging to different countries (funding difficulties in case of demonstrator projects in Greece)

For our project an additional difficulty is the selection of a demonstrator site and integration work

- Substantial area requirements of solar field and weight requirements made very hard finding a suitable consumer building causing severe delays in the project
- Significant time lost in search of suitable site (2 rejected sites before finding the one)
- Additional delays are attributed to long delivery periods of critical equipment during and after COVID-19.
- Integration aspects: extremely challenging given historical character of building

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Critical difficulties encountered during the project

A critical technical challenge is the integration of the demonstrator with the existing heating and cooling infrastructure of the consumer building in terms of engineering and control

Consumer building boiler and chiller

Boiler
125 kW

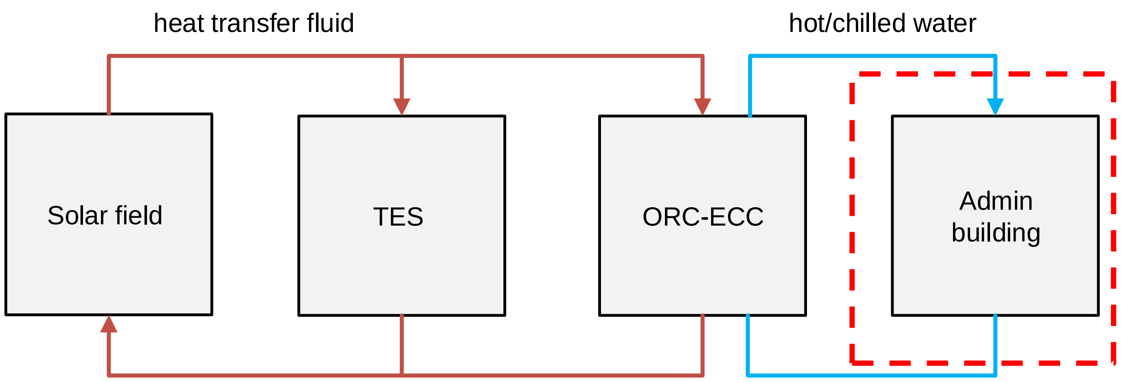
Chiller
62 kW

Critical difficulties encountered during the project

TES4Trig

A critical technical challenge is the integration of the demonstrator with the existing heating and cooling infrastructure of the consumer building in terms of engineering and control

Simple on a first glance…



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Critical difficulties encountered during the project

