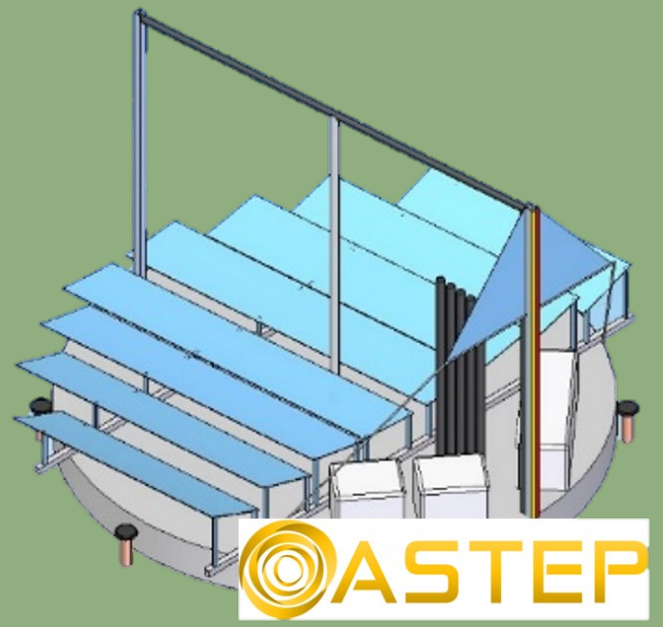
ASTEP

#SOMOS2030

APPLICATION OF SOLAR THERMAL ENERGY TO PROCESSES



19/11/2021

Mercedes Ibarra
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UNED · ANALISIS-DSC DYNAMIC & SECURITY COMPUTATIONS · Universidad Politécnica de Cartagena · David Reay & Associates · eBOS Technologies · Brunel University London · Crowdhelix · relational THE FINANCIAL SOLUTIONS COMPANY · POLITÉCNICA · ArcelorMittal · ΚΑΠΕ CRES · Politechnika Wrocławska · IRIS TECHNOLOGY GROUP · Università degli Studi della Campania Luigi Vanvitelli · Mandrekas

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Introducing UNED

Public university: National, open (non/semi-presential students)

28 degrees - 80 master degrees – 19 doctorate programs

9 Faculties - 2 Technical schools – 72 regional centers

ETS de Ingeniería Informática

ETS de Ingenieros Industriales

Facultad de Ciencias

Facultad de Ciencias Económicas y Empresariales

Facultad de Ciencias Políticas y Sociología

Facultad de Derecho

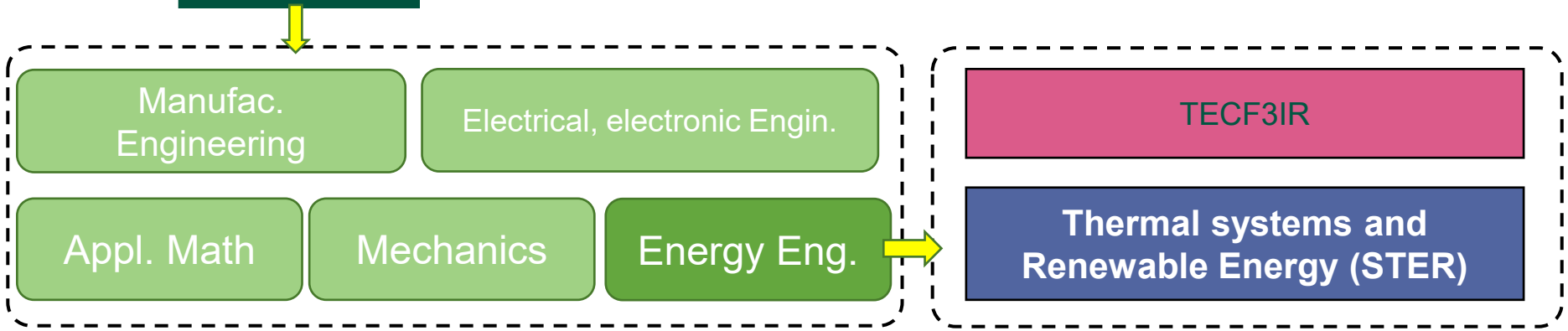
Facultad de Educación

Facultad de Filología

Facultad de Filosofía

Facultad de Geografía e Historia

Facultad de Psicología



Introducing STER (UNED)

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Research group

Created in 2007, within the Energy Engineering Department of UNED. Focused on **optimisation and energy management** in thermal systems, such as **CSP**.

- Several research projects, past and ongoing (HICCSA+DECCSA, RecSolCon, Eurofusion, STA, ACES 2030, **ASTEP**)
- 30 papers in international journals (JCR): power cycles; CSP receivers; optics; ISCC; Thermoeconomics; Solar chillers. More than 40 participation in congresses. 5 PhD. 6 patents.

Research lines:

- Power plants:
  - Concentrated Solar power
  - Integrated Solar Combined Cycles
  - Solar Heat for Industrial Processes
- Energy-saving in buildings
  - Heat and cooling systems
  - Energy simulation
- Concentrated Solar Power:
  - Design & simulation of collectors & receivers.
  - Simulation of heliostat fields
  - Simulation of solar thermal power plants
  - Power cycles
  - Development of new concepts (collectors, receivers, power cycles, energy storage systems)

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ASTEP - Application of Solar Thermal Energy to Processes

https://astepproject.eu/

Summary
Innovative Solar Heating for Industrial Processes (SHIP) concept overcoming current limitations.

- Modular and flexible integration of:
  - Innovative solar collector, SunDial
  - Thermal Energy Storage (TES), based on Phase Change Materials (PCM)
- Both integrated via a control system to allow flexible operation.

Consortium

15 partners including universities, research centers, SMEs, and big companies from 9 countries.

UNIVERSIDAD NACIONAL EDUCACION A DISTANCIA (UNED)

DYNAMIC & SECURITY COMPUTATIONS SL (ADSC)

UNIVERSIDAD POLITECNICA DE CARTAGENA (UPCT)

DAVID REAY & ASSOCIATES (DRA)

eBOS TECHNOLOGIES LTD (eBOS)

BRUNEL UNIVERSITY LONDON (BUL)

CROWDHELIX LIMITED (CHX)

POLITECHNIKA WROCLAWSKA (PWR)

UNIVERSIDAD POLITECNICA DE MADRID (UPM)

ARCELOR MITTAL TUBULAR PRODUCTS IASI (AMTP)

CENTER FOR RENEWABLE ENERGY SOURCES (CRES)

IRIS TECHNOLOGY SOLUTIONS SOCIEDAD LIMITADA (IRIS)

PRODUCTION TRADE AND SUPPORT OF MACHINABLE PRODUCTS OF SOFTWARE AND INFORMATICS RELATIONAL AE (RELA)

UNIVERSITA DEGLI STUDI DELLA CAMPANIA LUIGI VANVITELLI (SUN)

MANDREKAS DAIRY - GALAKTOKOMIKA MANDREKAS ANONYMI ETAIREIA (MAND)

Carefully selected to enable the achievement of the objectives set in cross-cutting call “Building a Low-carbon, climate resilient future” for Topic “Solar Energy in Industrial Processes”. Operational capacities, knowledge and experience of the project partners are on top-level in Europe, which ensures efficient exploitation and impact of the project.

ASTEP

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Objetive

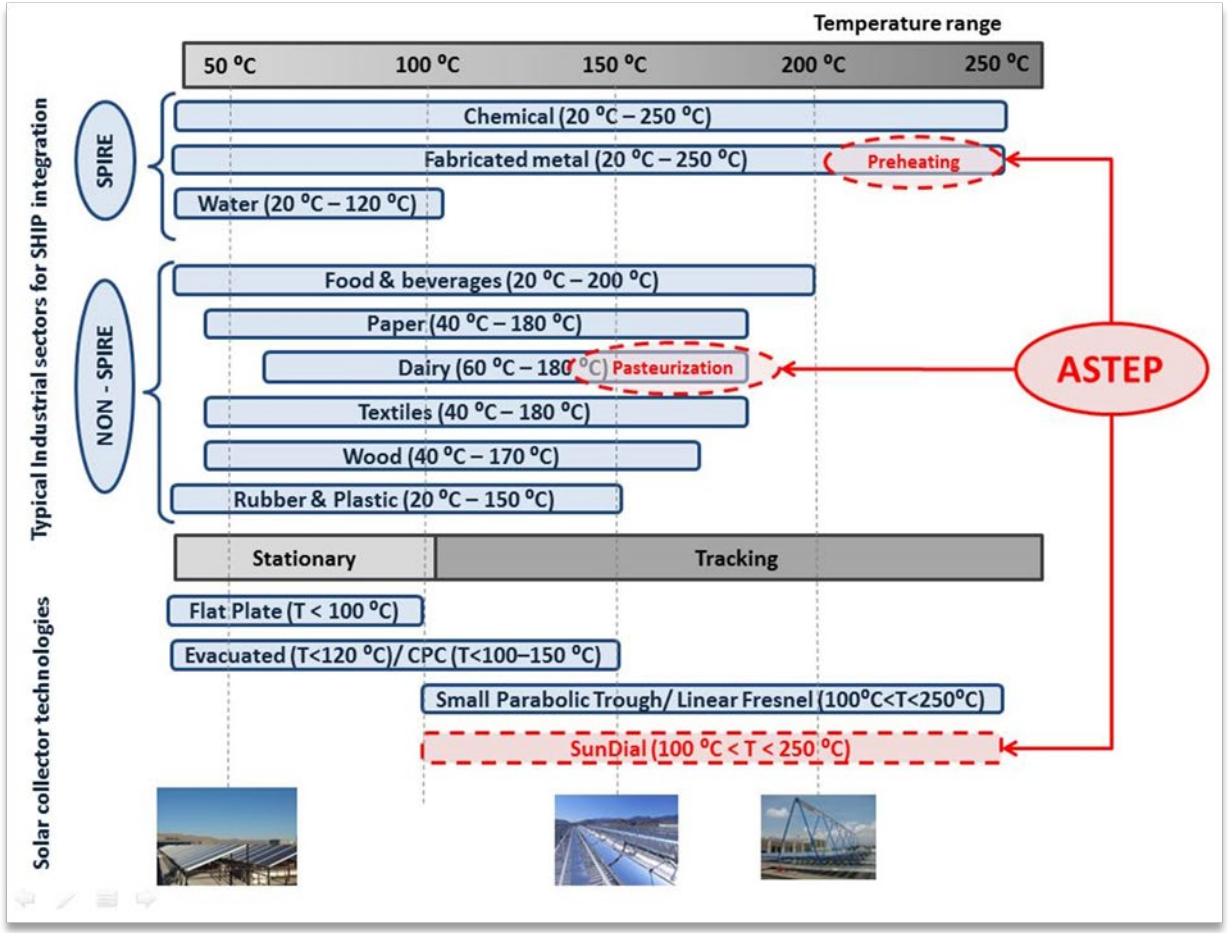
The main objective of ASTEP project is to successfully demonstrate the viability of applying solar thermal energy to partially cover heating, and heating and cooling demands on two different relevant industrial demo sites located on two different climate regions, and to further develop the implementation of solar thermal energy in industrial processes up to 400 ºC.

