SUSTAINABLE PLACES 2023

FRIEND SHIP

act!on heat

SHIP2FAIR

PLURAL

HYSTORE

zhenit

RHC for Buildings and Industry

Renewable Heating and Cooling Solutions for Buildings and Industry: 4th Edition

15th of June 2023, Madrid, Spain

sustainableplaces.eu

R2M RESEARCH TO MARKET SOLUTION

POLITÉCNICA

AGENDA

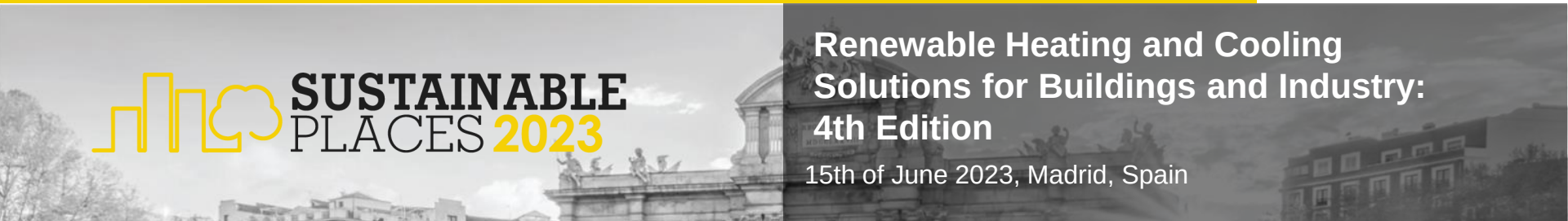
14:00 - 14:10 opening of the workshop

14:10 - 15:30 RHC solutions in Buildings

15:30 - 16:00 Coffee break

16:00 - 17:00 RHC solutions in industries

17:20 – 17:30 closing of the workshop



SUSTAINABLE PLACES 2023

HY STORE
Hybrid Services from Advanced Thermal Energy Storage Systems

HY STORE

Hybrid Services from Advanced
Thermal Energy Storage Systems

EVENT AND PLACE: Sustainable Places 2023, Madrid

DATE: June 15th, 2023

Qian Wang, Researcher, KTH Royal Institute of Technology, Sweden

Project Description

Duration:
January 2023 - December 2026 (48 months)

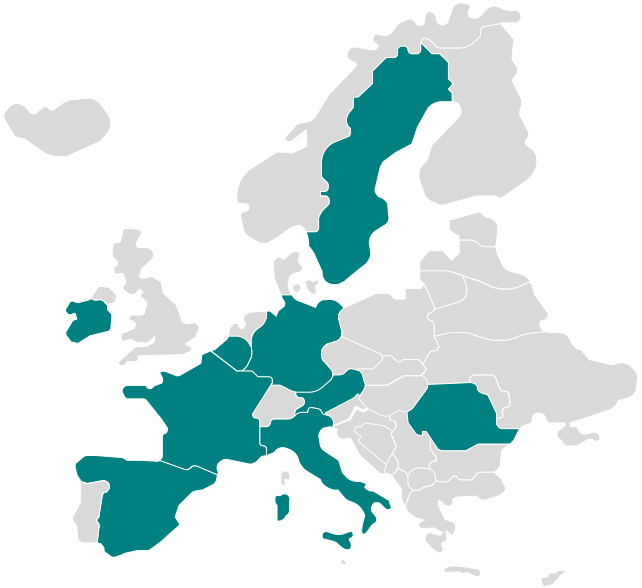
Call:
HORIZON-CL5-2022-D3-01

Partners:
18 partners from 8 countries

TRL:
4-7

Coordinator: ARCbcn.
David Verez (d.verez@arcbcn.cat)

Website:
https://www.hystore-project.eu/



Consortium


HY STORE
Hybrid Services from Advanced Thermal Energy Storage Systems


ARC
BCN
ENGINYERS CONSULTORS


KTH
VETENSKAP
OCH KONST


RUBITHERM
Phase Change Material


AIT
AUSTRIAN INSTITUTE OF TECHNOLOGY


OCHSNER
HEAT PUMPS


PINK


Sorption
Technologies


inovaLab


STAM
MASTERING EXCELLENCE


MASTON


DCU
Ollscoil Chathair
Bhaile Átha Cliath
Dublin City University


eurac
research


R2M
RESEARCH TO MARKET
SOLUTION


University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath


Montserrat


RAAL
complete cooling solutions


EIM

Context of the project

- **Thermochemical storage systems** (TCM) or even other **novel types of PCM storages** are either **absent from the market** or emerging as an early-stage innovation

- Historically, **TES systems have been considered** mainly as an **auxiliary component** for the energy systems at user levels.

- **Connection to the grid can unlock new demand**, leading to innovation (**lowering cost**) and increase the performance (**higher investment returns**) of TES.

- A holistic solution that integrate TES with **HVAC, energy network** on **building and local community level**

HYSTORE Mission

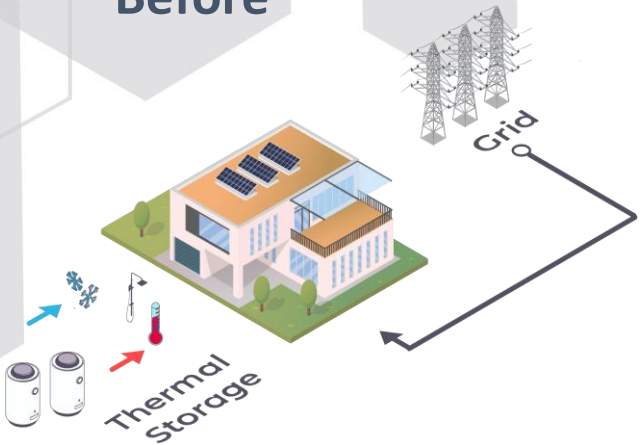
Develop and validate four innovative sets of **Thermal Energy Storage** (TES) concepts, based on **PCM** and **TCM** solutions.

The four novel concepts attain different applications:

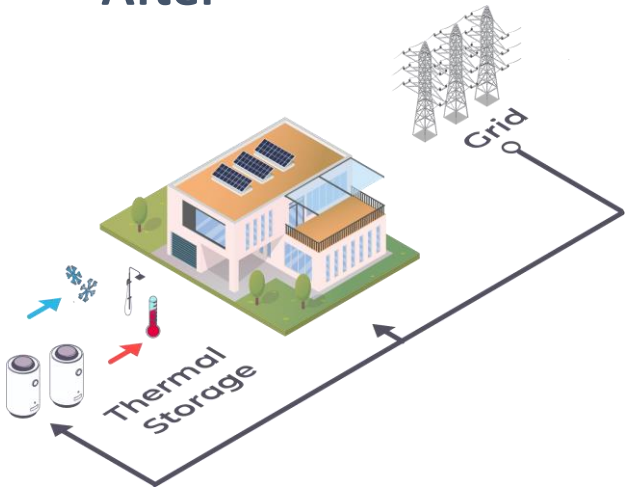
- Heating and cooling
- DHW
- Provision of hybrid services (related to heat and power) thanks to a **smart aggregator** and an **open-source multi-service platform**.