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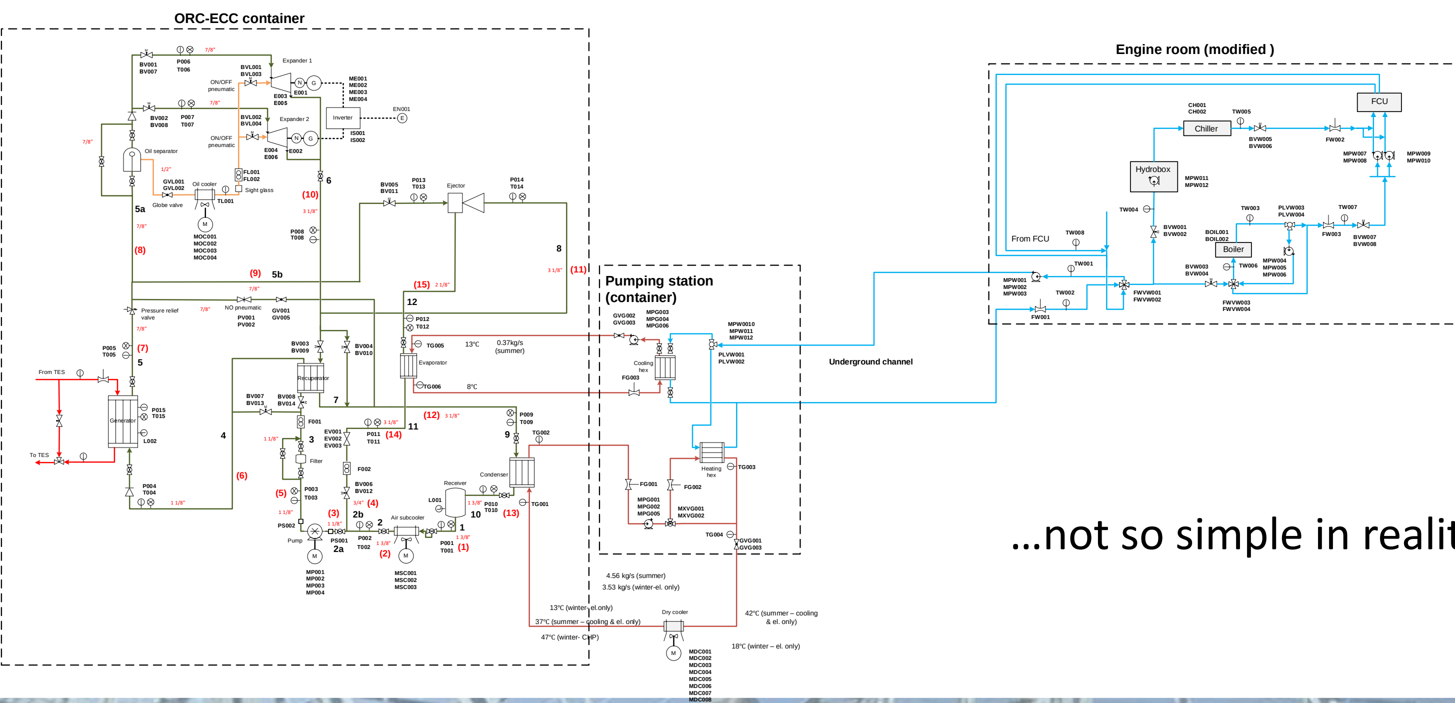
A critical technical challenge is the integration of the demonstrator with the existing heating and cooling infrastructure of the consumer building in terms of engineering and control



…not so simple in reality

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Design approved by Architectural Committee of LTCP Containers and monolith to be covered by Corten sheets to ensure architectural integration with historical building

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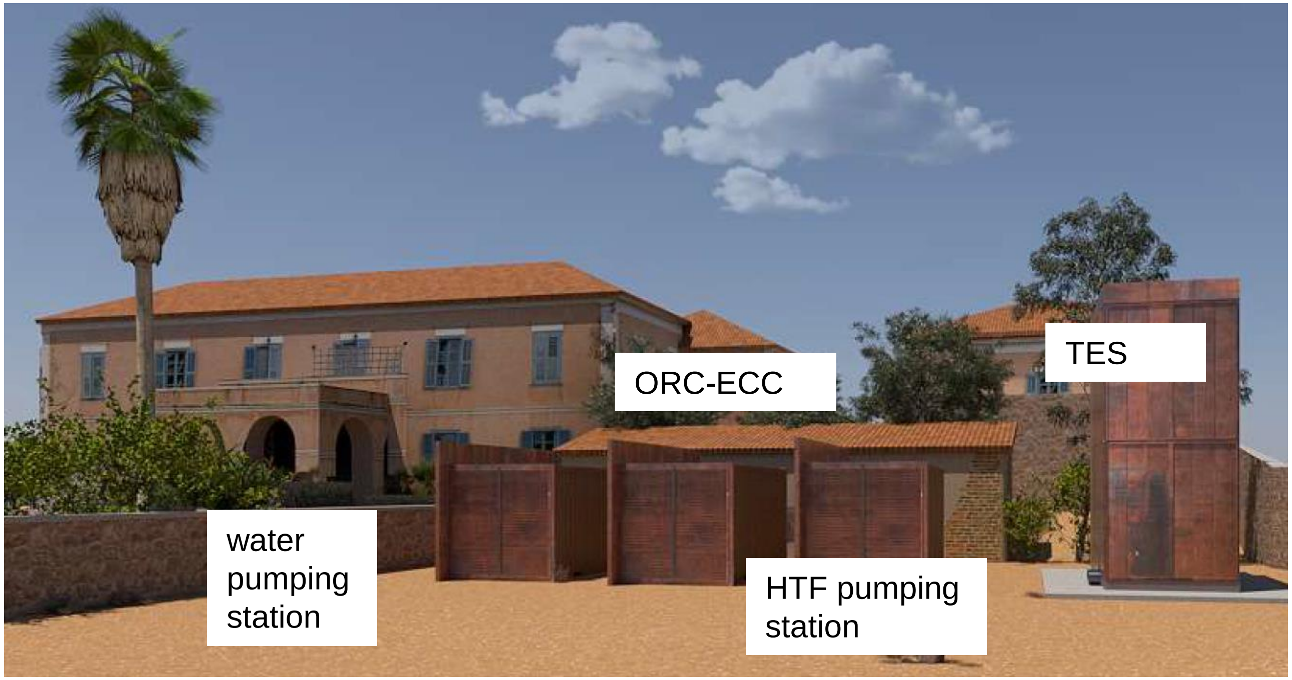