The project will:

Demonstrate its capability to cover a considerable part of the heat demand of the process industry at temperatures above 150 ºC and for latitudes where current designs are not able to supply it.

Allow full compatibility with the existing systems of potential end-users of Solar Heating for Industrial Processes (SHIP). → very competitive solution to substitute fossil fuel consumption.

The developed solar concept will be tested at two industrial sites to prove the objective's target of TRL5.



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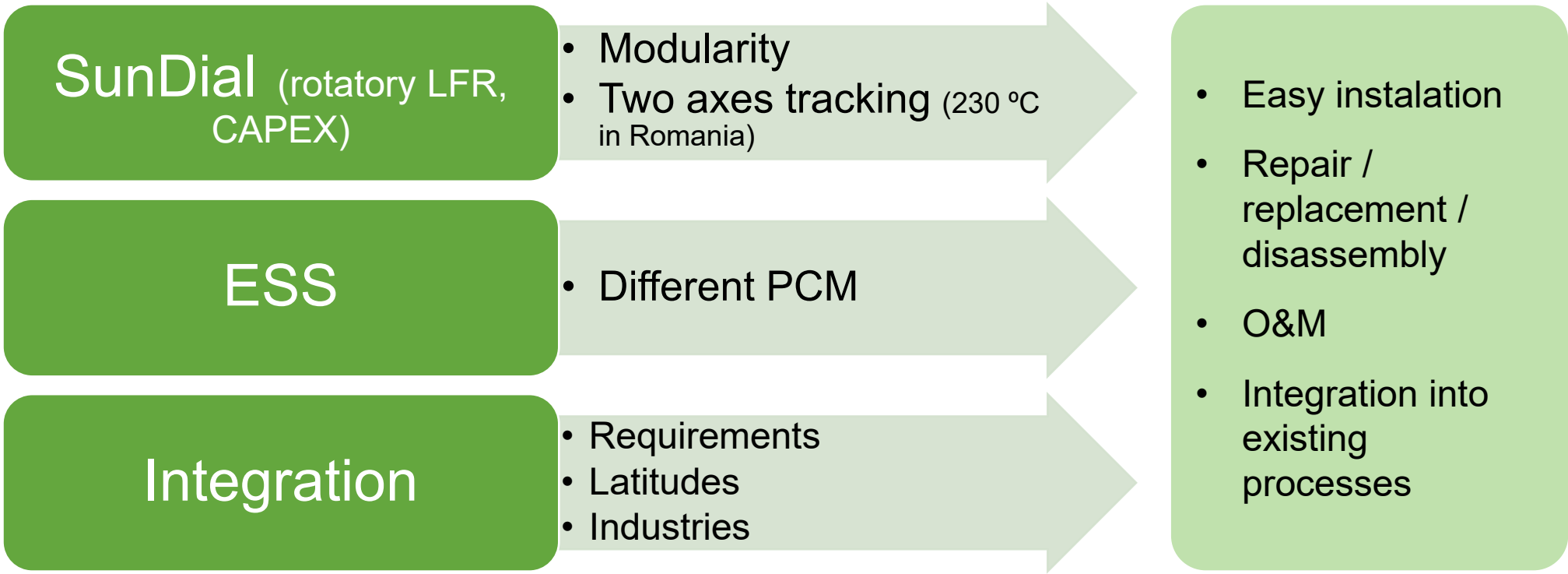

Timeline

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1. • Development of thermal demand profiles for the two end-users
2. • Dimensioning of the SunDial (Optical, thermal characterizatin and mech and structural asssessment)
3. • Dimensioning of the Thermal Energy Storage (TES) by CFD
4. • Steady state and Dynamic model: used to identify the most optimal configuration of energy generation and storage for each user
5. • Construction and test of the solar collectors and TES (Lab Scale)
6. • Models revision and design final system
7. • Transport and local construction at the location of final users
8. • Testing cycles

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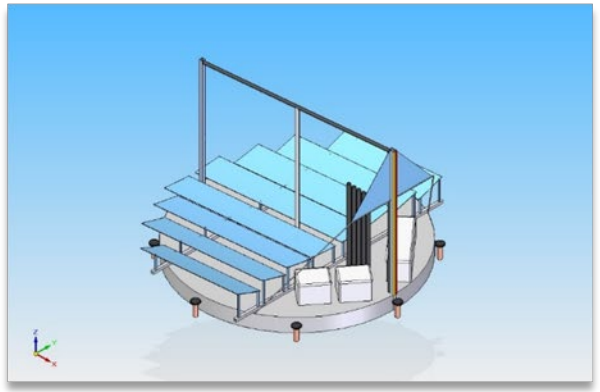
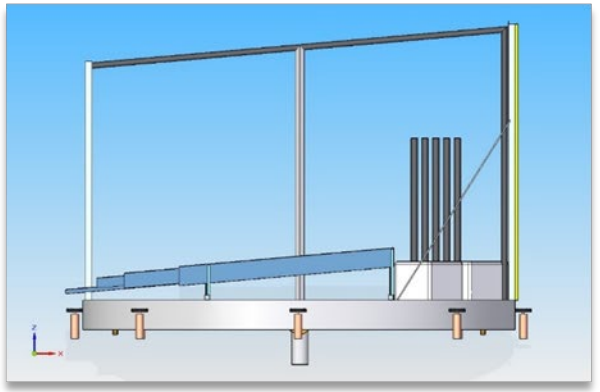
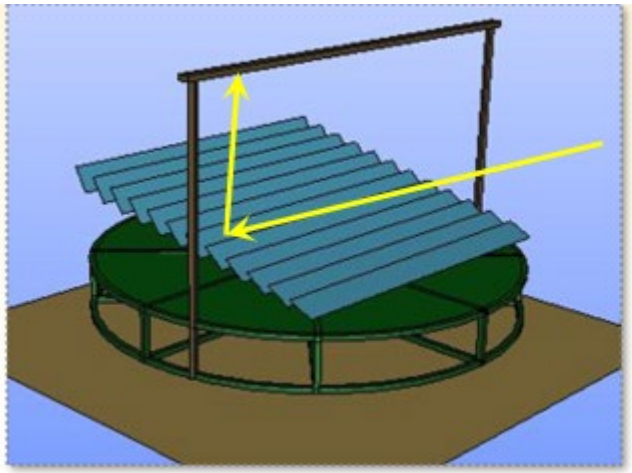
SunDial Collector

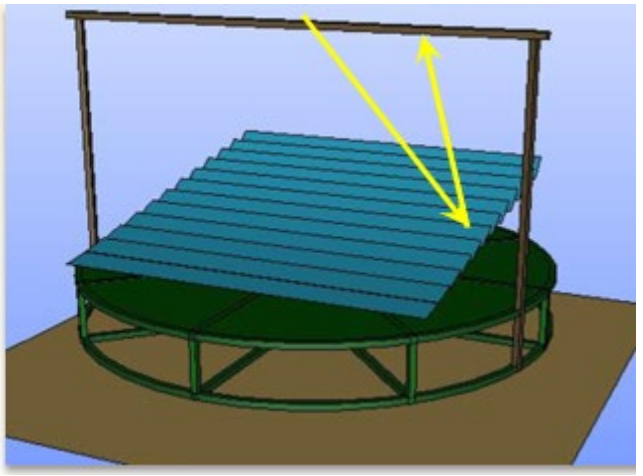
Rotatory Fresnel collector that consists of:

- Rotating plafaform (around the vertical axes)
  - It may include some slope to avoud high radiation losses at the end of the receiver
- Fresnel primary concentrating mirrors
  - curved from flat mirrors and parallel to the receiver
  - They can be fixed or not (two-axis tracking possible)
- A linear concentrator on top of the primary mirrors
- Spanish and international patents (by UNED and UPM)









SunDial Collector - activities

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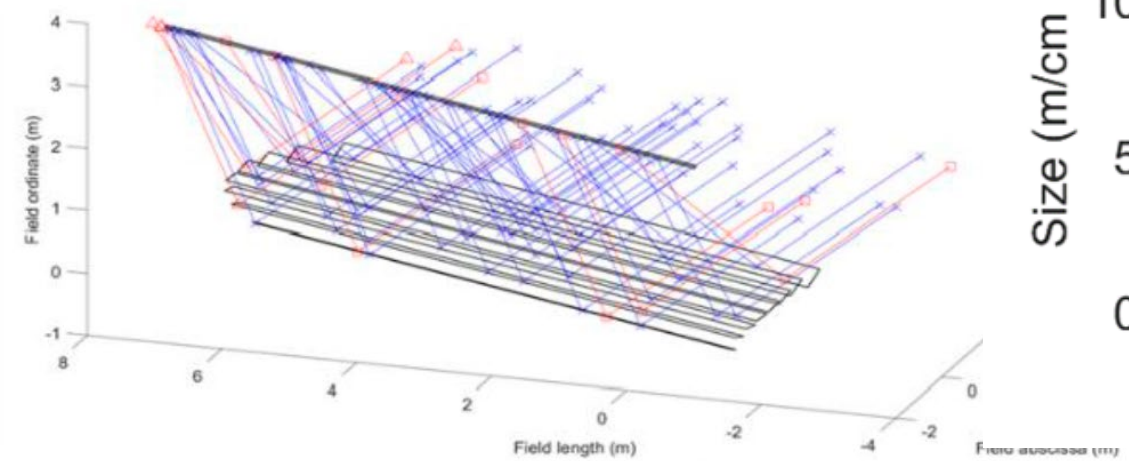
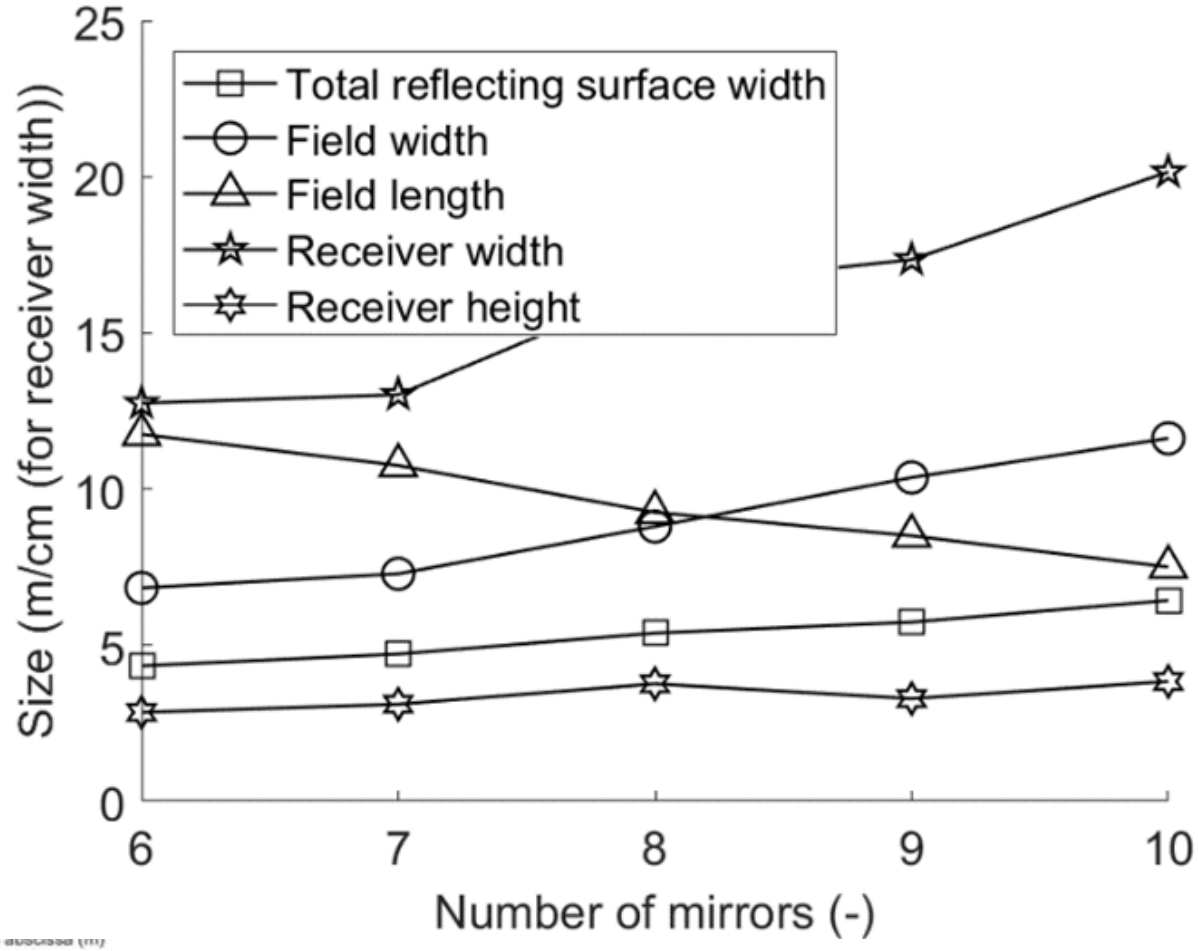
Caracterization