Challenges

Before



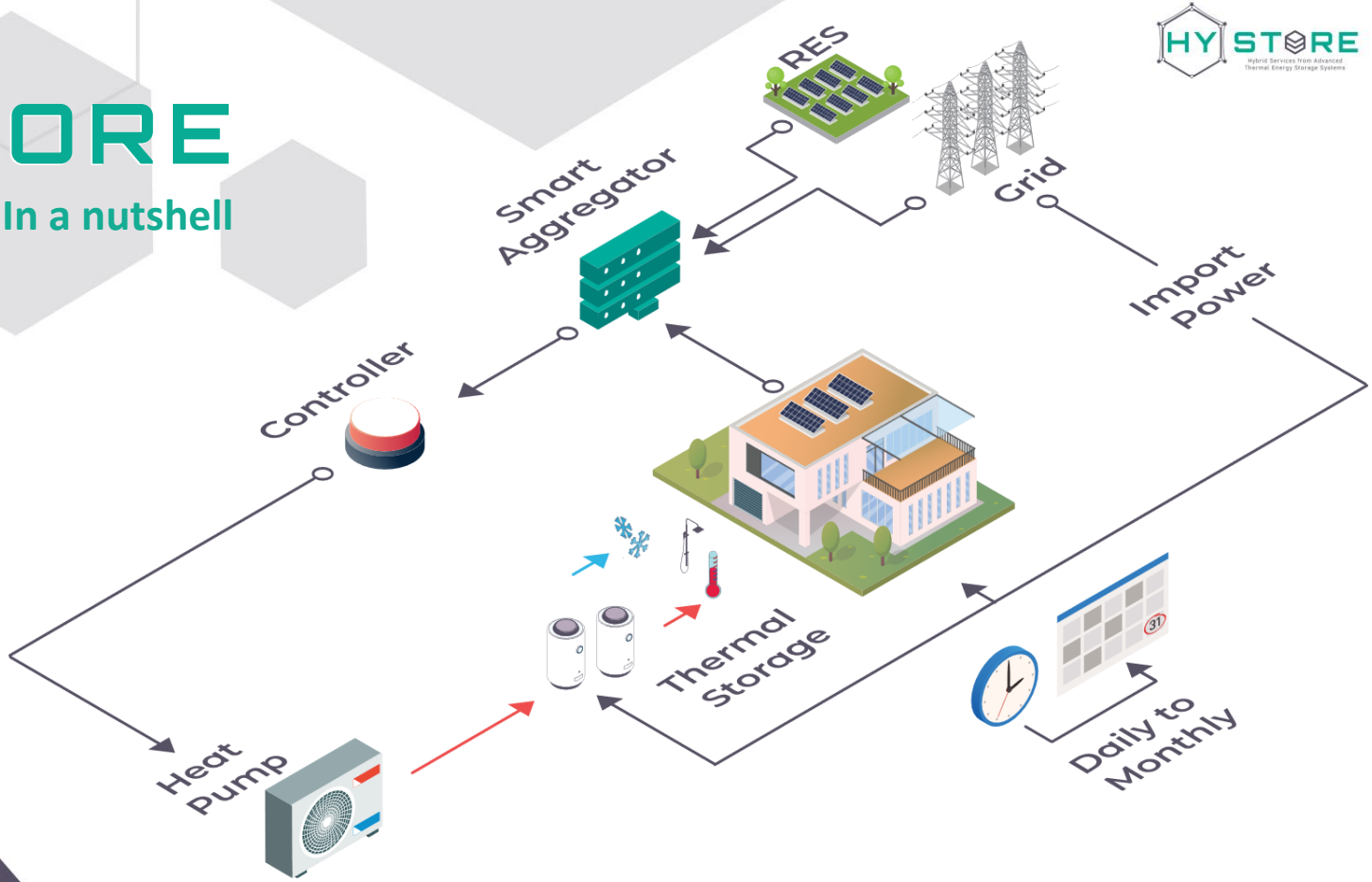
After

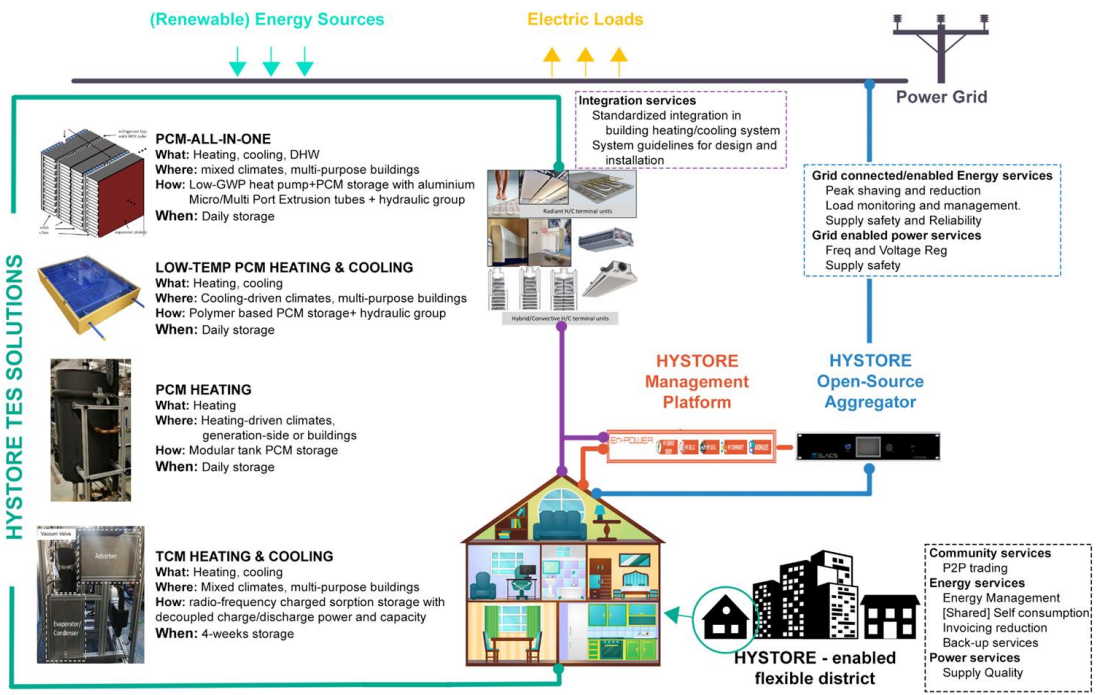


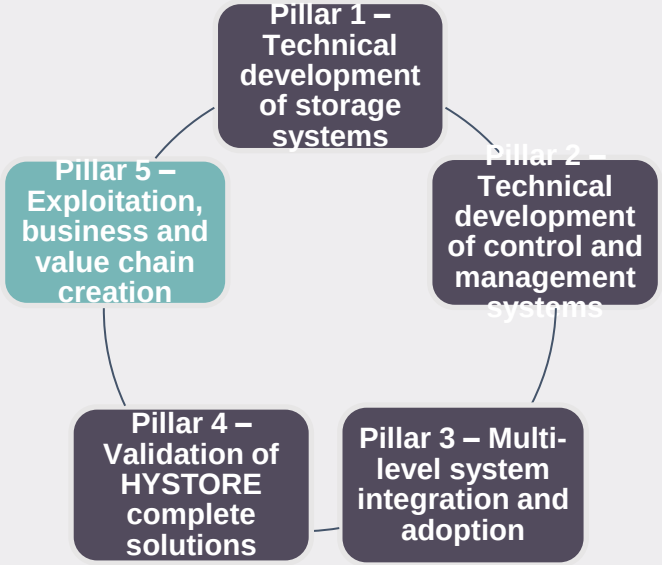
Connection to the grid that can unlock new demand, lower the cost and increase the performance of TES

HYSTORE

In a nutshell

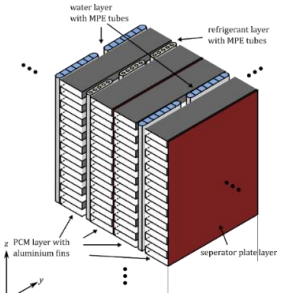



(Renewable) Energy Sources
Electric Loads
Power Grid
HYSTORE TES SOLUTIONS
PCM-ALL-IN-ONE
What: Heating, cooling, DHW
Where: mixed climates, multi-purpose buildings
How: Low-GWP heat pump+PCM storage with aluminium Micro/Multi Port Extrusion tubes + hydraulic group
When: Daily storage
LOW-TEMP PCM HEATING & COOLING
What: Heating, cooling
Where: Cooling-driven climates, multi-purpose buildings
How: Polymer based PCM storage+ hydraulic group
When: Daily storage
PCM HEATING
What: Heating
Where: Heating-driven climates, generation-side or buildings
How: Modular tank PCM storage
When: Daily storage
TCM HEATING & COOLING
What: Heating, cooling
Where: Mixed climates, multi-purpose buildings
How: radio-frequency charged sorption storage with decoupled charge/discharge power and capacity
When: 4-weeks storage
Integration services
Standardized integration in building heating/cooling system
System guidelines for design and installation
Grid connected/enabled Energy services
Peak shaving and reduction
Load monitoring and management.
Supply safety and Reliability
Grid enabled power services
Freq and Voltage Reg
Supply safety
HYSTORE Management Platform
HYSTORE Open-Source Aggregator
Community services
P2P trading
Energy services
Energy Management
[Shared] Self consumption
Invoicing reduction
Back-up services
Power services
Supply Quality
HYSTORE - enabled flexible district


Pillar 1 – Technical development of storage systems
Pillar 2 – Technical development of control and management systems
Pillar 3 – Multi-level system integration and adoption
Pillar 4 – Validation of HYSTORE complete solutions
Pillar 5 – Exploitation, business and value chain creation

PILLAR 1: High-performance thermal storages (TES)

ALL-IN-ONE PCM



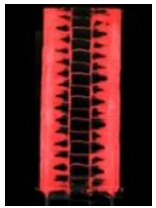
- HP + PCM storage box.
- Evaporator/condenser PCM integrated.
- Natural refrigerant propane (GWP=3).

PCM LOW-TEMP H&C

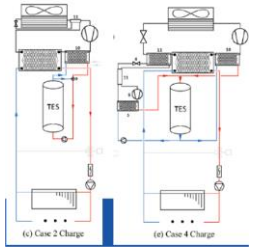
- Modular design (HP ready).
- Polymer based HEX and enclosure.
- High percentage of bio-based raw materials.

SoC algorithm

- Easy-to-install and low-cost sensors.
- Surface temperature sensors.
- Machine-learning techniques.
- TCM, pressure + temperature sensors.

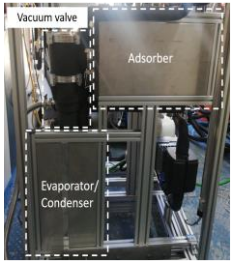


PCM Heating solution



- LHTES with HPs.
- Stainless-steel PCM storage tank.
- High energy density.
- Modular and compact system.

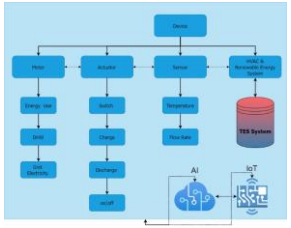
TCM HEATING & COOLING



- Radiofrequency charging.
- Water as refrigerant.
- Separated units for charging and discharging.

PILLAR 2: HYSTORE control, management and integration tools

Ontology for TES

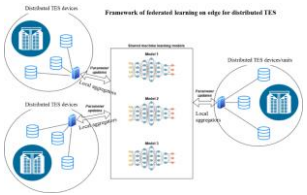


- IoT-based ontology.
- Built on SAREF framework.

ML models

- Interoperable software for TES asset and monitoring data management.
- ML models and optimization methods for TES-integrated energy network

Enhanced smart edge computing



- Federated learning.
- Deployed on buildings edge hardware (SEAS).
- SEAS and TES solutions joint AI training.

TES Smart energy aggregator

- Modular hardware aggregator
- Aggregation optimization.
- Open APIs will enable secure deployment

PILLAR 3: HYSTORE platform and integration

Optimal planning tool

- single building and LEC TES sizing
- TES energy services potential analysis

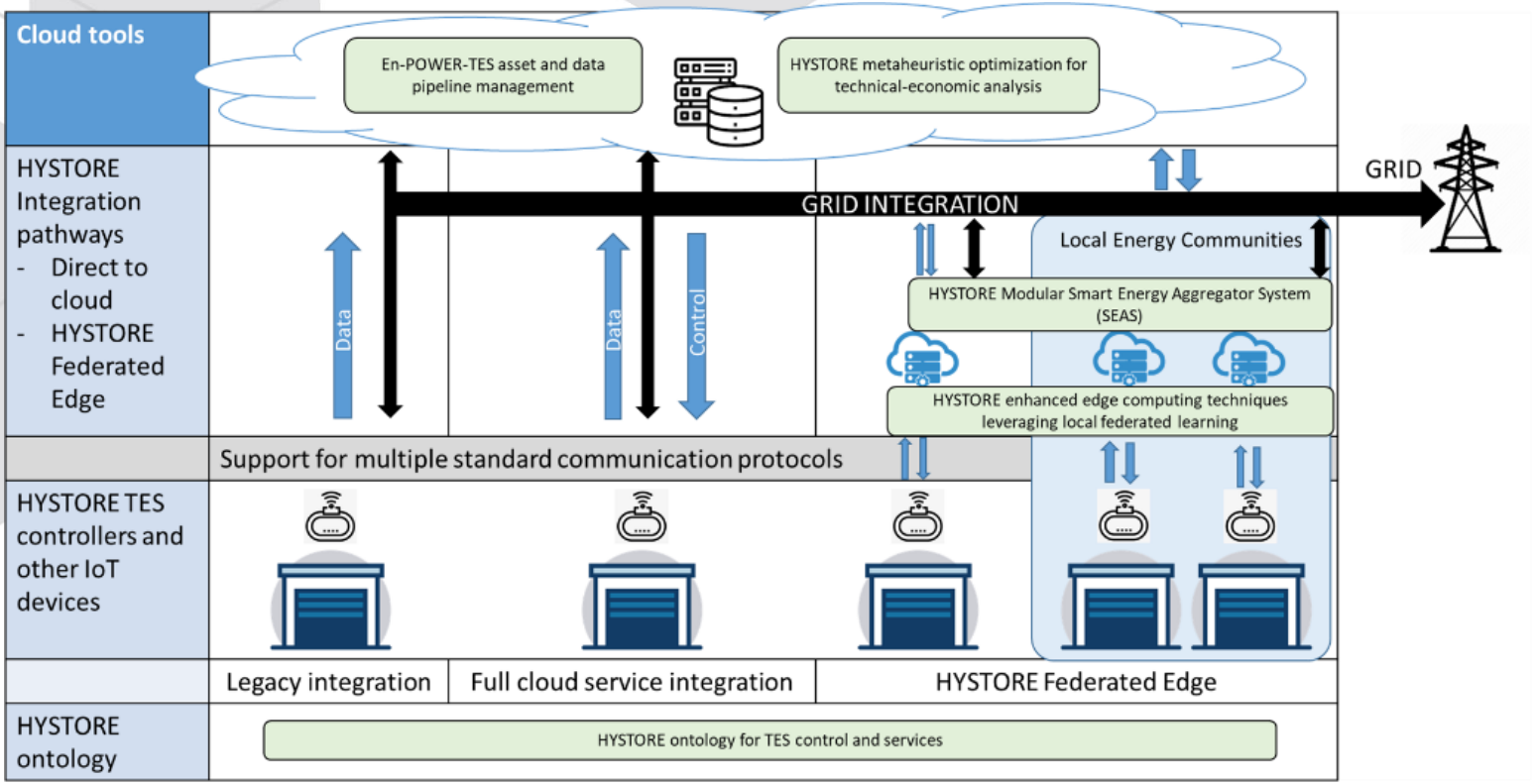
Data management

- Modular design
- Built on SAREF framework.
- Build on top of En-POWER platform

Realtime OS

- Open-source operating systems
- MELACS based
- Secure application of TES toward local energy community

HYSTORE holistic ICT architecture and integration pathways



HYSTORE Impact

+120% Energy Density

-50% CAPEX

Enhanced Installation Efforts

Competitive with Batteries

- Allow TES to be coupled and integrated with **grid-level aggregators** that can be federated in the context of both single buildings and local energy communities.

The HYSTORE demonstration sites

- 4 use cases.
  For each use case a representative business model will be selected.