Containers and monolith to be covered by Corten sheets to ensure architectural integration with historical building

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To respect architectural value of site, an underground piping network had to be installed

TES4Trig

- First solar ORC demonstration project in Greece
- First worldwide solar ORC-ECC for demo TRL
- System installation planned in Q4 2023
- Demonstration campaign to start in 2024

Thank you!!

Presented by Kostas Braimakis, NTUA (CCCC, 2023, Greece)

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CSPplus – Techno-economical evaluation of different thermal energy storage concepts for CSP plants

Dr. Gabriel Zsembinszki
University of Lleida, Spain
GREiA Research Group /
luisaf.cabeza@udl.cat
Universitat de Lleida

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CSP
CONCENTRATED SOLAR POWER

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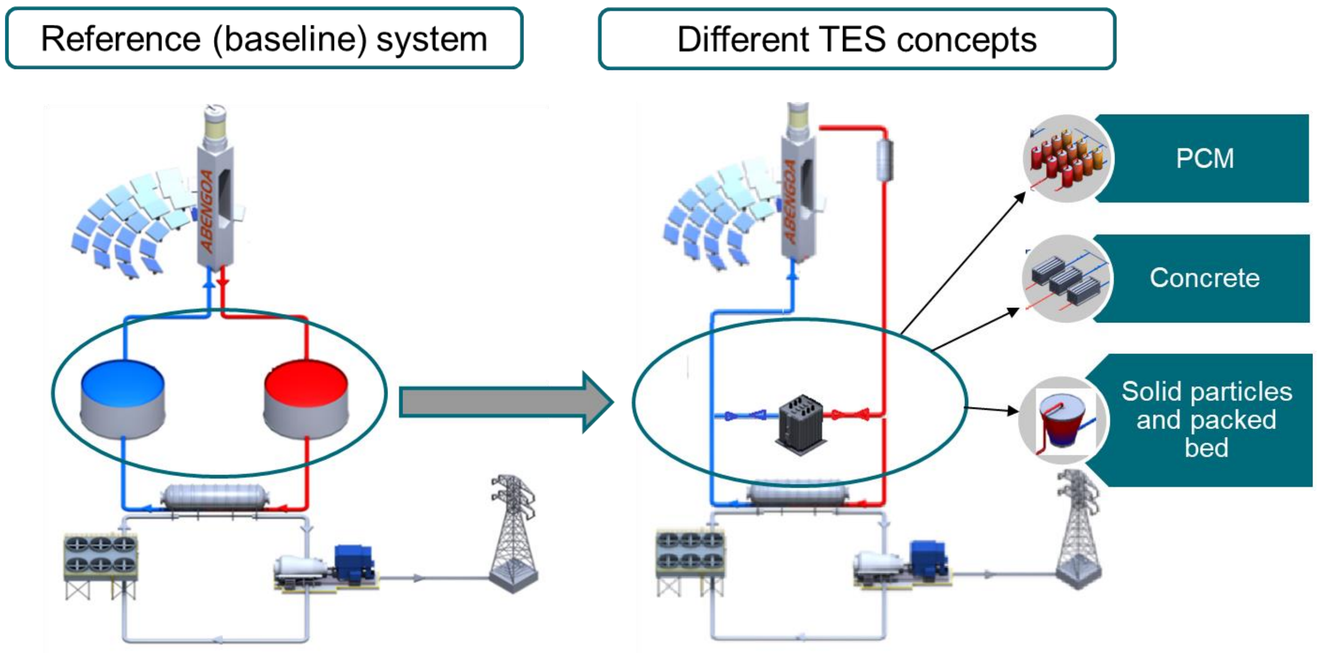
OBJECTIVES