Evaluation of the solar concentration on the receiver for several configurations

- Number of fields
- Field width
- Number of mirrors
- Location receiver

- Raytracing techniques (UPM)





SunDial Collector - activities

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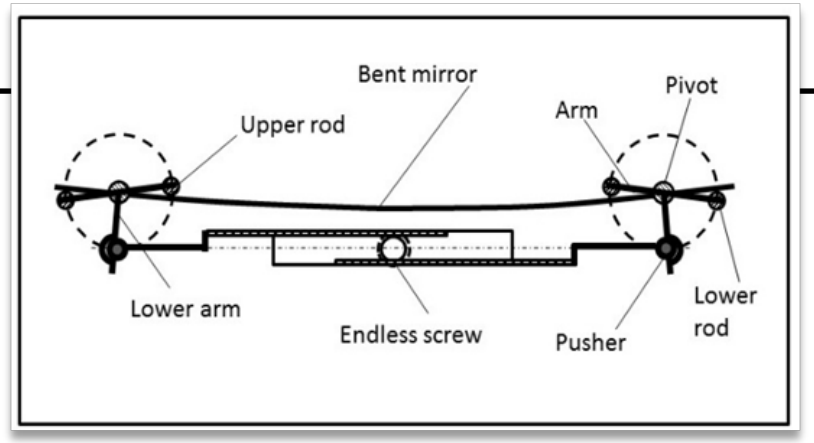
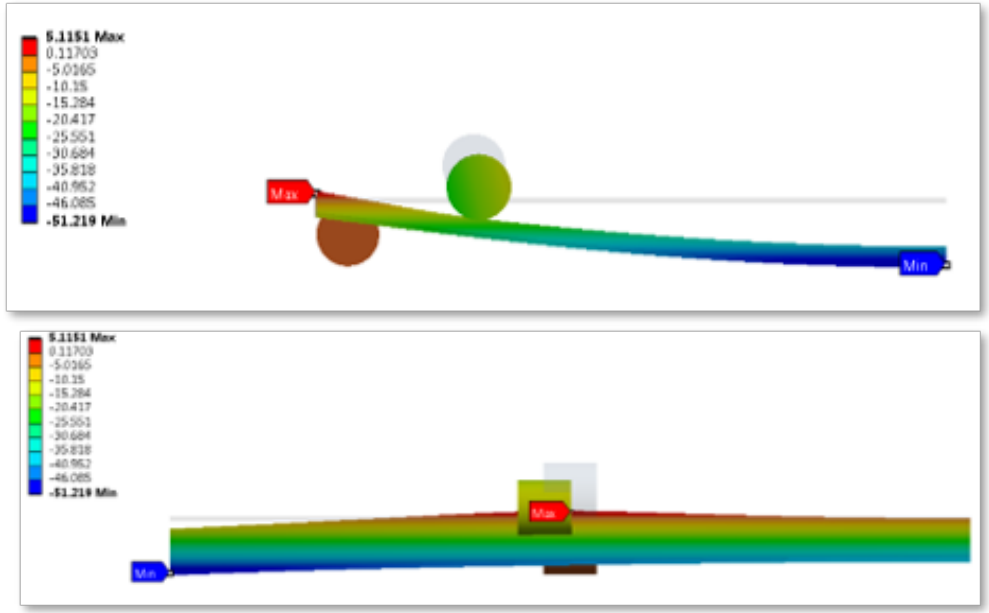
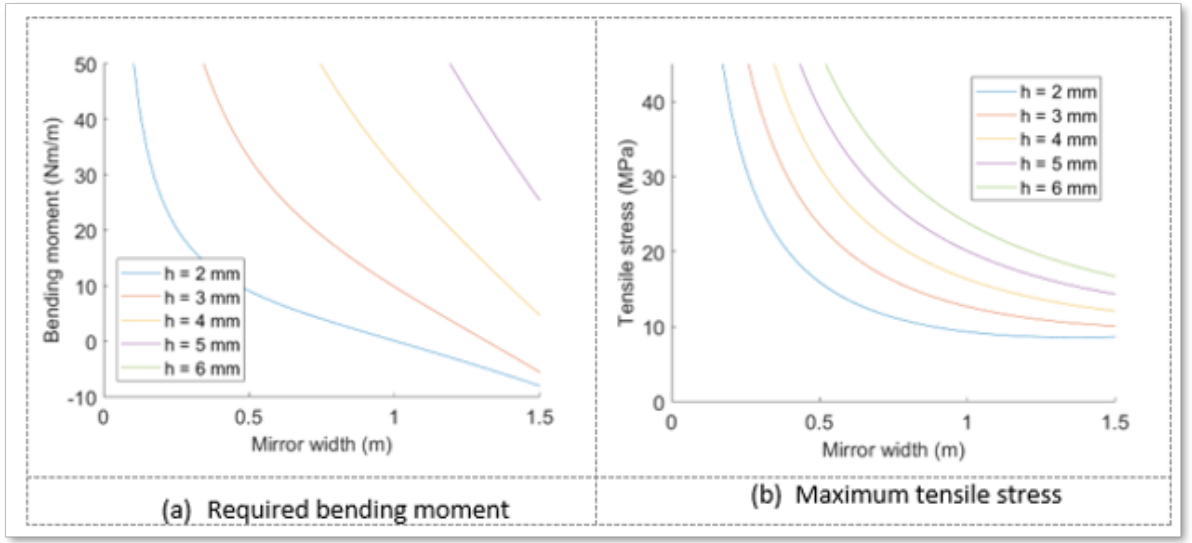


Mirror bending

Rotatory Fresnel collector that consists of:

- Testing of local stresses + concentration (FEM tools)
- Laboratory tests (UPM)





SunDial Collector - activities

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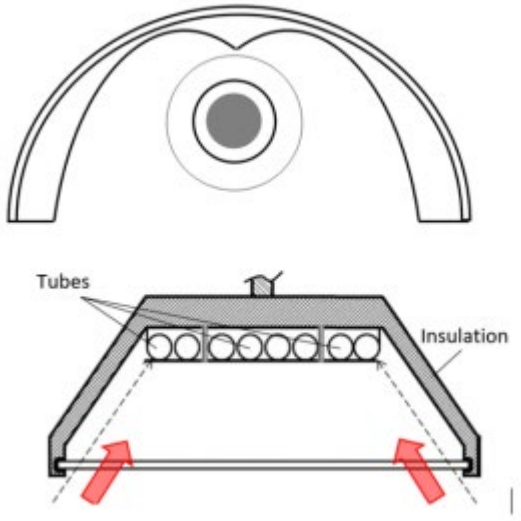
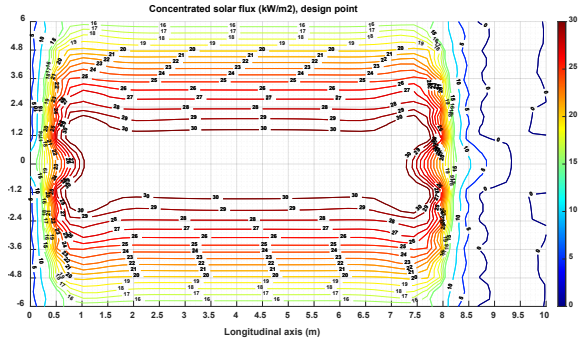
Receiver

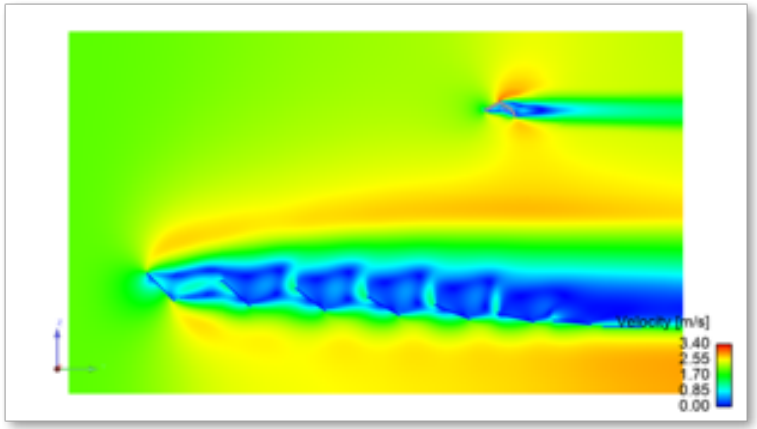
Several receivers analyzed

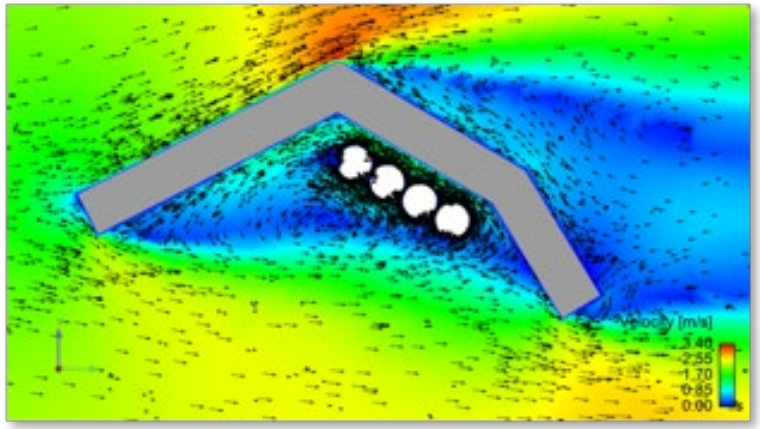
- Multitube
- Monotube + concentrator
- Modelling the thermal losses and absorption → temperature jump in the HTF
- CFD analysis
  - Heat losses in the receiver, including wind effect
  - For the multi- and mono-tube cases, different wind velocities and directions.