Use Case 4: DUBLIN

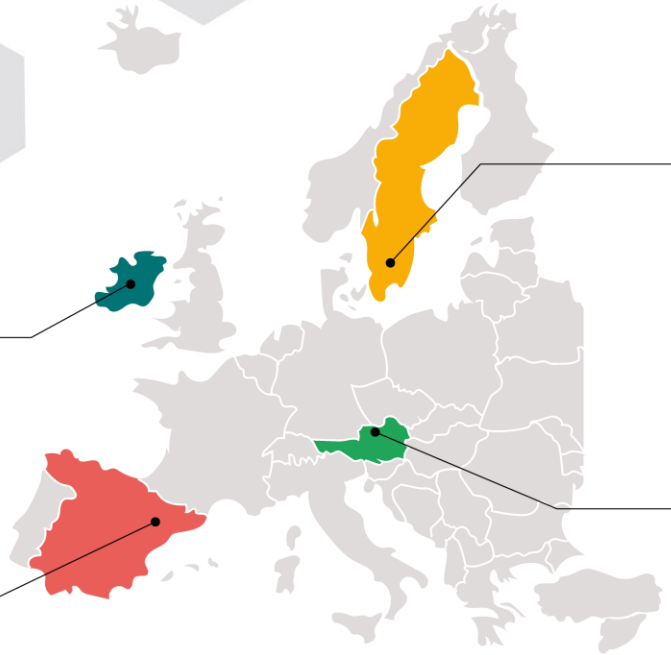
What: TCM H&C + smart platform
Use case: heterogeneous complex (university campus) with high RES share
Building services: heating
Grid services: higher RES usage, peak shaving, balance management

Replication scope: overall campus (30,000 people) and other Northern countries multi-functional buildings

Use Case 3: MONTSERRAT

What: TCM H&C + + low T H&C PCM + smart platform
Use case: heterogeneous complex with high RES share
Building services: heating and cooling
Grid services: peak load shifting, frequency and voltage regulation

Replication scope: overall complex (10 buildings) and mid-scale DHC (2.5 MWth)



Use Case 2: STOCKHOLM

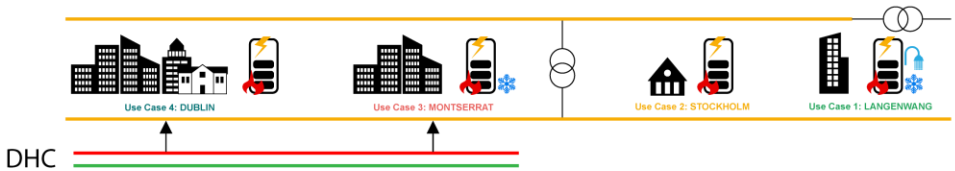
What: PCM HEATING + smart platform
Use case: residential building
Building services: heating
Grid services: peak shaving and shifting, demand-side management

Replication scope: overall campus and other close residential districts

Use Case 1: LANGENWANG

What: PCM-ALL-IN-ONE
Use case: multi-purpose building
Building services: heating,cooling, DHW
Grid services: peak shaving and shifting, demand-side management

Replication scope: other close mixed residential/industrial districts



THANKS FOR YOUR ATTENTION

Qian Wang, KTH

E-mail: qianwang@kth.se

HYSTORE – Grant Agreement n. 101096789

Funded by the European Union

"Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them"

Presentation of the Act!onHeat project

This project has received funding from the EU's Horizon 2020 programme under grant agreement no 101033706.

www.actionheat.eu

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Introduction

Objectives

Strategic heating and cooling planning is further disseminated and taken up

The quality of strategic heating and cooling planning is increased.

Strategic heating and cooling planning leads to the implementation of decarbonisation measures.

Consortium and geographical

- CREARA
- CSE
- Fraunhofer ISI
- TUW
- E-think
- ICLEI
- ECLAREON

Main indicators

120 municipalities that start, continue or improve strategic heating and cooling planning, encouraged by support packages.

30 pre-feasibility studies carried out for individual projects within the municipalities. Encouraged by support packages and advice

15 projects for which financing options are being developed

Support Facility

- Tutoring in applying
- THERMOS & Hotmaps
- Support & feedback to mapping and modelling of projects

Training & Capacity building

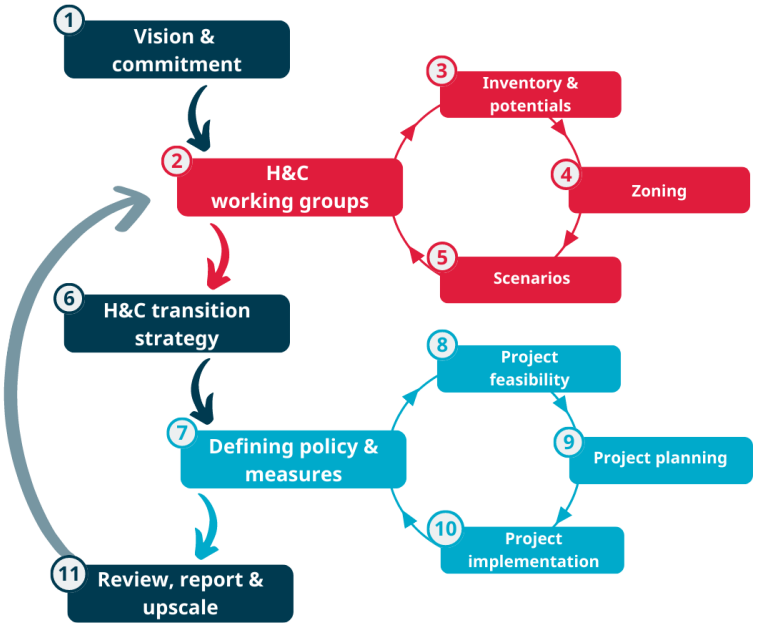
- Training programme
- Training materials

Enabling policy and project implementation

- Stakeholder dialogues
- Project events
- Ambassador programme

H&C Workflow

- The workflow tries to depict the planning process for H&C interventions from the initial concept to the review and upscale of the implemented project.
- The different tasks identified were clustered in three intervention areas (Policy, Planning and Execution) depending on the actors involved.



Policy
City planning
Execution

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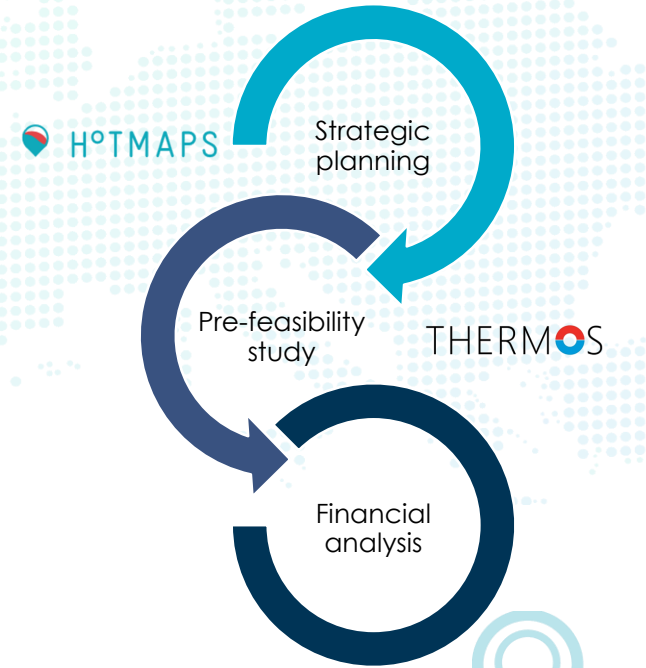
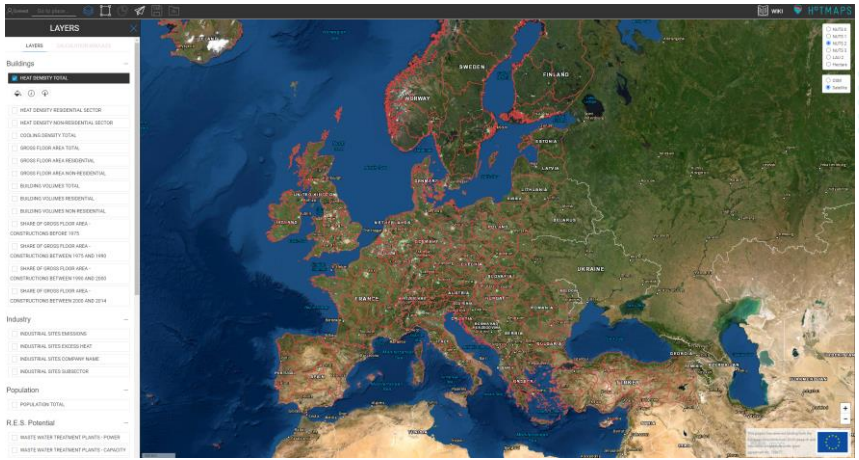
Methodology

- The support is delivered in three different areas that could feed into eachother:
  - Strategic planning
  - Prefeasibility studies
  - Financial analysis
- The support is provided through two simultaneous support facilities associated to each of these topics
- Two open-source tools developed in previous Horizon projects are used to assess the support activities and quantify the main parameters
  - Hotmaps
  - THERMOS
- Interested parties can apply using the Online Application Form available in the Act!onHeat website



Planning tools

HOTMAPS



Vision

Motivate strategic energy planning for public bodies by facilitating the identification, analysis, modelling and mapping of resources and technological solutions.

Objectives

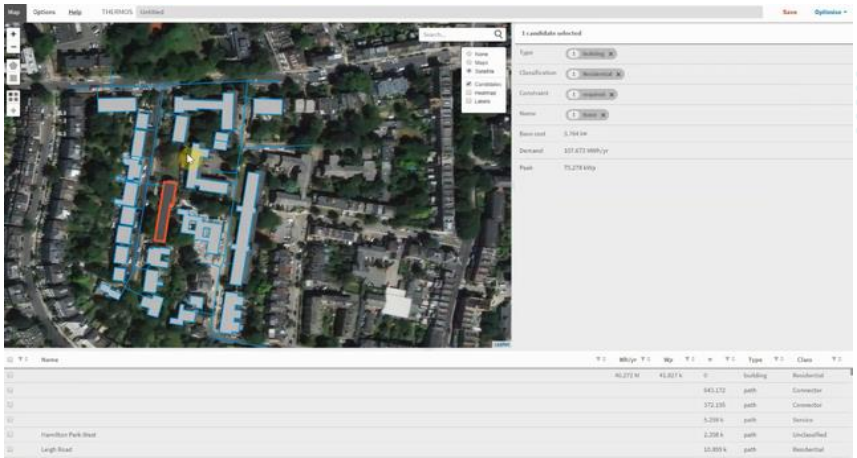
- Develop an open source tool
- Provide initial data
- Providing proven, easy-to-use software

Results

Maps in GIS format of the characterised resource (energy demand, potential for the development of a heat network, biomass supply capacity, ...).

Planning tools

THERMOS



Vision

Scaling up and accelerating the development of low-carbon climate networks in Europe, allowing upgrades, renovations or extensions to be considered quickly and easily.

Objectives

- Mapping demands and generation alternatives for the whole street in the pilot cities
- Establish a methodology for local energy mapping applicable to the EU.
- Develop and implement algorithms for modelling and optimising heat networks.

Results

Open source online tool that allows the modelling of heat networks taking into account real costs, tariffs, performances, operation,... in a versatile and easy to use way.

Support provision

Call for applications
Selection process to be a participant in the different support facilities provided within the Act!onHeat project

- There will be 3 separate calls to select 40 strategic planning projects, 10 prefeasibility studies and 5 financial anylises each
- Participants will be accepted until the KPIs for each call are fulfilled
- In case the consortium's resources are exceeded, applications will be accepted on the basis of selection criteria available on the project's website
- Each participant will be assigned to a member of the consortium according to their geographical location to deliver tailored support

Actors involved

- Local and regional authorities
- Utilities
- Consultancies and energy companies
- Energy agencies
- Researchers and academia
- Policy makers
- H&C industry and industry associations
- Local government networks

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Ongoing Support Facility Case Studies

LEA HESSEN
LANDES ENERGIE AGENTUR

- Energy agency in Hessen (Germany)
- Heat planning will be mandatory next year
- First point of contact for the municipalities on heat planning

3 comprehensive workshops attended by numerous Hessian municipalities. Experts from the Act!onHeat consortium gave keynote speeches.

Targeted *training webinars* for members of LEA Hessen. The topics are:

- "Data for municipal heating and cooling planning"
- "Developing a data inventory for heat planning"
- "Using the hotmaps database and toolbox for strategic heating and cooling planning"

Provide advice for a quick advisory service for district heating. This includes the development of a *best-practice slide deck for RES in district heating networks*.

Ongoing Support Facility Case Studies

Lokaal bestuur Zelzate

- Zelzate Town in East Flanders (Belgium)
- Sources of a large amount of residual heat nearby
- Already identified a potentially economically viable heat network

As part of the Support Facility, THERMOS tool has been used to answer specific heat network related questions for the local government.

Experts from the Act!onheat consortium have been meeting regularly with various stakeholders to gather the required data on building heat demands, drilling costs, and heat supply costs for THERMOS to produce accurate results.