The objective of CSPplus is to reduce by 30% the capital expenditure (CAPEX) and by 3-4% the operating expenditure (OPEX) in the next generation of CSP plants



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PROJECT PARTNERS

University of Lleida (UDL), Spain - coordinator

Ben-Gurion University of the Negev (BGU), Israel

Çukurova University (CU), Turkey

Abengoa Innovación (ABE), Spain

University of Barcelona (UB), Spain

Barış Teknolojik Tesisat Sistemleri (BARIS), Turkey

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EXPECTED IMPACT

Social impact:

- Creation of new qualified jobs in Europe

Environmental impact:

- Achieving a final carbon footprint of 18 kgCO2eq/MWh (35% of the commercial CSP)

Economic impact:

- A estimated CAPEX 30% lower than actual costs
- An estimated 15% OPEX reduction in storage systems

Strengthen the competitiveness and growth of European companies:

- Strengthening EU leadership in renewables
- Improving EU energy security

Improving innovation capacity:

- Several innovative components based on the new TES concepts

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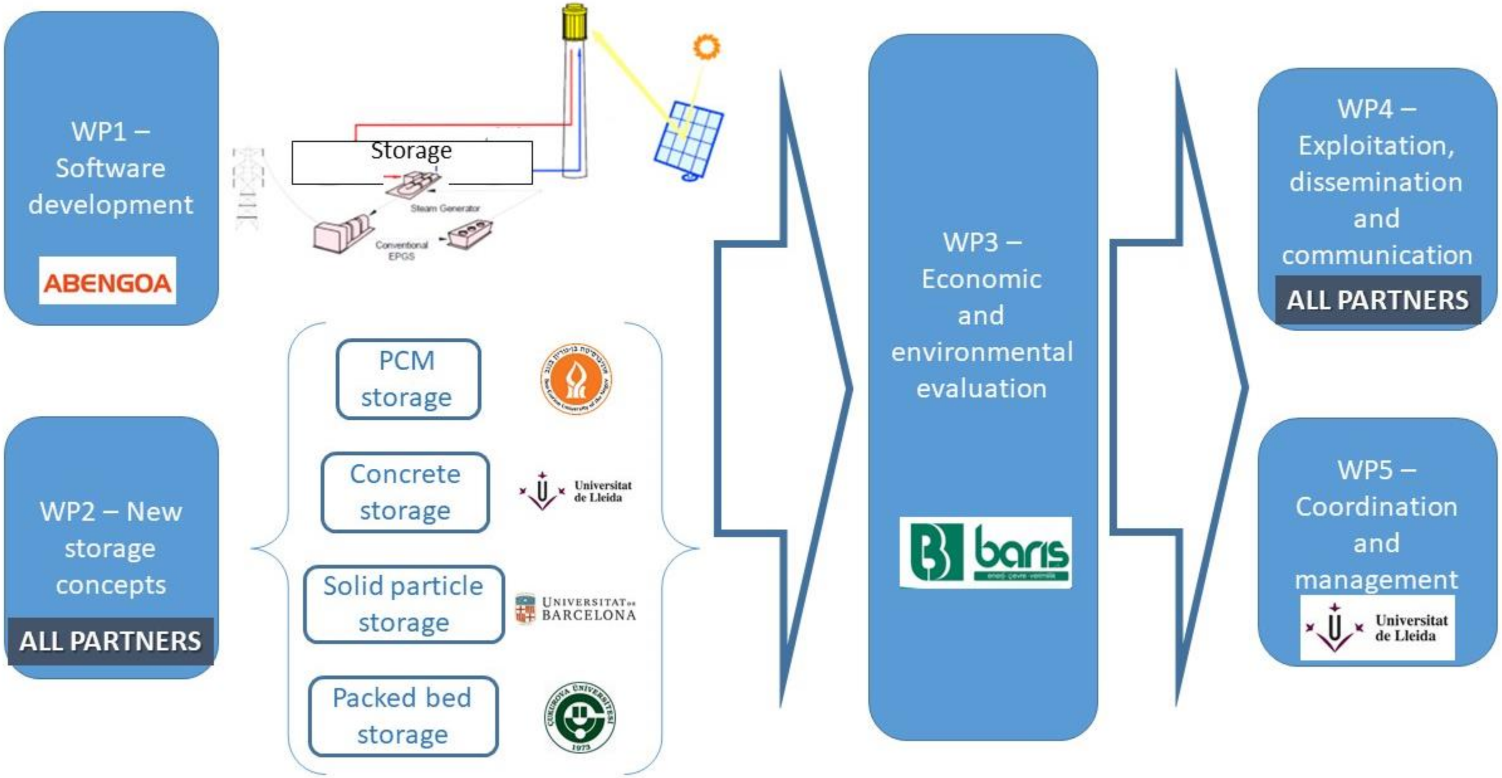
WP DESCRIPTION