→ Multitube was discarded









[REF] Thermal losses characterization for the receiver of the SunDial, the rotary Fresnel collector. Ruben Barbero et al. Presented at Solarpaces 2021. https://astepproject.eu/wp-content/uploads/2021/10/Poster_SolarPaces2021_CFD.pdf

SunDial Concept – final design

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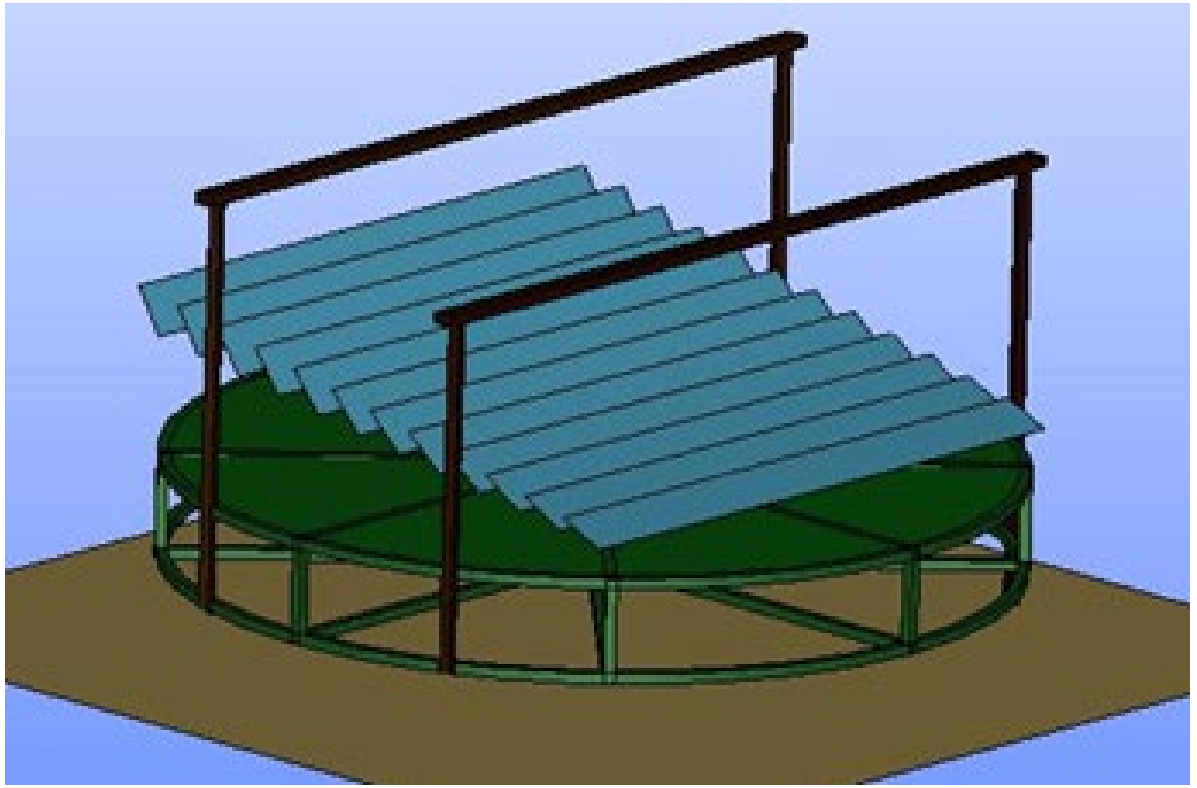

The configuration finally selected includes two semi-fields of mirrors and single-tube receiver design

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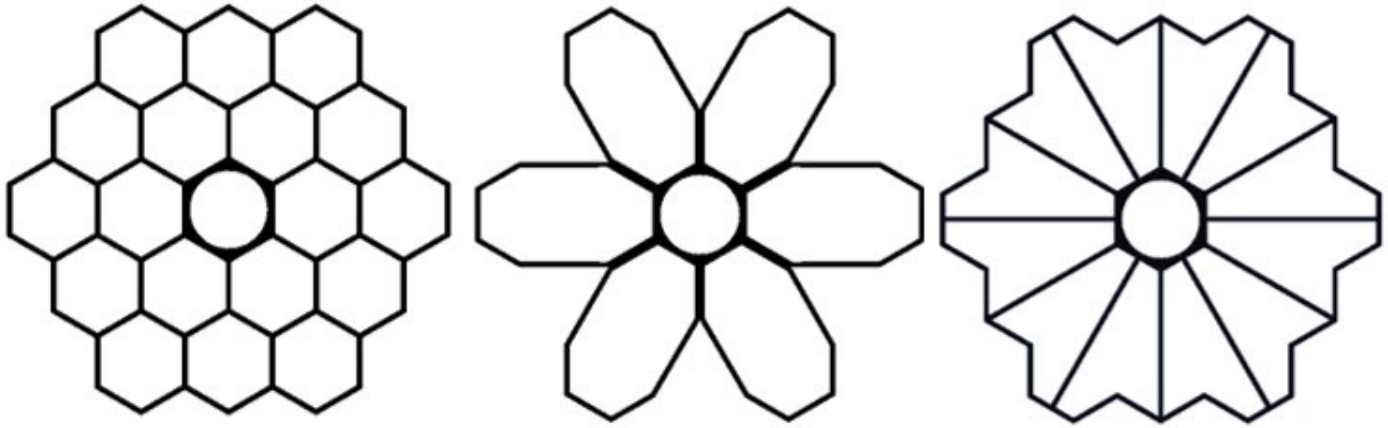
TES Concept - activities

Hybrid thermal ESS

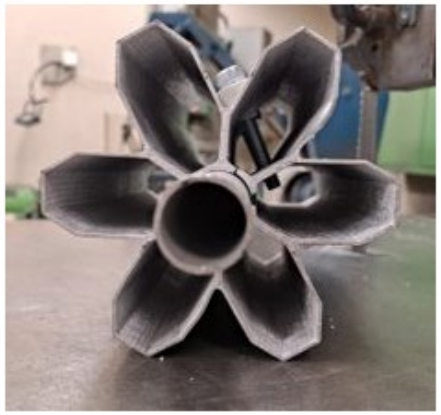
- Passive design: honeycomb pannels in a Shell
  - Choice of the panel design
- Active design: uneven design of the structure to modulate the flow

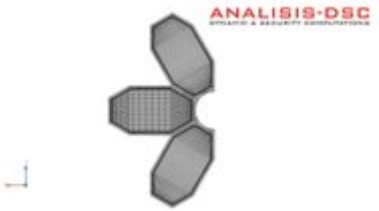


HEX
Area%: 14.4%
Mass: 437 g

Y-SHAPED
Area%: 11.6%
Mass: 266 g

FIN
Area%: 15.0%
Mass: 369.6 g





TES Concept:

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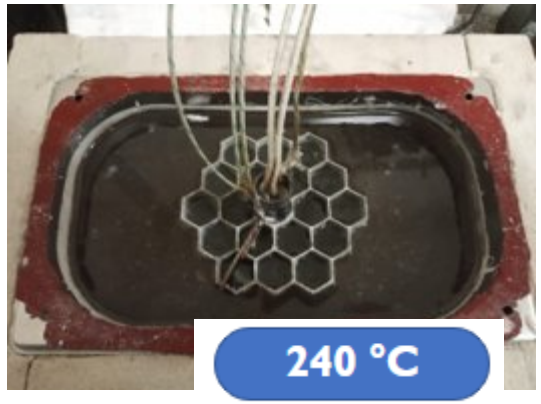
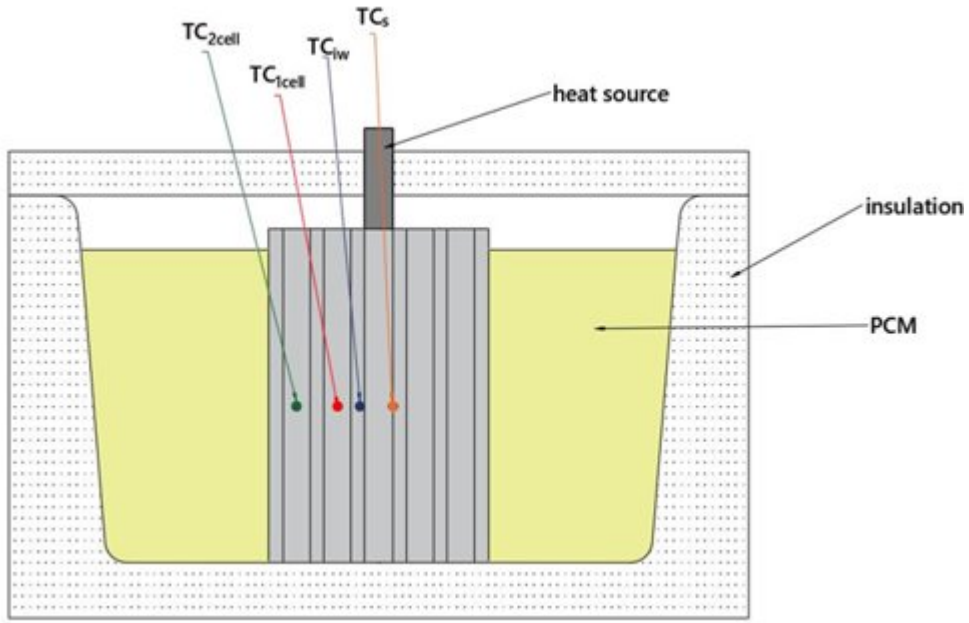
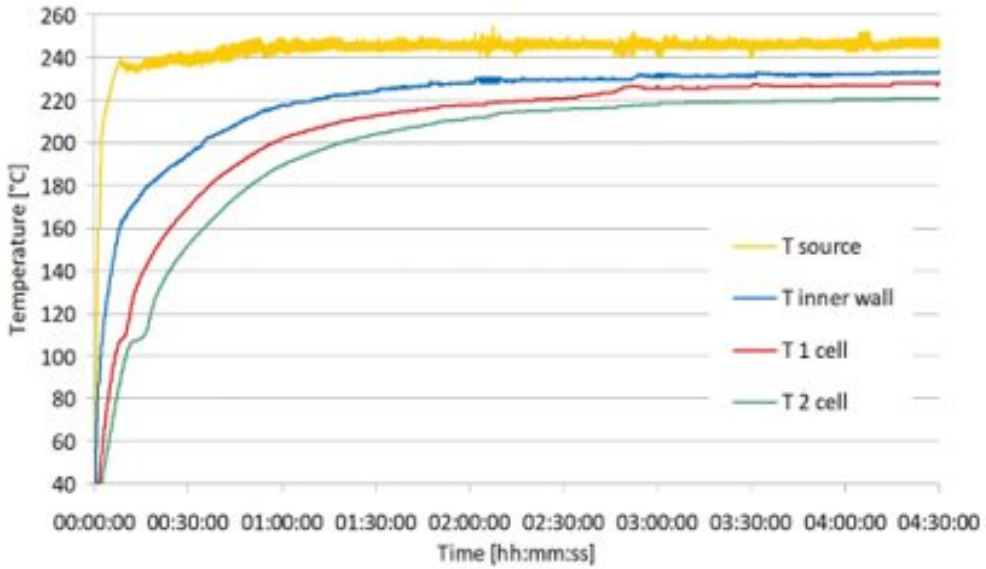
Testing materials and manufacturing