The output of the collaboration will be a pre-feasibility study for the local government. Currently, initial results are being produced and discussed between experts from the Act!onheat consortium and the local government.

Ongoing Support Facility Case Studies

Macedonian Academy of Sciences and Arts

- Research Center for Energy and Sustainable Development (RCESD)
- Objective to set up a data inventory to assist Macedonian municipalities in their H&C strategy

Currently participating in targeted *training webinars* as part of Act!onHeat. The topics are:

- "Data for municipal heating and cooling planning"
- "Developing a data inventory for heat planning"
- "Using the hotmaps database and toolbox for strategic heating and cooling planning"

Experts of Act!onHeat assist **RCESD** in the collection of data to *set up the Hotmaps toolbox for Macedonia* to be used by Macedonian municipalities in the development of their H&C strategy.

Act!onHeat will host a workshop to Macedonian municipal authorities to show in detail *how the toolbox works*

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Future outlook

How will Renewable Heating and Cooling Solutions for Buildings and Industry technically change in the future?

- Encompass demand and supply
- Treat heating and cooling as a whole
- Aggregate demand
- Integrate RES and waste heat

Which will be the role of Renewable Heating and Cooling Solutions for Buildings and Industry in the future EU energy system?

- Help to reach EU 2050 goals
- Reduce overall demand
- Support decarbonisation
- Promote self-consumption

Thank you for your attention

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This project has received funding from the EU's Horizon 2020 programme under grant agreement no 101033706.

www.actionheat.eu

SUSTAINABLE PLACES 2023

PLURAL

PLUG-AND-USE RENOVATION WITH ADAPTABLE LIGHTWEIGHT SYSTEMS

Renewable Heating and Cooling Solutions for Buildings and Industry: 4th Edition

Madrid, 15/06/2023

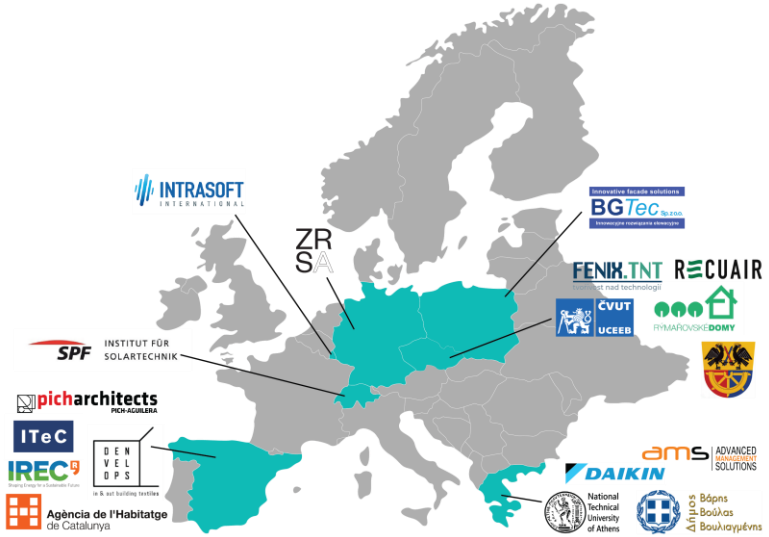
Maria Founti, Project Coordinator

National Technical University of Athens, Greece

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958218.

- The H2020 **PLURAL** brings together 18 partners from 7 European countries (Greece, Spain, Luxembourg, Switzerland, Germany, Poland and Czech Republic) with overall budget of 9.5 million EUR.

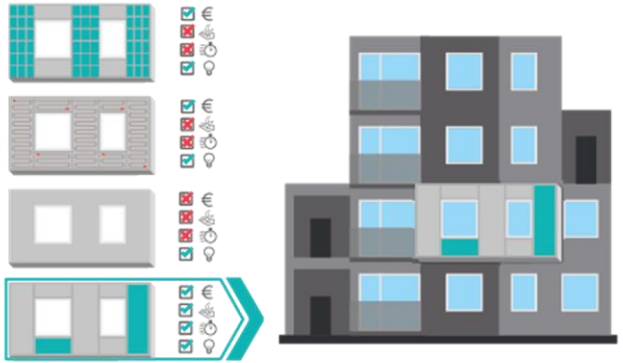
- START: October 1, 2020
- END: September 30, 2024
- DURATION: 48 months



PLURAL aims to design, validate and demonstrate a palette of versatile, adaptable, scalable, **off-site prefabricated Plug-and-Use (PnU) kits**.

The key is to understand how to select and **integrate various renewable energy technologies,** incorporate them in **prefabricated façade components** and optimize their performance for different building types, climates and socio-economic conditions.

PLURAL demonstrates the integration of **hybrid passive and active systems into one kit** and their ability to work together in **synergy** for façade retrofitting, reaching NZEB.



Key Objectives

1) **Near zero energy consumption of buildings renovated with PnU kits**
2) **Cost-effective renovation**
3) **Fast-track renovation**
4) **Environmentally-friendlier deep renovation**
5) **Flexibility – Adaptability**

- Three PnU kits: the **SmartWall, the ConExWall**(external Wall Heating and Cooling kit) and the **DENcomfort with eAHC** (external Advanced Heat and Cool recovery kit)
- Six demonstration sites implementing the PnU kits (3 real and 3 virtual)
- Enhancement of occupant satisfaction via a **user centric approach** that implements learning based control methods and strategies.
- A **Building Information Modelling** (BIM) based **data handling platform** and a **Decision Support Tool** (DST) are developed to enable the optimal component selection, and integration, best PnU kit design, faster and low-cost manufacturing and installation.
- PLURAL focuses on how to manufacture the PnU kits minimizing energy use and material waste (implementing **lean manufacturing principles-F.Q.Ps**).
- Develops **training tools** for main stakeholders (planners, installers, building owners and end users);
- Improves the **life cycle based (LCA, LCC) performance standards** applied in the building sector.

- The **PLURAL** PnU kits will be integrated at **three different real demo building sites**, located in **Greece, Spain** and the **Czech Republic**, featuring different climate conditions, heating/cooling needs and user requirements.

Mediterranean climate (hot summer)
2 of 10 flats - SmartWall

Greek demonstrator in Vari-Voula-Vouliagmeni (VVV)

Mediterranean climate (mild summer)
1 block of 2 – DEN Comfort.

Spanish demonstrator in Terrassa

Continental climate (warm, humid)
Whole building-ConExWall

Czech demonstrator in Kasava

- **PLURAL** also includes **three virtual building demos** for simulating and validating the performance and operation of the solutions. The real demonstrators will also be used for their virtual assessment under conditions that differ from the actual ones. The virtual demos are located in **Switzerland**, **Germany** and **Sweden**.

Alpine climate
ConExWall

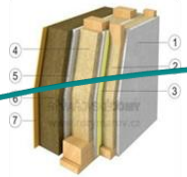
Virtual demonstrator in Bern

Continental climate
SmartWall

Virtual demonstrator in Berlin

Boreal climate
ConExWall

Virtual demonstrator in Väsby



KPIs Definitions Requirements

Development / Optimization of PnU kits

Testing of PnU kits

Manufacturing

Validation in real and virtual demonstrations

Development of LYSIS & MODEST IT Tool

Achieved

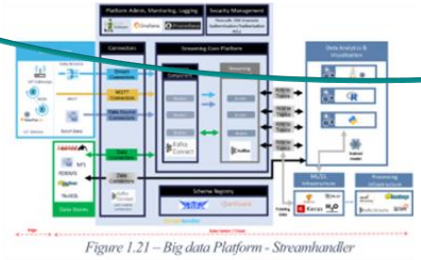


Figure 1.21 – Big data Platform - Streamhandler

Achieved and expected Results

2021

Definitions-Requirements-KPIs

- **Technical status and requirements for all cases defined**
- **Architectural design, BIM models completed**
- **Monitoring methodology defined**

2022

Optimization of PnU kits

- **Completion of component optimization and assembly of PnU kit prototypes**
- **Completion of testing and simulation campaigns**
- **Set FQPs for manufacturing**

2023

Implementation of monitoring platforms, DST

- **Manufacturing**
- **Monitoring systems, monitoring protocols implemented**
- **Functional DST**
- **Façade retrofitting**

2024

Validation

- **Proof of NZEB status for renovated buildings**
- **Manufacturing/ installation procedures validated**
- **Market uptake/business models**

Near zero energy consumption

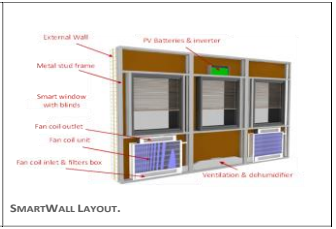
Cost-effectiveness

Fast renovation

Environmentally-friendlier/ Flexibility

The three core PnU kits

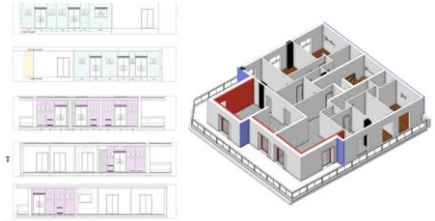
INTERNAL AND EXTERNAL SIDE

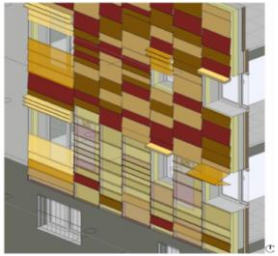


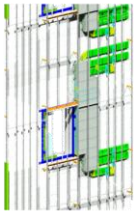
SMARTWALL LAYOUT.

The SmartWall: Heat pump driven by PVs and solar thermal- fan coils integrated in the design

Architectural Design

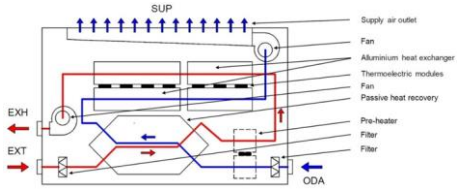


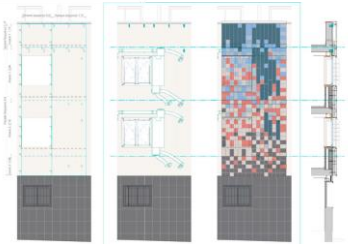




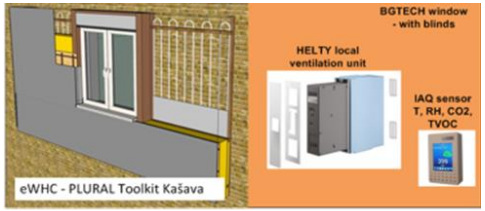
The DEN Comfort: PVs driving the eAHC ventilation unit

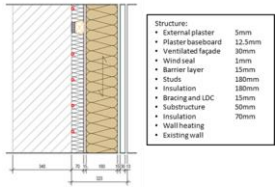
eAHC ventilation unit

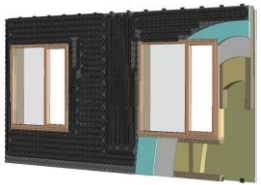


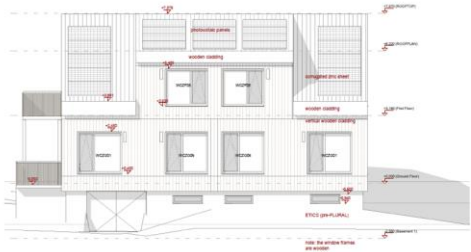


The ConExWall: Heat pump driving the eWHC system/active hydronic

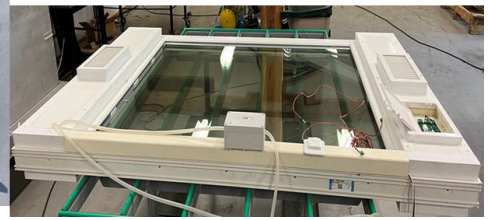




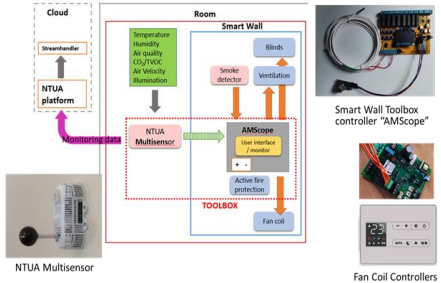




The Heat Harvesting Window



The Toolboxes



Smart Wall Toolbox controller "AMScope"