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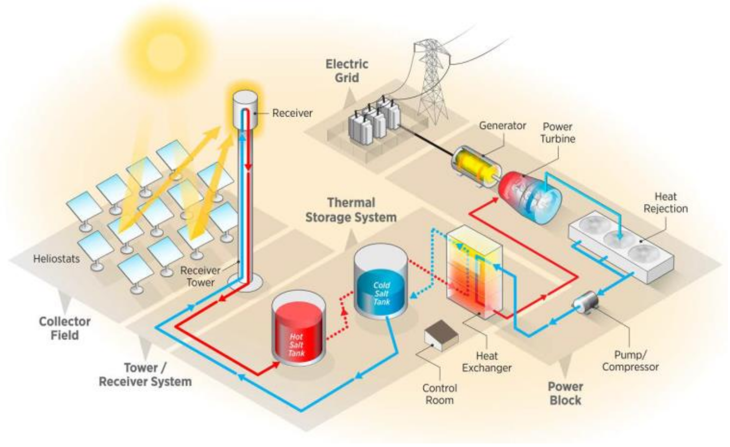
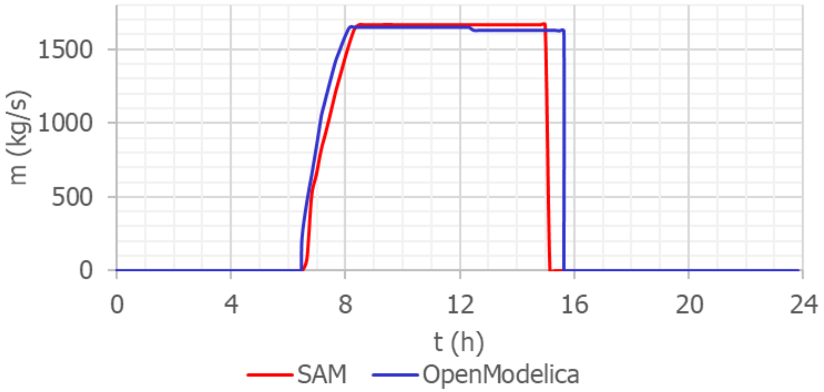
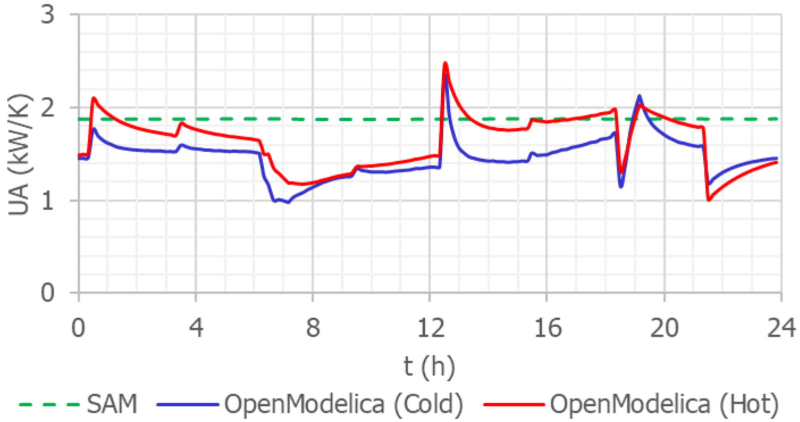
KEY OUTCOMES