By Worclaw Univ.







TES Concept: CFD Simulation

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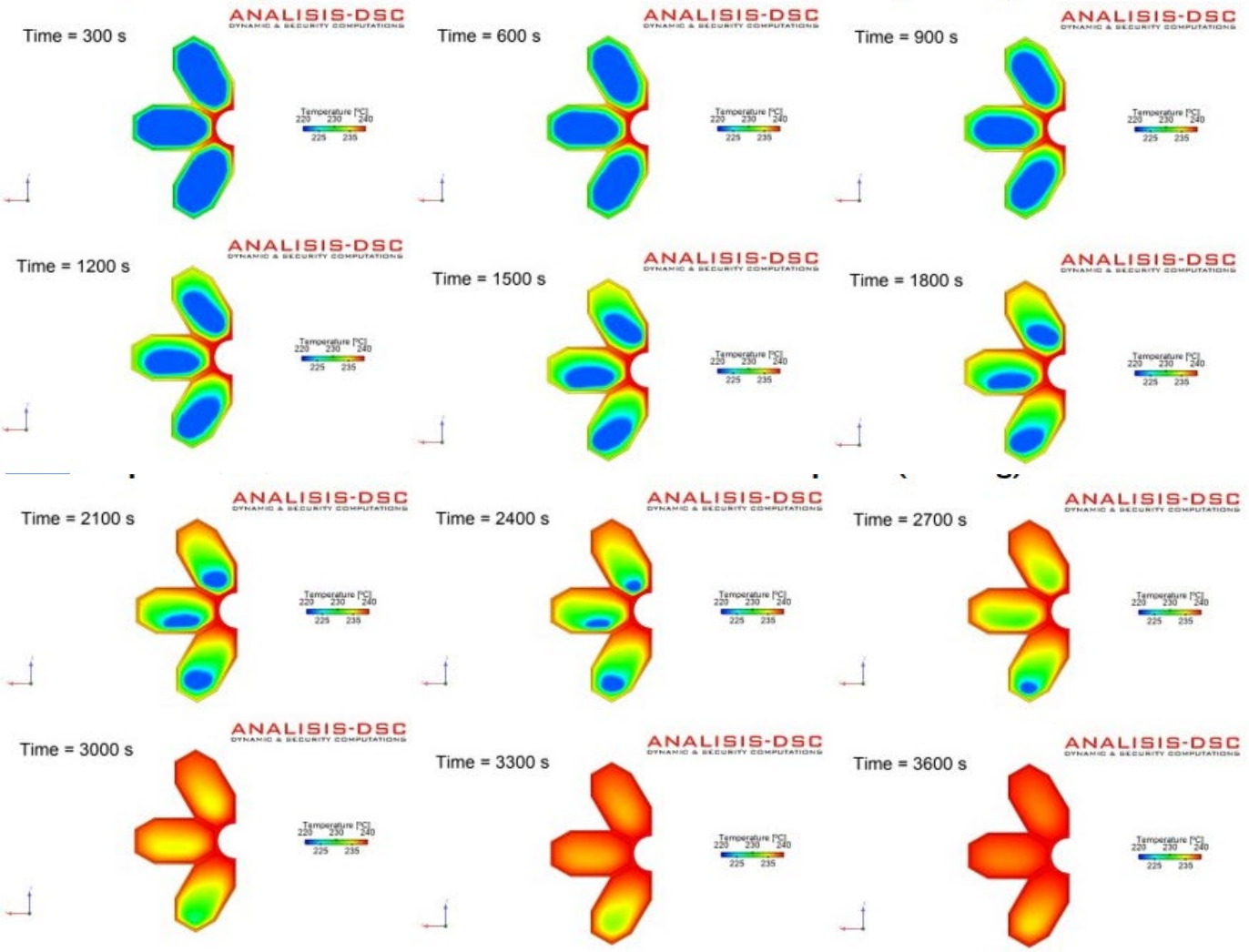
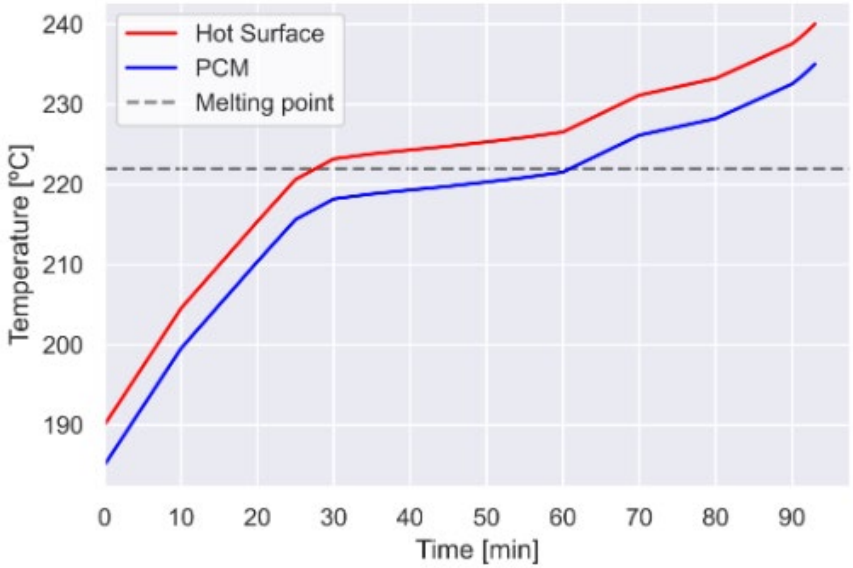
❑ Temperature variation as a function of time – Middle plane (Melting)





The temperature raises uniformly until PCM reaches the melting point.

At that moment, the temperature rise slows down for a while

TES Concept - activities

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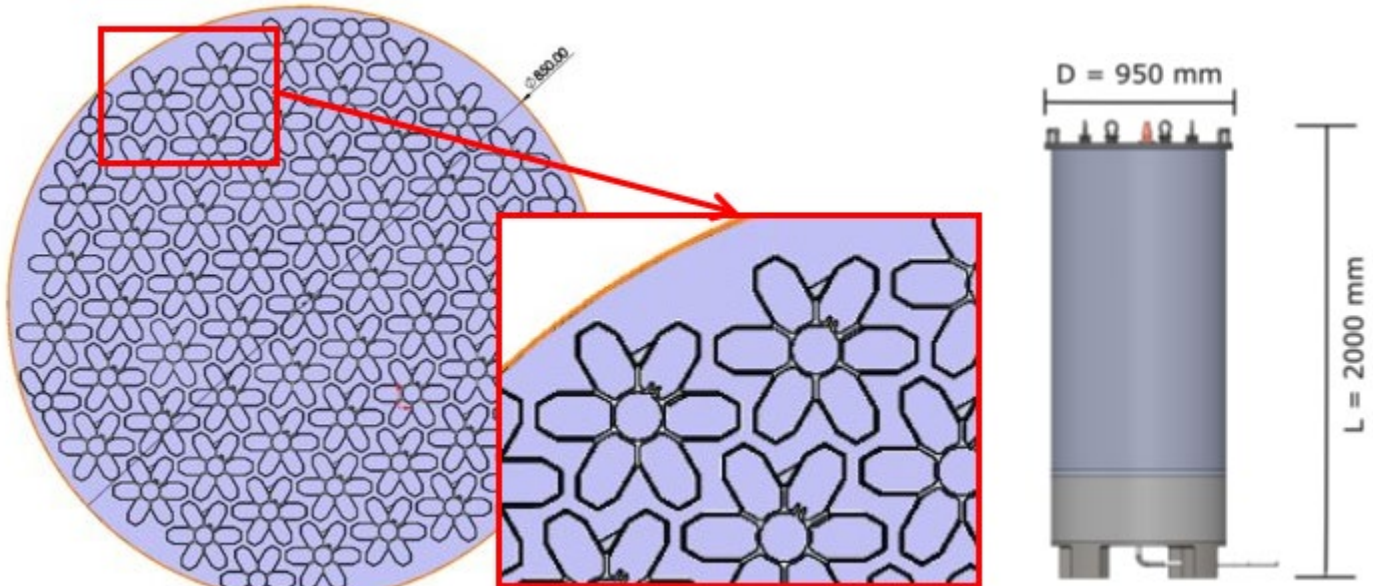
Module design (U.Cartagena)

Number of inserts	366
Number of tubes	61
Number of inserts per layer	59
Number of insert layers	6
Number of spaces between inserts	156
Shell inner diameter	85 cm
Approximate height	200 cm
PCM in-between inserts / PCM inserts - shell	~90 %
Total volume of PCM*	597 dm^3
Approximate total PCM mass (counting shell-insert dead zone)	1170 kg