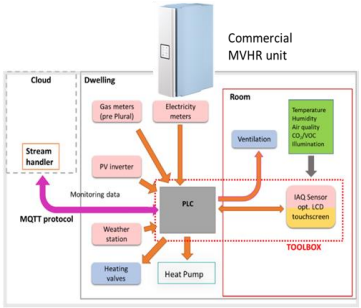
Fan Coil Controllers

NTUA Multisensor

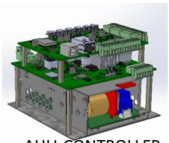
The SmartWall toolbox for Voula

Electricity meters

PLC

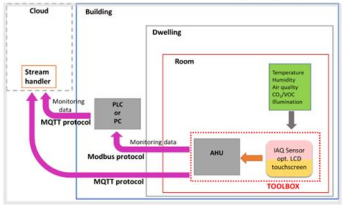


The Kasava toolbox for the eWHC PnU



AHU-CONTROLLER

IAQ-CVUT



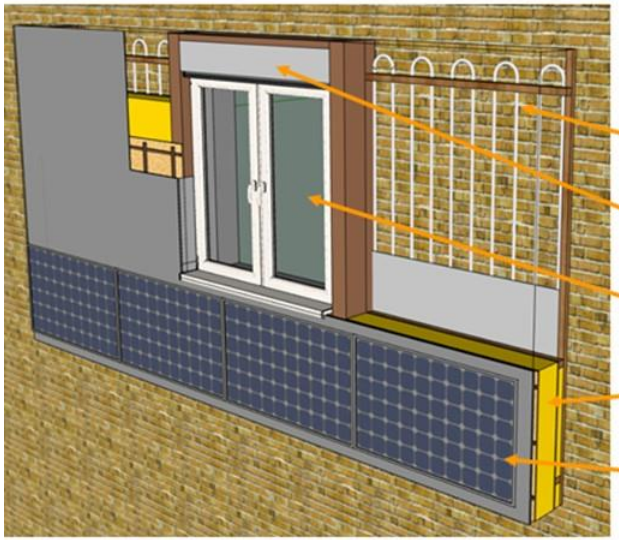
Functions of SmartWall (AMS)

- Versatile prefabricated panel developed by AMS that can be installed externally or internally to an existing building façade.
- It consists of a metal or other material frame, insulation materials, gypsum/cement boards for covering and various types of coatings for finishing and rendering.
- Depending on the position and the existing wall that is going to be attached, the SmartWall may include a window, or a door with a shutter or blind.
- SmartWall also can feature a big variety of electromechanical equipment to cover any demand of the building renovated.
- This includes space in the panel for a heating/cooling unit that can be diversified depending on the application or the renovation scheme.

Prototype and implementation of SmartWall

The SmartWall prototype

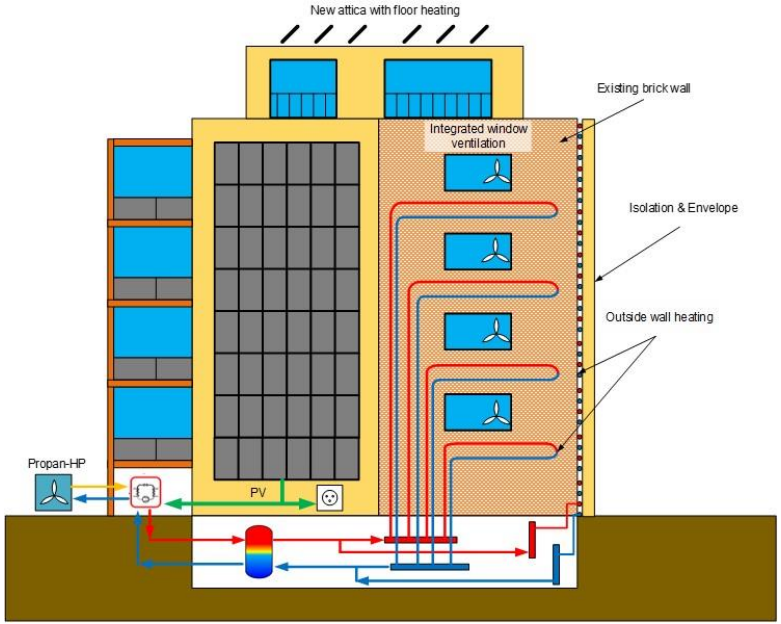
Installation at the NTUA living-lab



Functions of the prefabricated wood frame modules (attached to the existing facade):

- Heating element (replaces radiator inside building)
- Decentralized ventilation with heat recovery
- New window (pre-mounted in module)
- Thermal insulation
- Optional: building integrated photovoltaic

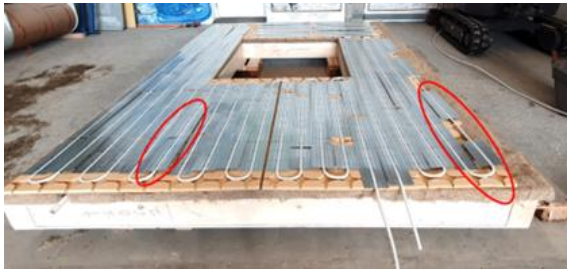
Field of application and advantages of ConExWall



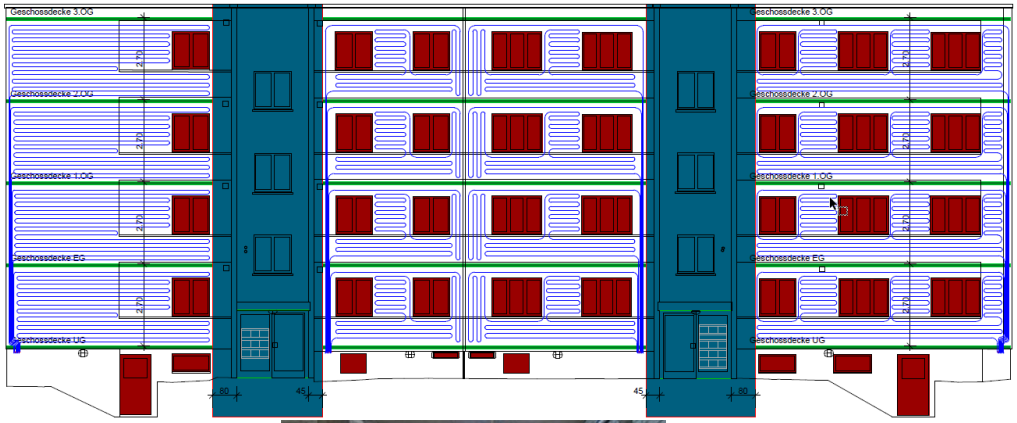
- Application for renovation of buildings with an old, non-insulated facade (or removable old insulation)
- Adding of a low-temperature heating distribution (thus, substitution of fossil fuels with high-efficiency heat pumps)
- Building can be renovated while beeing occupied (difference to floor heating)
- Industrial pre-fabrication is possible (lack of professionals is less relevant, cost reduction for larger buildings)
- Focus on space heating, cooling is possible as well (if moisture is avoided)

Prototype and Implementation of the ConExWall

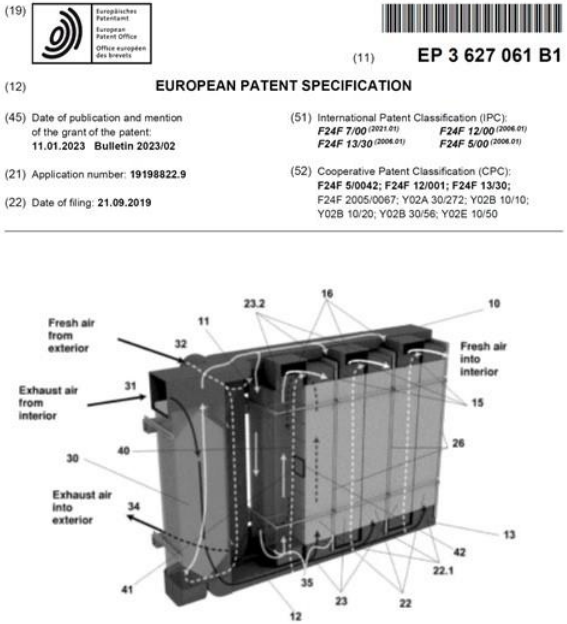
Construction of the Heating layer on a Prototype



Modularity of the heating loops and façade panels at the Swiss Demonstrator



- EU patent: **EP 3 627 061 B1**
- Ventilation unit with the function of cooling/heating of ventilated spaces using a combined heat exchanger consisting of a passive counterflow part and an active part using thermoelectric modules.
- Provide space ventilation, as well as could provide space heating or cooling.
- Passive module comprising at least one passive heat air exchanger for heat recovery. It has at least two inputs and at least two outputs.
- An active module comprising at least one active heat air exchanger. The active module also has at least two inputs and at least two outputs.



(19) Europäisches Patentamt / European Patent Office / Office européen des brevets

(11) EP 3 627 061 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent: **11.01.2023 Bulletin 2023/02**

(21) Application number: **19198822.9**

(22) Date of filing: **21.09.2019**

(51) International Patent Classification (IPC): ***F24F 7/00*** *(2021.01)* ***F24F 12/00*** *(2006.01)* ***F24F 13/30*** *(2006.01)* ***F24F 5/00*** *(2006.01)*

(52) Cooperative Patent Classification (CPC): **F24F 5/0042; F24F 12/001; F24F 13/30;** F24F 2005/0067; Y02A 30/272; Y02B 10/10; Y02B 10/20; Y02B 30/56; Y02E 10/50

Prototype and Implementation in DENcomfort Wall

The eAHC prototype

The DENcomfort Wall prototype (DENVELOPS)

Key Performance Indicators

KPI	Performance Value	Target value	Results achieved in M24 of PLURAL
Near zero energy consumption of buildings renovated with PnU kits	U-value (W/m²K) of PnU kit	0.23 W/m²K	PnU designed with U-value matching nZEB; U-value results: Voula/SmartWall: 0.31 W/(m²K), Terrassa/DENcomfort: 0.23 W/(m²K), Kasava/ConExWall: 0.24 W/m²K²
	Primary Energy consumption per building	<90 kWh/m²a (depends on country)	Voula/SmartWall: 84 kWh/ m²a (fulfils NZEB) Terrassa/DENcomfort Wall: 76 kWh/m² a (fulfils NZEB) Kasava/ConExWall: 93 kWh/m²a (fulfils NZEB)
Cost-effectiveness	Renovation Costs	58% less than conventional renovation	Parameters influencing costs: planning, design, site preliminaries, on-site and off-site labor, substructure, materials, BEM, factory costs, redesign, financing. The overall cost reduction cannot be defined yet. Major cost reduction is expected for onsite labor costs.
Fast-tract renovation	Time required for deep renovation	At least 50% reduction	Parameters influencing renovation time: Measurements & design, permits & approvals, engineering, procurement & logistics, manufacturing & site preparation, onsite works, clean up. First estimates indicate significant time savings in procurement and logistics (ca. 60%) and for onsite works (ca. 40%)
Environmental impact	CO2eq/m² per PnU kit	0.5 tCO_2eq/m^2	SmartWall: 0.116 tCO_2eq/m^2 DENcomfort: 0.0815 tCO_2eq/m^2 ConExWall: 0.079 tCO_2eq/m^2
	Recyclability per PnU kit	70% material recyclability	SmartWall: 90% DENcomfort: 70% ConExWall: 78%
Flexibility – Adaptability	per PnU kit	System combinations	SmartWall: 8 defined DENcomfort: 3 defined ConExWall: 2 defined

PLURAL experiences in relation to RHC

Advantages of prefabrication and integration of RES in the component/system design for heating and cooling:

- PnU kits can successfully integrate RES (PVs, OPVs, solar thermal systems, various types of heat pumps, ventilation, air-handling, hydronic systems) and achieve efficient operation.
- Storage (thermal, electrical) and low carbon footprint materials and components could be part of the PnU design
- Flexible solution for retrofitting including EV-charging
- Effective “ integrated” solution for decarbonised, adaptative and regenerative Built Environment

Challenges:

- PnU kit design and RES need to be adapted to building characteristics
- Industrialization, component integration as part of the manufacturing: new business models
- Lack of regulatory framework for active building façade components
- Acceptance (industrial, end-user and social): Restricted due to lack of large-scale demonstrations, long-term performance evaluation, harmonized standards, economies of scale to reduce costs

Question 1: How will Renewable Heating and Cooling Solutions for Buildings and Industry technically change in the future?