System modeling (WP1)







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KEY OUTCOMES

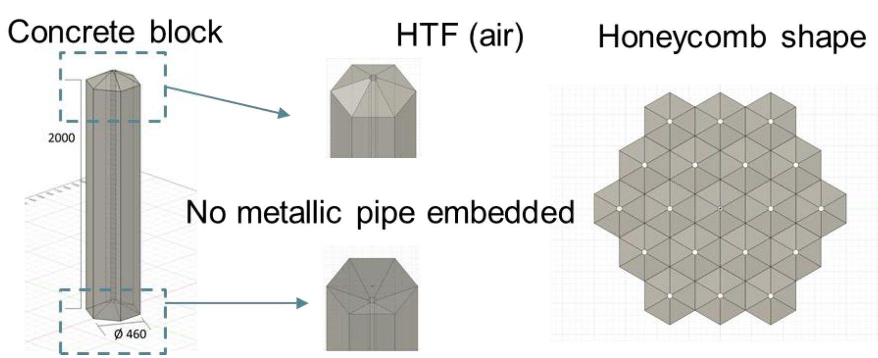
Concrete TES (WP2)

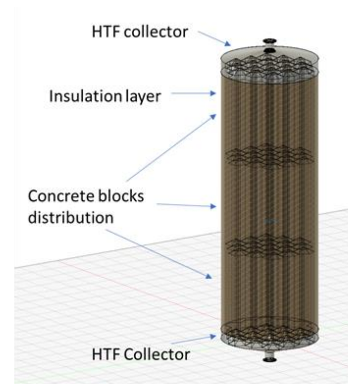
- New concrete formulation





- Novel modular design





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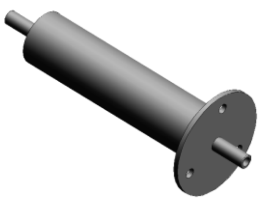
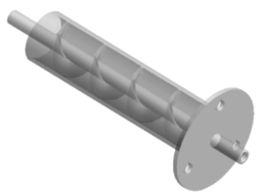
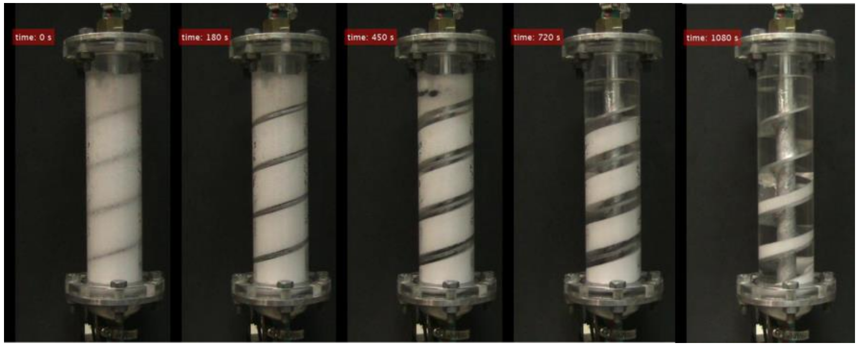
KEY OUTCOMES