Conceptual design

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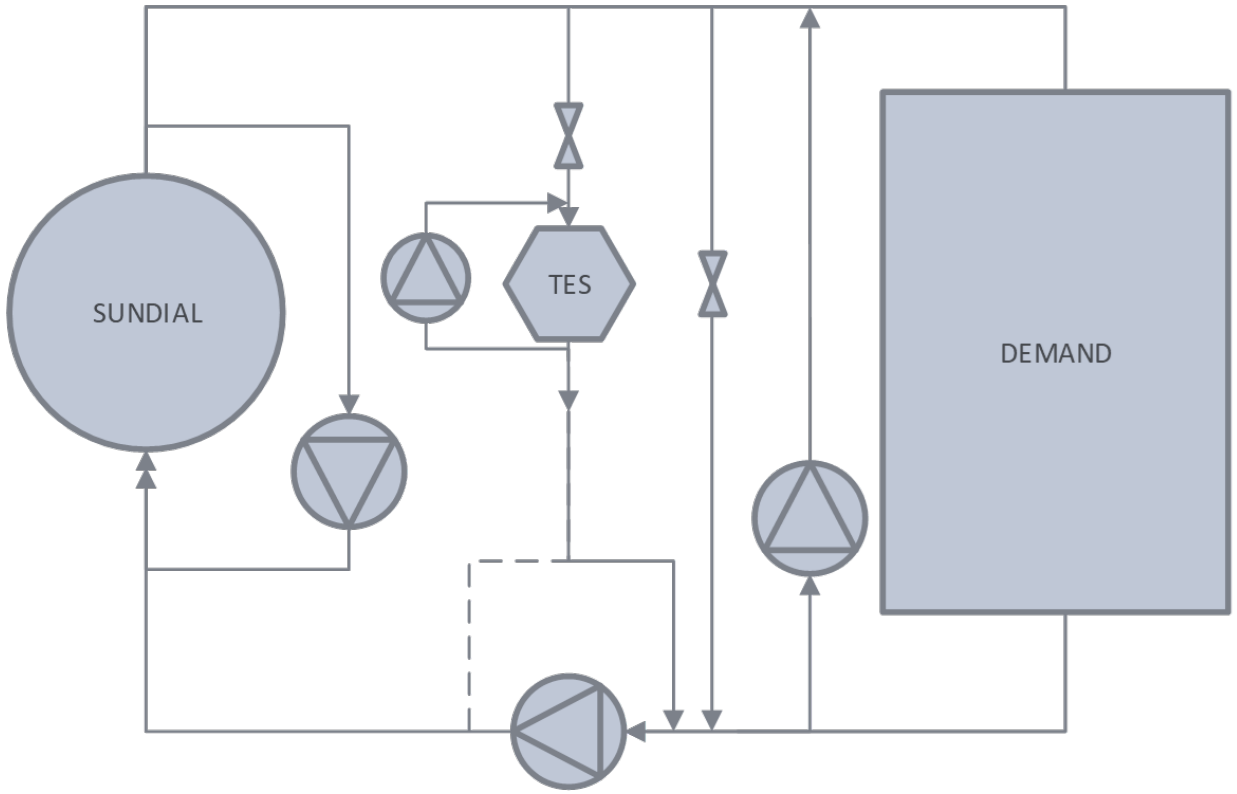

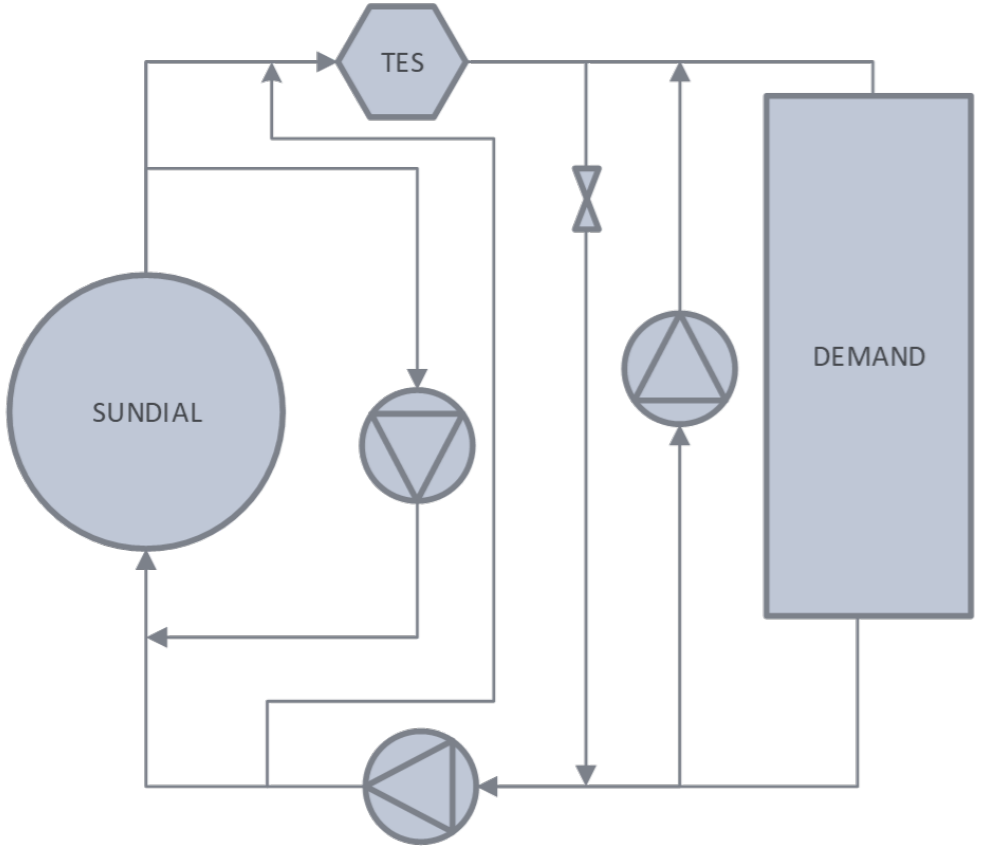

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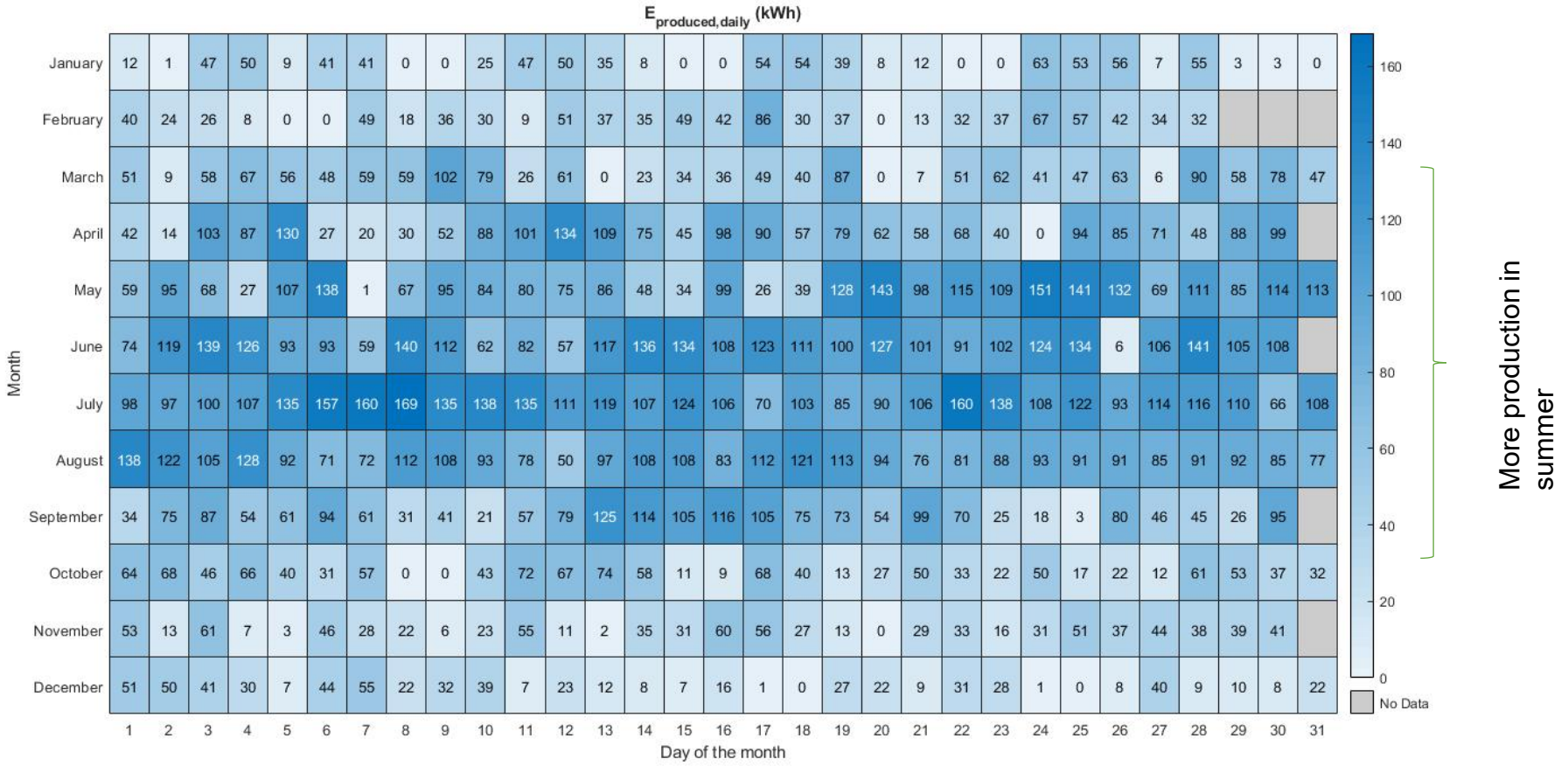
Conceptual design – steady steate modelling