- RHC can unlock new potentials for energy savings and reduction of emissions in the **building sector** when combined in “active” envelop components to offer integrated solutions for deep retrofitting and new construction.
- RHC technologies are rather mature. Need to focus on integration and cost-reduction: R&I efforts are needed to standardize and replicate RHC systems leading to cheaper equipment that is easier to install.
- Further research is needed to quantity potentials of integration of RHC solutions and their components in active envelop solutions towards complete, fast, lower cost solutions
- Take a system approach and have more demonstration projects to optimize the integration of RHC solutions in active components in different set-ups and to allow for better system integration.
- The environmental impact of RHC solutions in a building life cycle perspective needs further investigation.

Question 2: Which will be the role of Renewable Heating and Cooling Solutions for Buildings and Industry in the future EU energy system? (e.g. based on project investigations or on your perspective as an expert)

- RHC systems could provide solutions/options beyond compactness, e.g. more eco-friendly materials, recyclable-reusable components, "standardization" of size/materials to make them interchangeable.
- Prefabricated, fully-integrated 'plug in and play', modular, hybrid/multisource RHC systems could offer cost reduction and increased market acceptance
- Integration of RHC systems in building components could create new business opportunities based on local /regional value chains

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958218.

Contact us via e-mail:
info@plural-renovation.eu

THANK YOU FOR YOUR ATTENTION!

www.plural-renovation.eu

AGENDA

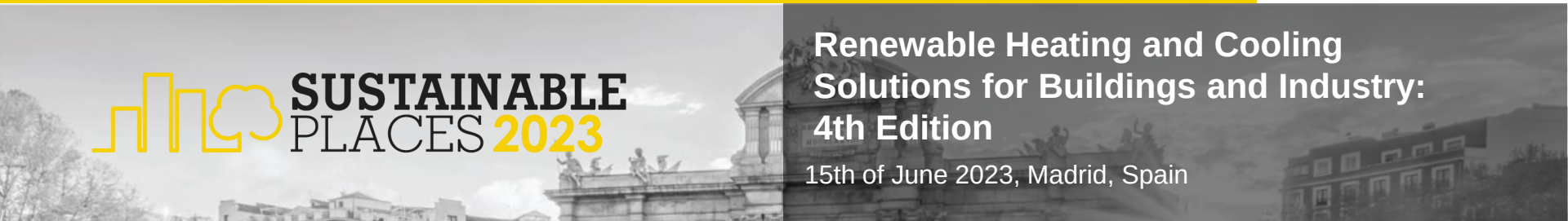
14:00 - 14:10 opening of the workshop

14:10 - 15:30 RHC solutions in Buildings

15:30 - 16:00 Coffee break

16:00 - 17:00 RHC solutions in industries

17:20 – 17:30 closing of the workshop



FRIEND SHIP

Forthcoming Research and Industry for European and National Development of SHIP

SUSTAINABLE PLACES 2023

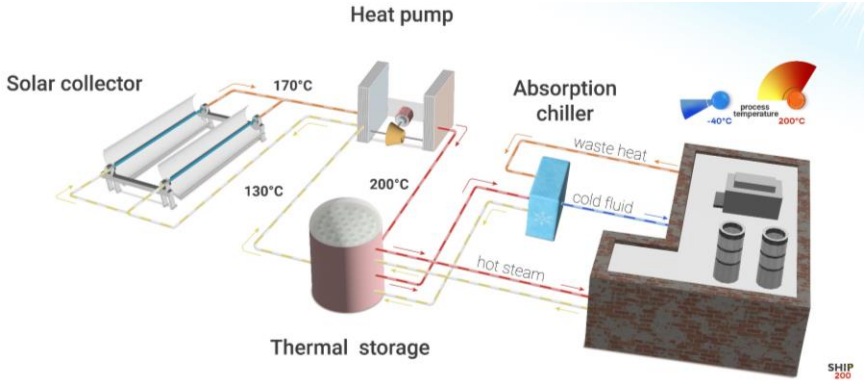
WORKSHOP – “Renewable Heating and Cooling Solutions for Buildings and Industry: 4th Edition”

15/06 at 14-17:30

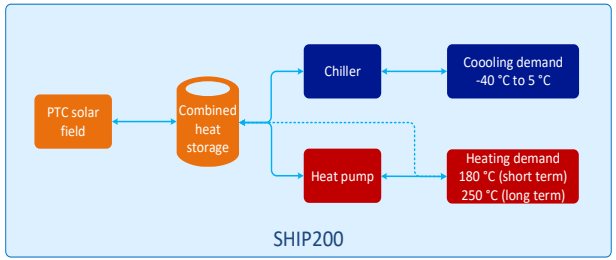
FRIENDSHIP

Anouk Muller

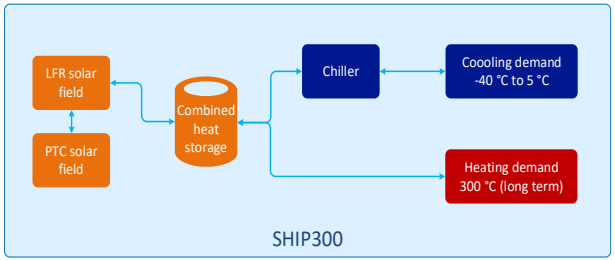
FRIENDSHIP in a nutshell



Start: 01/05/2020
Duration: 48 months
Coord: CEA
Consortium: 10
Budget: 4,999,423.74 €
Type of action: RIA
Topic: LC-SC3-RES-7-2019 Solar Energy in Industrial Processes
Overall Concept Video



Validation of SHIP200 in relevant conditions
Demo site Grenoble (FR), Annual DNI 1,400 kWh/m²



Numerical validation of SHIP300 in relevant conditions
End-users sites (DE, PT, SP)

Advances done from SP22

Main innovations

FRIENDSHIP aim at superior performance by **incorporating several new improvements and functions to the standards SHIP solution**:

- **Low-cost solar collectors** combined with **selective coatings** (improve absorbance) and **nanoparticles** (improve heat transfer)
- An advanced **very high temperature heat pump** that enables continuous and stable heat supply at target temperatures **between 180 and 250°C**
- A **high-density combined thermal storage** that allows the storage of heat from the solar heat loop as well as from the process loop
- An **advanced control management** will allow the enhancement of the quality and availability of heat, to match the process demands and rationalise the use of the existing energy sources
- A cooler that enables **cold production** for industry from the residual high-temperature heat, either by using an **absorption** or **ejector** chiller

Status

- Finished – New selective coating to be used for the solar field of SHIP200 DEMO
- Deliverable: D2.1 Design engineering report for a solar thermal system with high availability
- 3 Papers :
  - Review of the spectrally selective (CSP) absorber coatings, suitable for use in SHIP; Noč L.; Jerman I.; Solar Energy Materials and Solar Cells 2022, 238.
  - A review of the use of nanofluids as heat-transfer fluids in parabolic-trough collectors; Chavez Panduro E.; Finotti F.; Largiller G.; Lervåg K.; Applied Thermal Engineering 2022, 118346.
  - Environmentally sustainable electroplating of selective cobalt-chromium coating on stainless steel for efficient solar collectors; Zäll, E., Nordenström, A., Järn, M., Mossegård, J., Wågberg, T.; Solar Energy Materials and Solar Cells 2022, 111821.
- 1 video on Heat Production : https://vimeo.com/782532916

Advances done from SP22

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Status

- Prototype commissioned and test campaign ongoing at SINTEF
- Public Deliverable 3.1: Initial heat pump concepts and integration principles for SHIP200 targeting heat delivery up to 200 °C (steam cycle) and 250 °C (e.g. CO2 cycle)
- 1 video on Heat Production : https://vimeo.com/782532916

Advances done from SP22

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Status

- Prototype manufacturing ongoing and test campaign coming soon at CEA
- Deliverable: D5.1 Detailed design of PCM storage
- Dissemination: IN-POWER workshop 2020, SolarPACES 2021
- 1 video on Heat Storage : https://vimeo.com/814166694

Advances done from SP22

Main innovations

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Status

- Modelling of digital twins in Modelica ongoing at CEA
- 1 Paper:
  - Solar Field Output Temperature Optimization Using a MILP Algorithm and a 0D Model in the Case of a Hybrid Concentrated Solar Thermal Power Plant for SHIP Applications; Kamerling, S.; Vuillerme, V.; Rodat, S.; Energies 2021, 14, 3731.
- Dissemination: SWC 2021, EuroSun 2022

Advances done SP22

Main innovations

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Status

- **Prototype commissioned and tested at CEA**
- Deliverable: D4.2 Optimal design of ejector chiller concepts targeting cold production down to 5 °C (short term) and -10 °C (long-term)
- Deliverable D4.3 Optimal design of absorption chiller concepts targeting cold production down to -20°C (short term) and -40°C (long-term)
- 2 Papers :
  - Choked liquid flow in nozzles: Crossover from heterogeneous to homogeneous cavitation and insensitivity to depressurization rate; Wilhelmsen Ø.; Aasen A.; Chemical Engineering Science 2022, 248, Part B.
  - One-dimensional mathematical modeling of two-phase ejectors: Extension to mixtures and mapping of the local exergy destruction; Wilhelmsen Ø., Aasen A., Banasiak K., Herlyng H., Hafner A.; Applied Thermal Engineering 2022, 119228.
- Dissemination: SolarPACES 2021, ICR 2023, Pôle Cristal 2023

WP4 – Absorption chiller prototype

Absorption chiller, front view

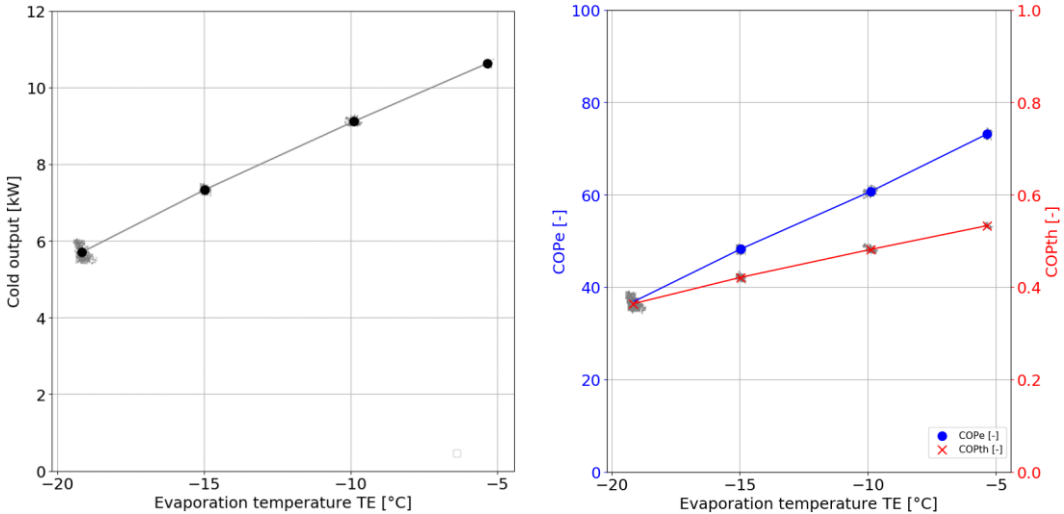
Absorption chiller prototype assembly completed. The assembly of the prototype as well as the tightness and pressure tests were finished in the beginning of August.