PCM TES (WP2)

- Lab-scale storage unit

- Lab-testing

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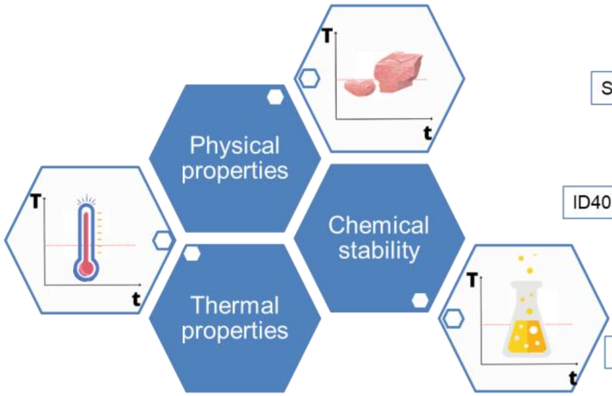
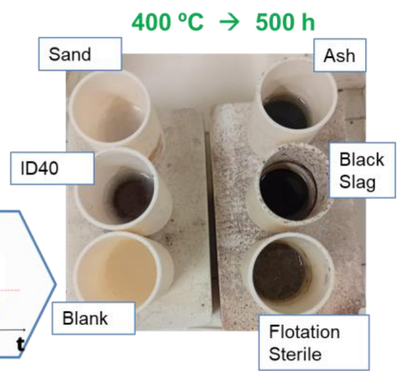
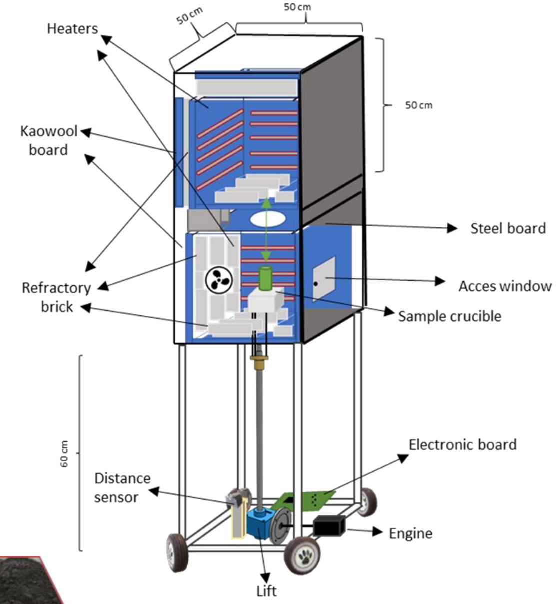
KEY OUTCOMES

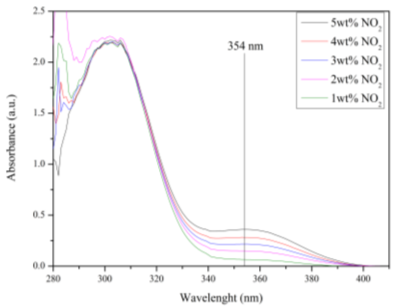
Solid particles TES (WP2)

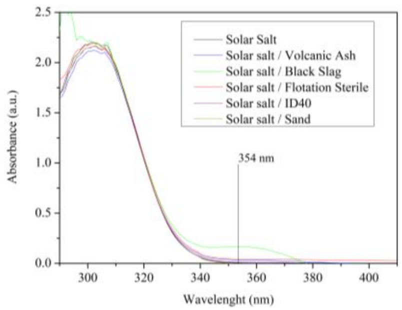
- Alternative solid particles evaluation