Steady state modelling

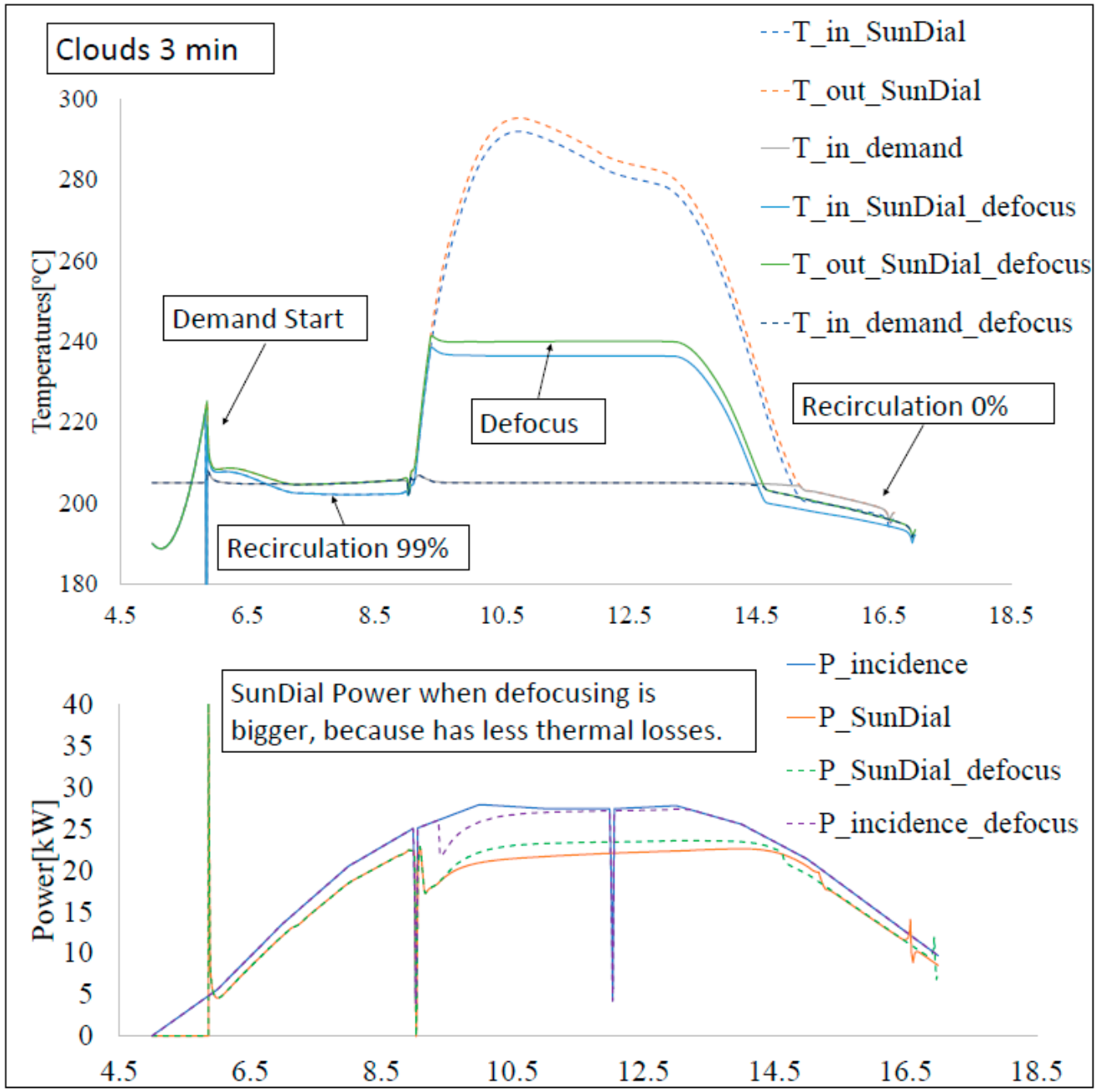
- For yearly calculations
- It allows for comparison of sites and configurations
  - Parallel configuration vs. Series
  - Sizing of thermal storage vs. Demanded power
  - Evaluation of several thermal fluids



Conceptual design – dynamic state modelling

Dynamic modelling

- For daily calculations
- It allows for evaluting the performance of the system in transient situations:
  - Demand activated/deactivated
  - Thermal storage full/empty
  - Clouds



[REF] Dynamic Analysis of the SunDial, the Rotatory Fresnel Collector. Magdalena Barrenche et al. Presented at Solarpaces 2021. https://astepproject.eu/wp-content/uploads/2021/10/20210901_Paper_DynamicSunDial_v1.pdf

Integration and case studies

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Integration and case studies

Validation of the concept in two industrial case studies:

- 1 module of 17 kW_{th} (peak): 50 kWh (Winter) – 135 kWh (Summer) daily
- 25 MWh yearly, avoiding 5.7 tCO_2 (KPI 6), 2 tNG (KPI 7), 5 kg NO_x (KPI 8)

1

Dairy industry

- Corinth (37.93N)
- Steam: 8 bar – 175 ºC (pasteurization) and 5 ºC (storing products)
- Fixed mirrors
- Tilted mirrors field

2

Steel industry

- Iasi (47.1N)
- 220 ºC (pre-heating for coating)
- 2-axes tracking system
- Non-tilted mirrors field

Integration and case studies: Dairy industry

Obj: cooling and heating systems for production of milk, yogurt and cream

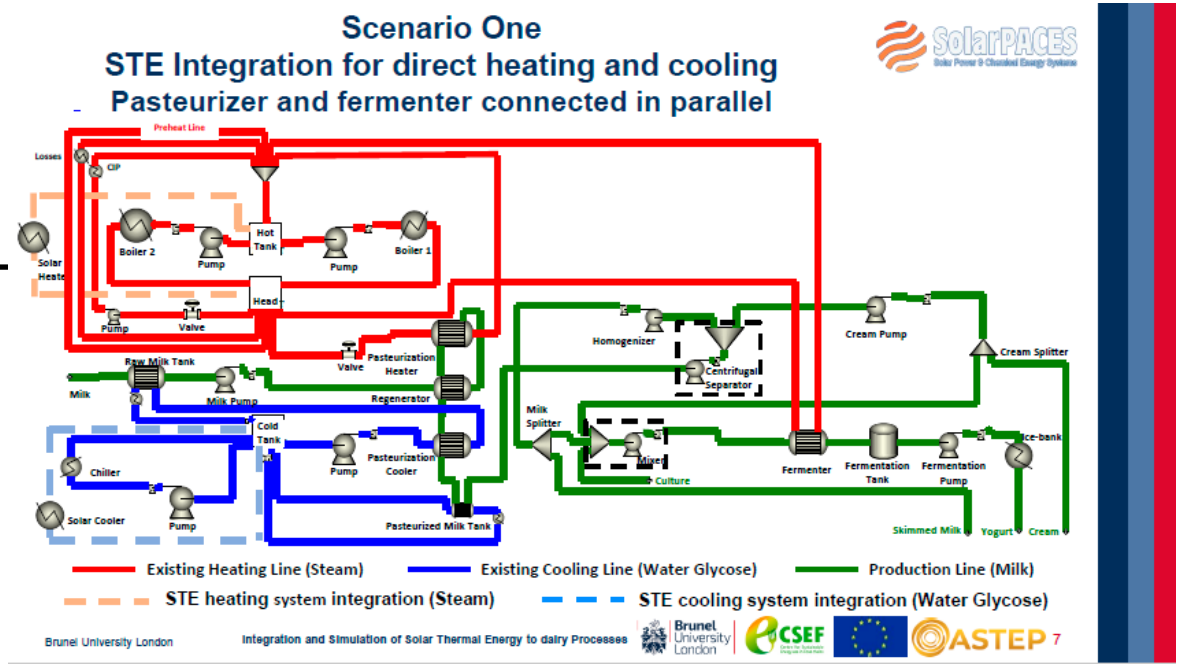
Simulation of the integration using ASPEN Plus

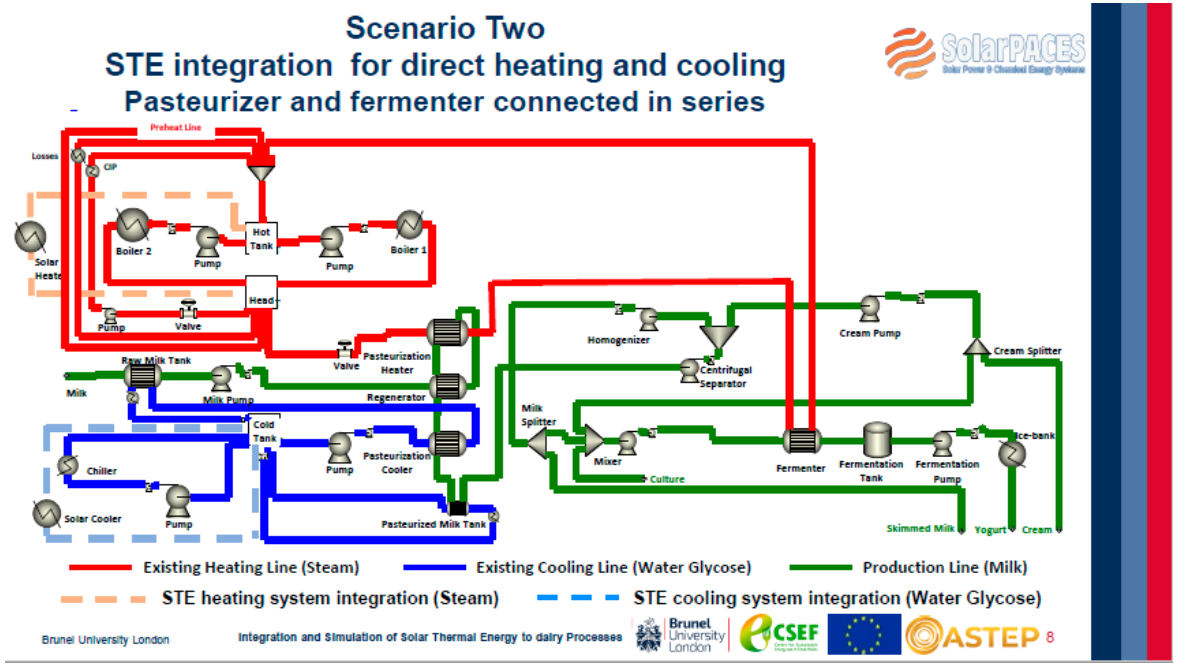
- Two different scenarios are considered
- 32% of the total energy use

The processes require:

- a heating system to provide heat at 180ºC
- a cooling system to provide cooling at 0-4ºC

Results: scenario two was more energy efficient compared to scenario one





[REF] Integration and Simulation of Solar Thermal Energy to Dairy Processes. Tannous et al. Presented at Solarpaces 2021.
https://astepproject.eu/wp-content/uploads/2021/10/Submited-presentation.pdf

Implementation

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	Workpackage	Lead	Year 1	Year 2	Year 3	Year 4
WP1	Project Management and Coordination	UNED				
WP2	Requirements for ASTEP & Concept Design	BUL				
WP3	Application of SunDial Technology to the ASTEP Concept	UNED				
WP4	Application of Thermal Energy Storage to the ASTEP Concept	UPCT				
WP5	Combined ASTEP Specification Design	UPM				
WP6	Construction, Testing and Validation of ASTEP Concept at Laboratory Environment	UPM				
WP7	ASTEP Concept at Industrial Sites	DRA				
WP8	Sustainability Assessment	VERT				
WP9	Exploitation, Dissemination and External Communication	CHX				
WP10	Ethics requirements	UNED				