WP4 – Absorption chiller prototype

Photograph of the semi-virtual test bench

Performance measurements at steady-state points and dynamic tests were carried out during winter ‘22-’23

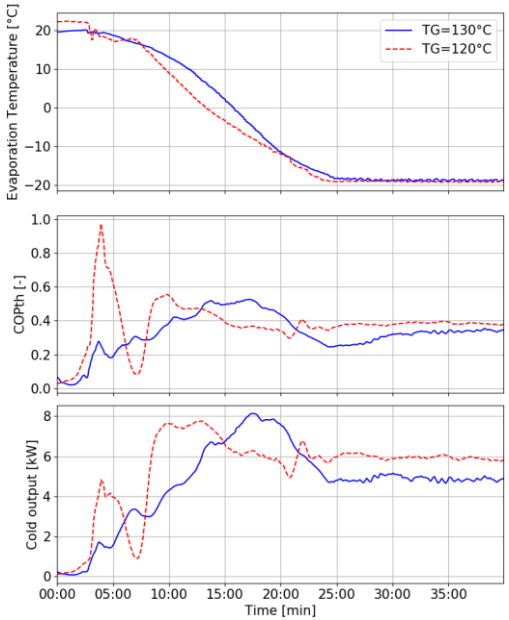
WP4 – Absorption chiller prototype



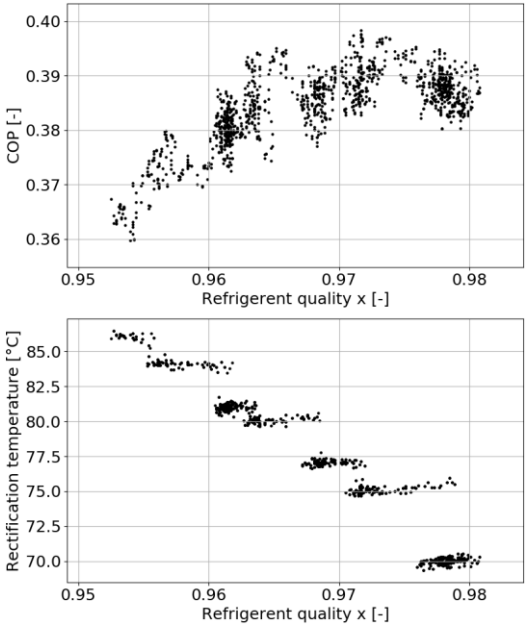
Evaporator temperature variation impact on cold production and COP with T_G=120°C, T_A=20°C and $\dot{M}_{pump}$=180 kg/h

At -5°C, 11 kW with a thermal COP of 0.54.
At -20°C, 6 kW with a COP around 0.36.
Electric COP ranging from 35 to 70 !

WP4 – Absorption chiller prototype



Evolutions of different parameters during the start-up of the prototype



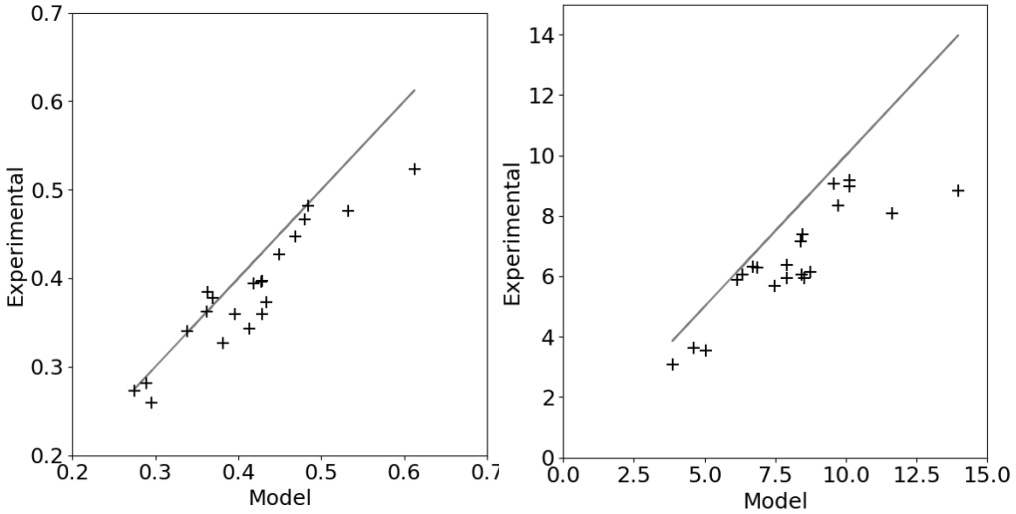
Rectification temperature impact on refrigerant quality and on the COP

Dynamic results are satisfying with around 30min for stabilization

Once the values of the regulation parameters are identified, the start-up of the machine can be easily operated.

Optimal COP is observed for a quality of around 0.975

WP4 – Absorption chiller prototype



a) COP

b) Cold power

Numerical and experimental results comparison of COP and cold power with $\dot{M}_{pump}$=170 kg/h

A model was developed for design and preliminary performance simulations.

Plate heat exchangers provide satisfying heat transfer but the species mass transfers inside the absorber and the generator remain limited.

Future investigations will be carried out in order to improve the distribution of fluids and the time of contact between species in these heat exchangers.

FRIEND SHIP

Forthcoming Research and Industry for European and National Development of SHIP

SUSTAINABLE PLACES 2023

Thank you for your attention !

SHIP2FAIR

Solar Heat for Industrial Processes towards Food and Agro Industries commitment in Renewables

Project Presentation

SP2023: Workshop on 'Renewable Heating and Cooling Solutions for Buildings and Industry: 4th Edition'
15th of June 2023, Madrid, Spain

Dimitris Papageorgiou – Papageorgiou@tvpsolar.com
TVP SOLAR

Miguel Zarzuela – mzarzuela@fcirce.es
circe - **Project Coordinator**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 792276.

RHC for Buildings and Industry

SUSTAINABLE PLACES 2023

Renewable Heating and Cooling Solutions for Buildings and Industry: 4th Edition

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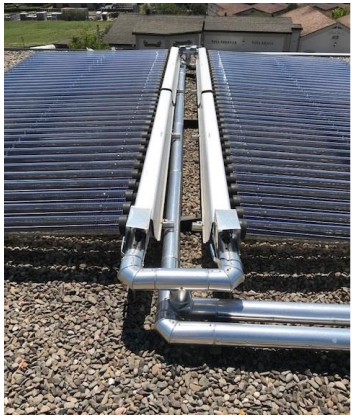


Concept

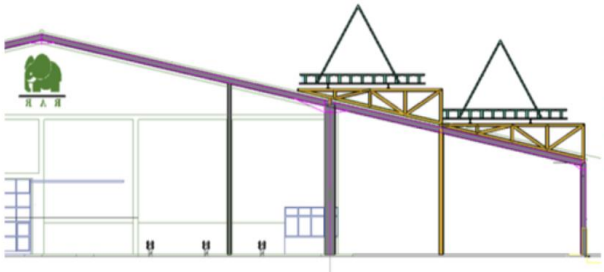
Unveil the untapped potential of solar heat for agroindustries in the EU

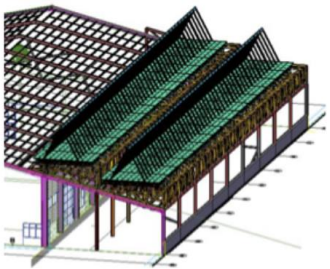
⇨ Integration of Solar Heat in Industrial Processes - **SHIP**

⇨ Tools & methods for the development **SHIP**

Demo-sites in:
France - Italy - Spain - Portugal

BUDGET: 8M €
DURATION: 2018-2023





Partners

Coordination

circe

Solar technologies providers

INDUSTRIAL SOLAR renewables onsite

SOLID solarinstallation+design

TVP SOLAR

R&D and consulting

BEST Bioenergy and Sustainable Technologies

cea

EDF

LINKS ISMB

RINA

Agro-food field experts

cooperativas agro-alimentarias España

LARNAUDIE FIGEAC - CASTELNAU/DARY

MARTINI

RAR 1982 DOCE & PORTUGUESA

BODEGAS RODA RIOJA ALTA

Dissemination & Training

EUREC The Association of European Renewable Energy Research Centres

Expected results

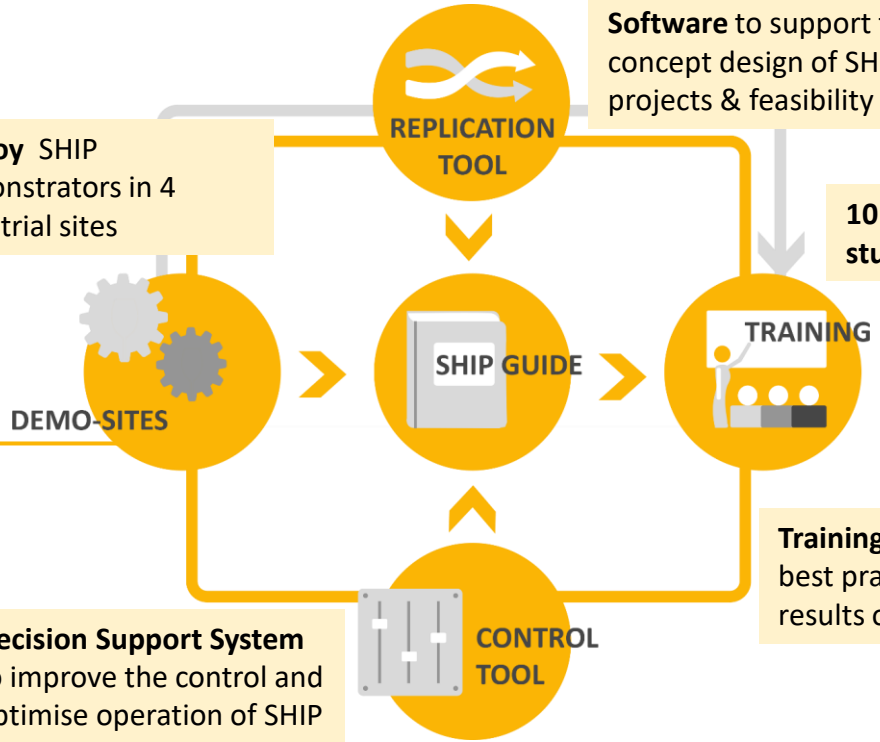
Sugar boiling
Porto, Portugal

Foie-gras production
Castelnaudary, France

Spirits distillitation
Pessione, Italy

Wine fermentation & stabilization
La Rioja, Spain

Deploy SHIP demonstrators in 4 industrial sites



Software to support the concept design of SHIP2 projects & feasibility studies

10 feasibility studies

Training, making use of best practises and results of the project

Decision Support System to improve the control and optimise operation of SHIP

Tools & Methods: Replication Tool (1/2)

A software to support non-experts in the concept design of SHIP projects & in pre-assessing their feasibility

It provides preliminary answers to practical questions:

- What is the best technology for my case?
- How much surface is needed?
- How much solar energy will I produce?
- At what temperature?
- Do I need a storage? If so, which size?
- How much CO2 will I save?
- What will be the CAPEX? The OPEX?
- What will be the payback time?