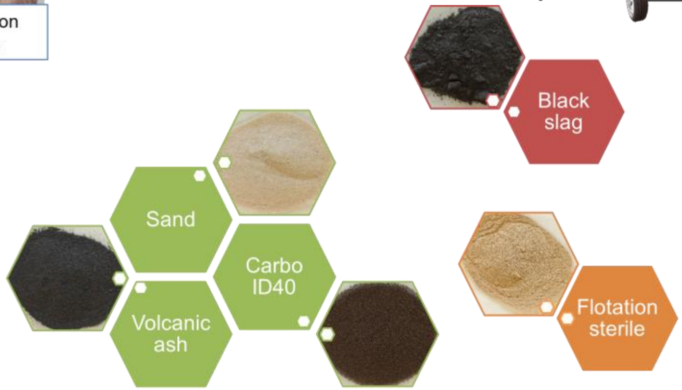












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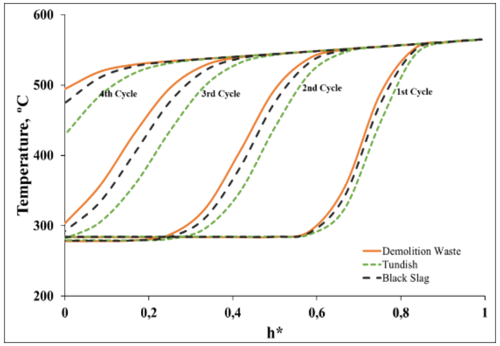
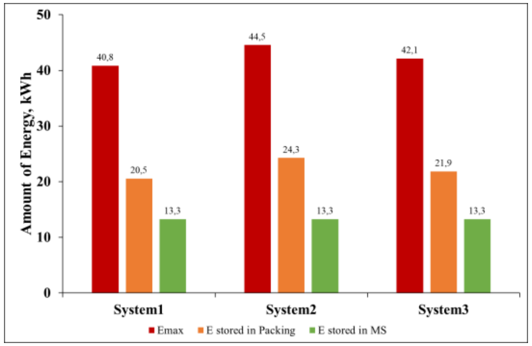
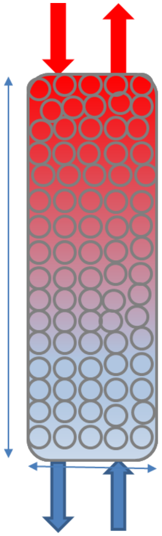
KEY OUTCOMES

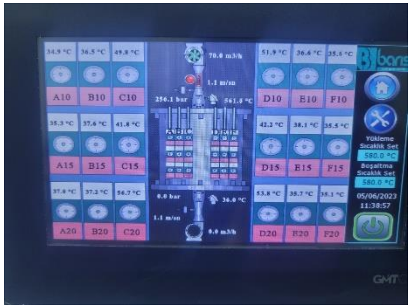
Packed bed TES (WP2)

- Numerical simulations

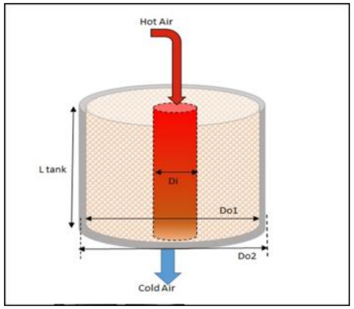








- Packed bed set-up and lab-testing



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EXPERIENCED GAINED AND BENEFITS

- Strong collaboration between project partners
  - Preparation of applications to other calls by the consortium due to CSP funded project results
  - Joint PhD supervisions
  - Collaborative papers (e.g., UDL-BGU, UB-CU, UDL-UB)
- Participation in conferences / workshops and other international scientific events
  - Organization of final CSPplus conference in May 2023
  - Organization of Researchers Night event
  - Participation in international conferences, seminars or symposiums, workshops, etc.
- Publications
  - Journal papers (6 already published, several in preparation)
  - Conference papers

Thank you!!

Presented by Dr. Gabriel Zsembinszki (GREiA Research Group, University of Lleida, Spain)

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