Solar Energy Helix

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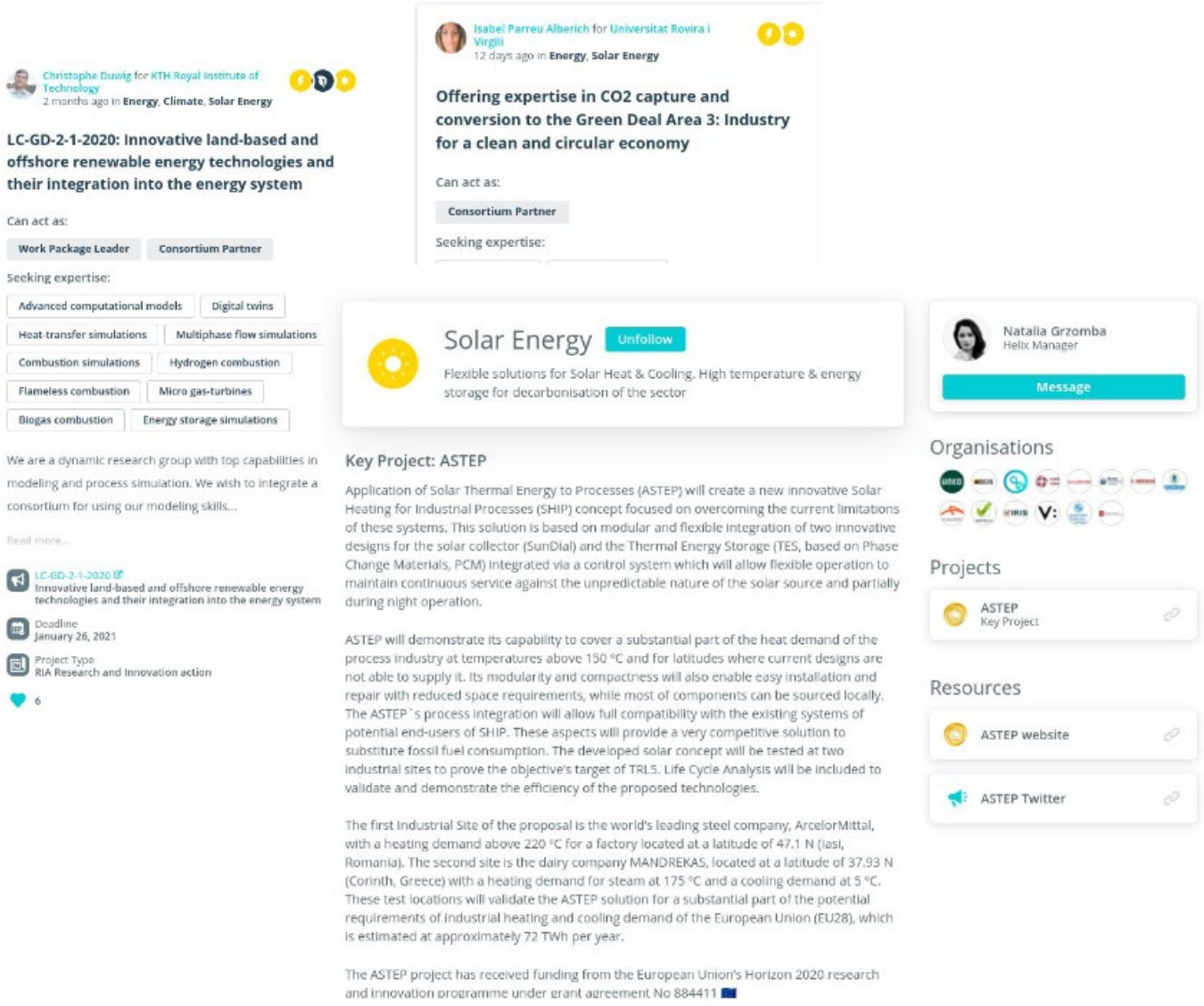
- virtual community hosted by the Crowdhelix platform: https://crowdhelix.com/helixes/solar-energy
- cluster of like-minded stakeholders that will have access to updates on the project and collaborate with experts in the field of solar energy
- virtual space for posting collaboration opportunities, expertise offers, and project updates
- organisations from outside the Crowdhelix Network can request joining the Helix by emailing astep@crowdhelix.com



Keep up with the project!

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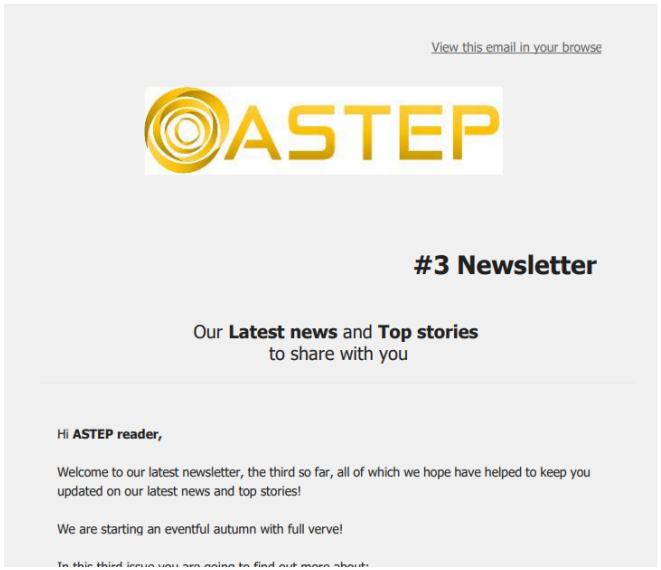
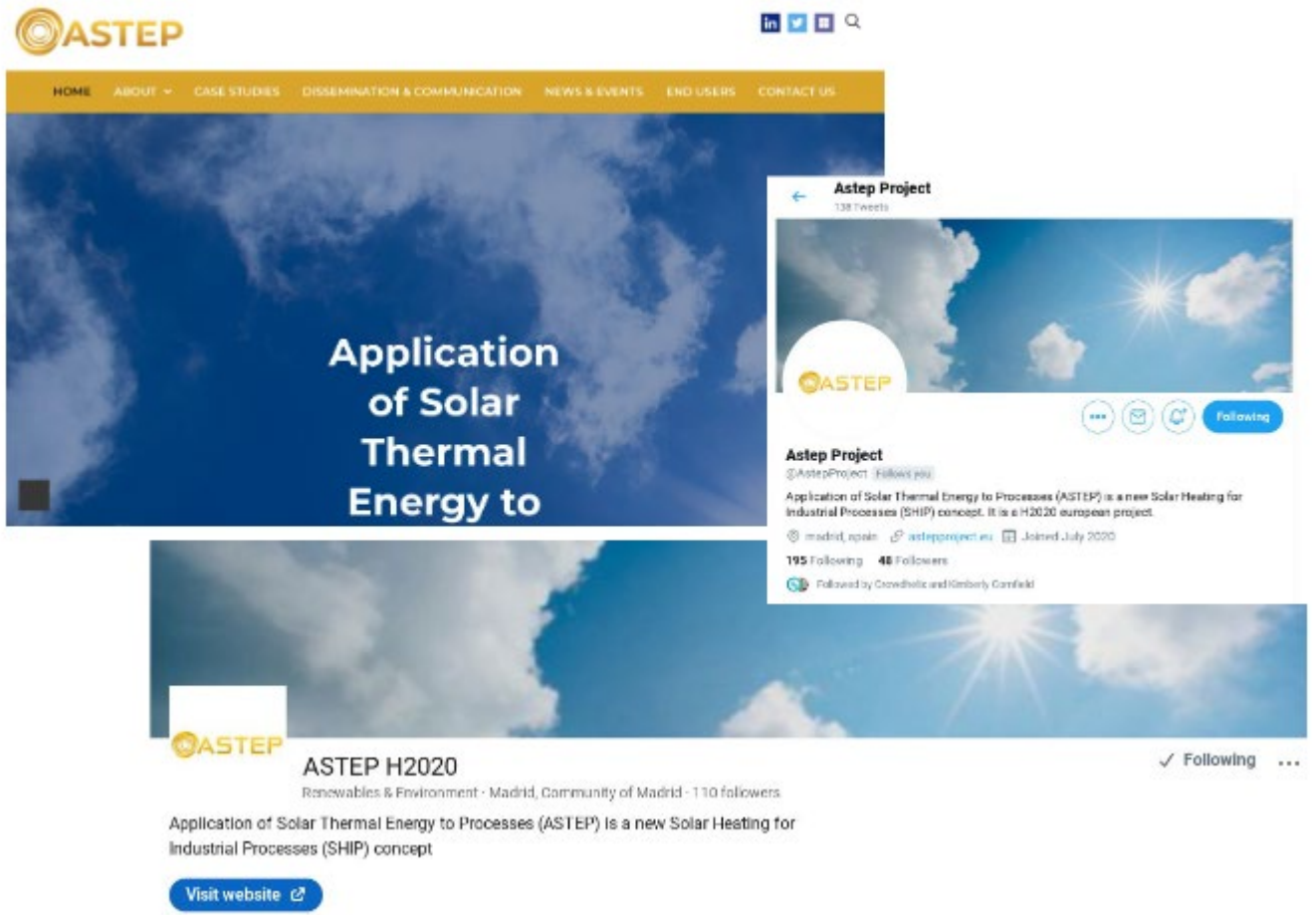
Website: https://astepproject.eu/

Twitter: @AstepProject

Newsletter – twice a year

- 3 already published
- To sign up: https://astepproject.eu/subscribe-to-our-newsletter/





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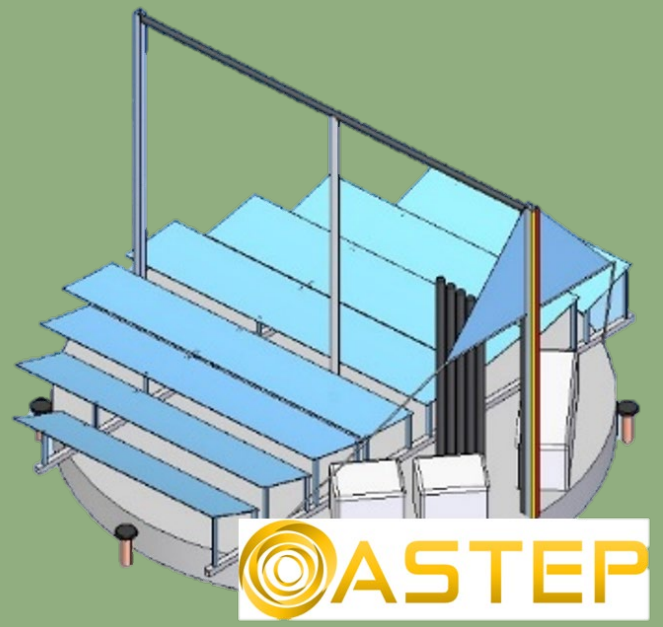

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