Tools & Methods: Replication Tool

(2/2)

5-step input process:

REPLICATION TOOL

Basic inputs provided by the user:

- Energy demand: quantity and temperature
- Use of energy (cooling, heating, …)
- Fluid used in the process (steam, water, air)
- Site location
- Space availability

The demo-sites & the flagship projects

SHIP systems fully validated in real processes:

Novel solar collectors demonstrated in average irradiance areas through demonstration campaign

- **Total capacity:** 1.7 MWth
- **Solar fraction:** 24% av.
- **Yearly average solar efficiency:** 44% (M&R)-54% (RODA)

- **Primary energy savings:**
  - 2 GWh/year
  - 570 tCO_2/year avoided
  - 2.7 GWh/year increase of RES in industrial heating

First demo-site installed

Wine fermentation & stabilization
La Rioja, Spain

BODEGAS RODA
Haro . Rioja Alta . España

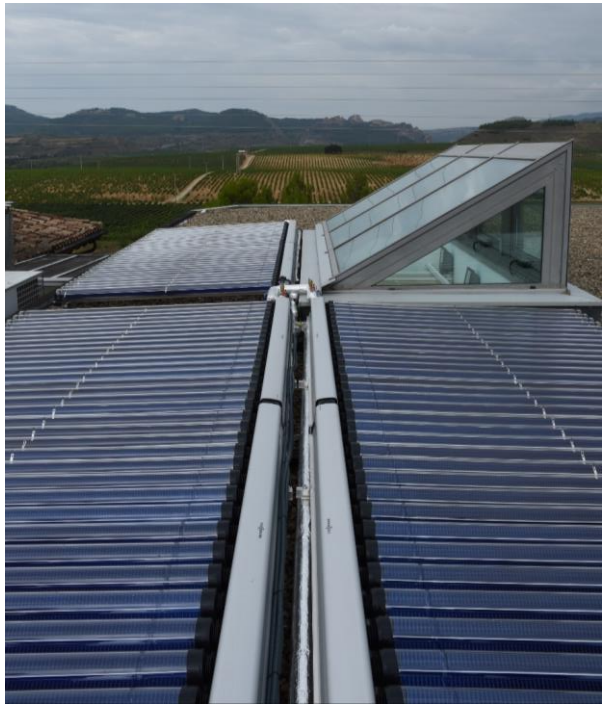
Solar thermal to provide heating & cooling
Viessman Vitosol 200TM 70m^2 area + Absorption machine

Heating

- Radiant floor heating for malolactic fermentation
- Heat for adsorption process
- Pipe cleaning & desinfecting
- High-pressure cleaning

Cooling

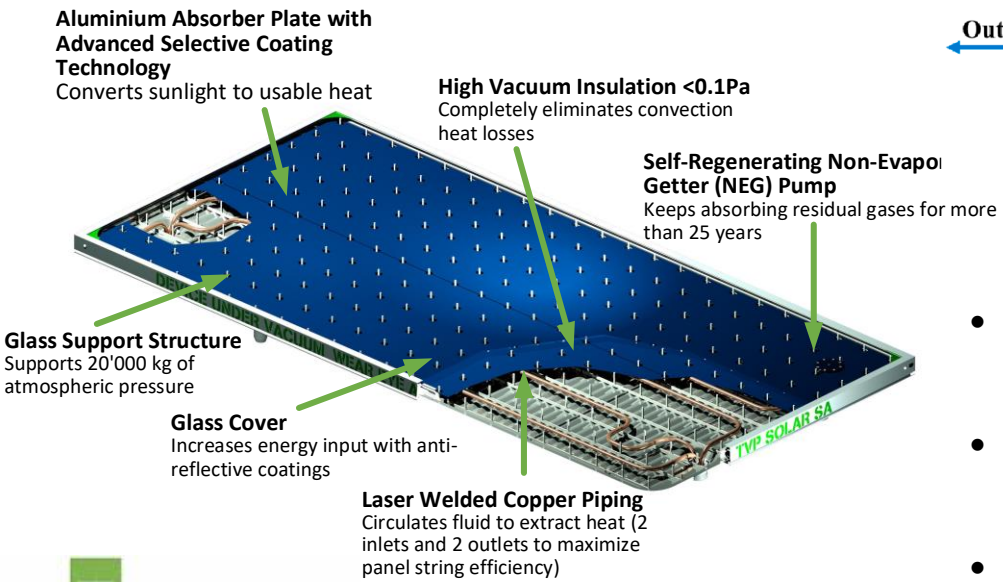
- Fermentation process
- Ageing

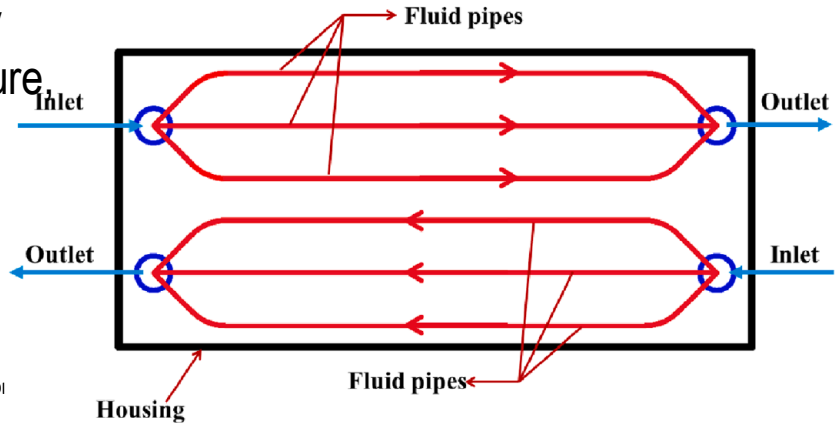


High Vacuum Flat Panel (HVFP): The World Best Solar Thermal Collector

SHIP2FAIR

- Best efficiency and highest energy production at any operating temperature, with any ambient temperature, in any climate condition
- SolarKeyMark certified 65˚C to 200˚C





- High-vacuum insulation suppresses thermal losses
- 20 years consistent & predictable performance without any degradation
- Designed for industrial-scale applications

TVP SOLAR

Demo-site: Martini & Rossi SpA

Steam 3.7 bar – Summer
Space Heating – Winter

SOLAR FIELD SPECS		
Location	Pessione, Turin, Italy	
Solar Field Peak Power	329	kW
Energy Production	349	MWh/y
SF Outlet Temperature	165	°C
Solar Field Peak Efficiency	56	%
# Of Panels	298	#
Gross Area	596	m^2
Installed Area	1.073	m^2
Panels' Tilt Angle	35	°

M&R solar system: construction

1

Rooftop surface preparation

2

Beams for substructure

5

Indirect steam generator

3

Substructure for panel installation

4

Solar field installation completed

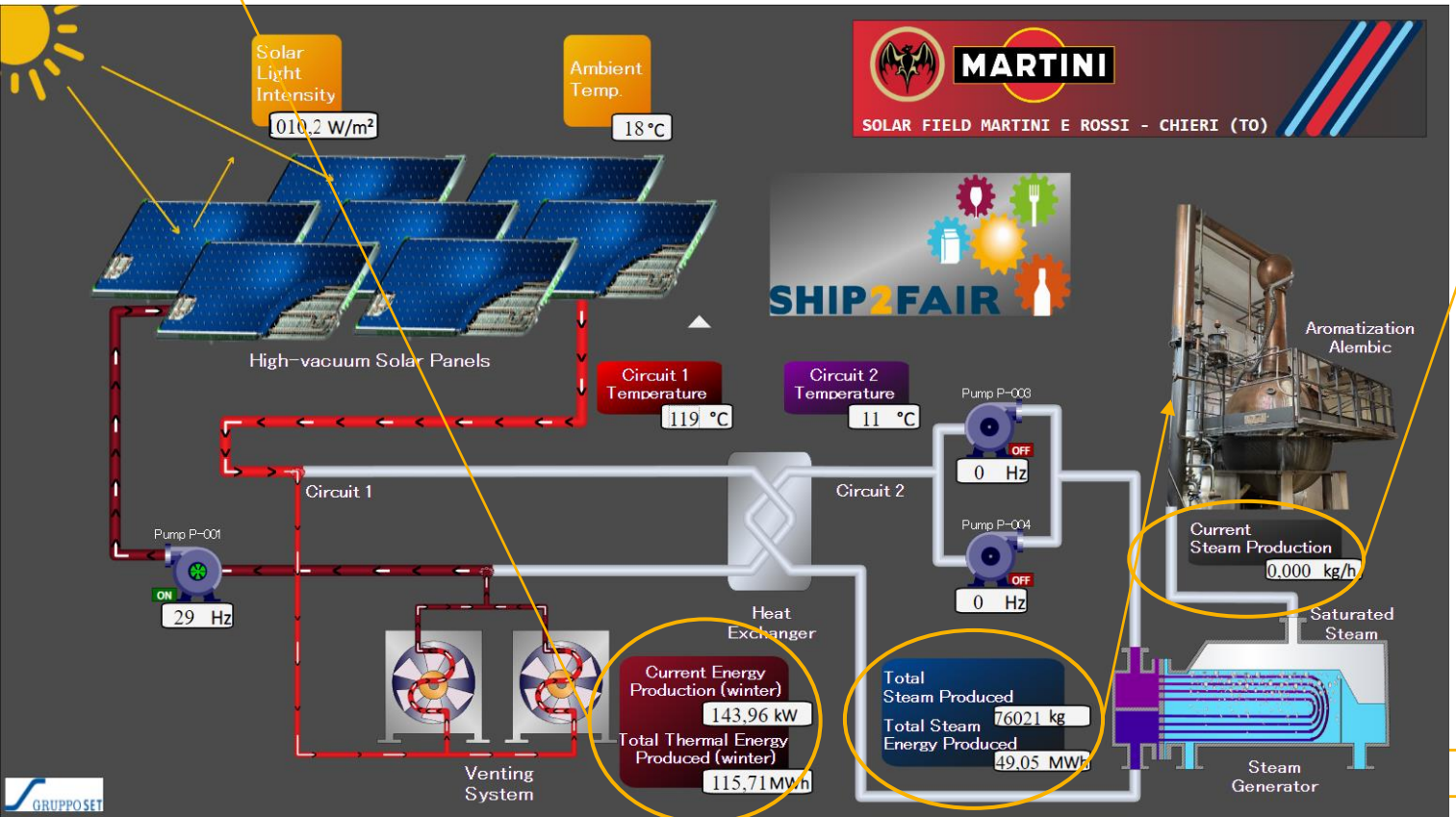
MARTINI

TVP SOLAR

SHIP2FAIR

System Integration

Total and real time energy production in Winter Mode



Real time steam production in Summer Mode

Total energy produced in Summer Mode

Renewables

Demo-site: Jean larnaudie

Foie-gras production
Castelnaudary, France

Technology: HVFP
Solar Field size: 1600 m² – 1MW$_{th}$
Cascade application:

- Boiler feed water pre-heating @150C
- Water tank heating @60C

SHIP2FAIR

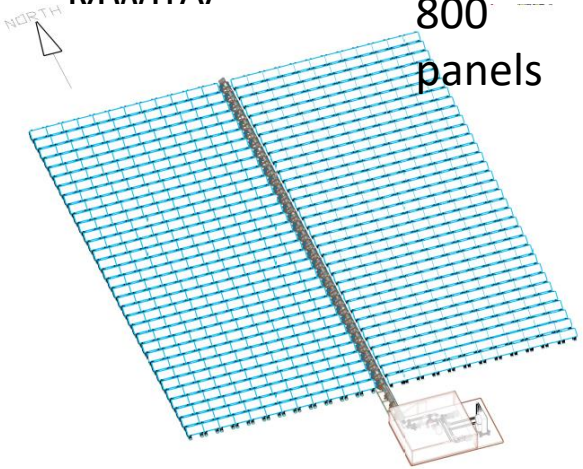
Demo-site: Jean Iarnaudie

Initial design

- Single application: boiler pre-heating
- Operating T: 175°C
- Usable heat generation: 926 MWh/y

Optimal design

- Dual application: boiler pre-heating & low temperature process heat
- Operating T: 1st module: 155°C; 2nd: 65°C
- Usable heat generation: 1'220 MWh/y (+30%)

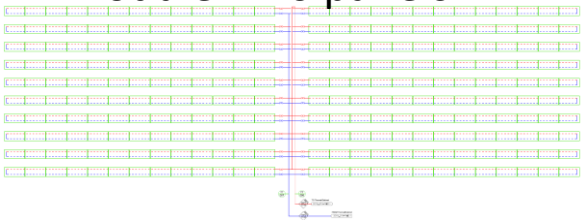


800 panels

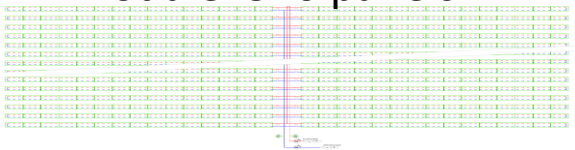
Canards d'Auzan

TVP SOLAR

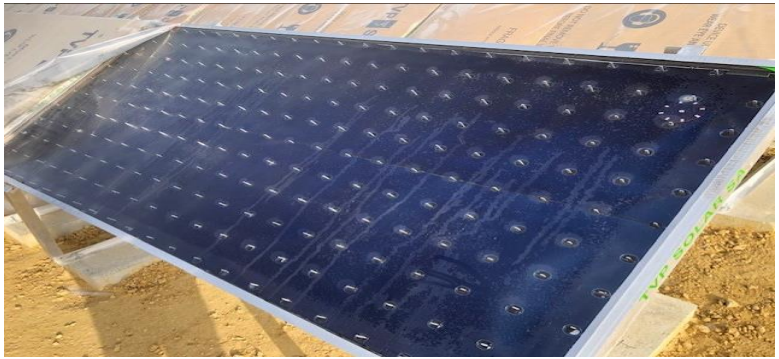
1st module: 270 panels



2nd module: 510 panels

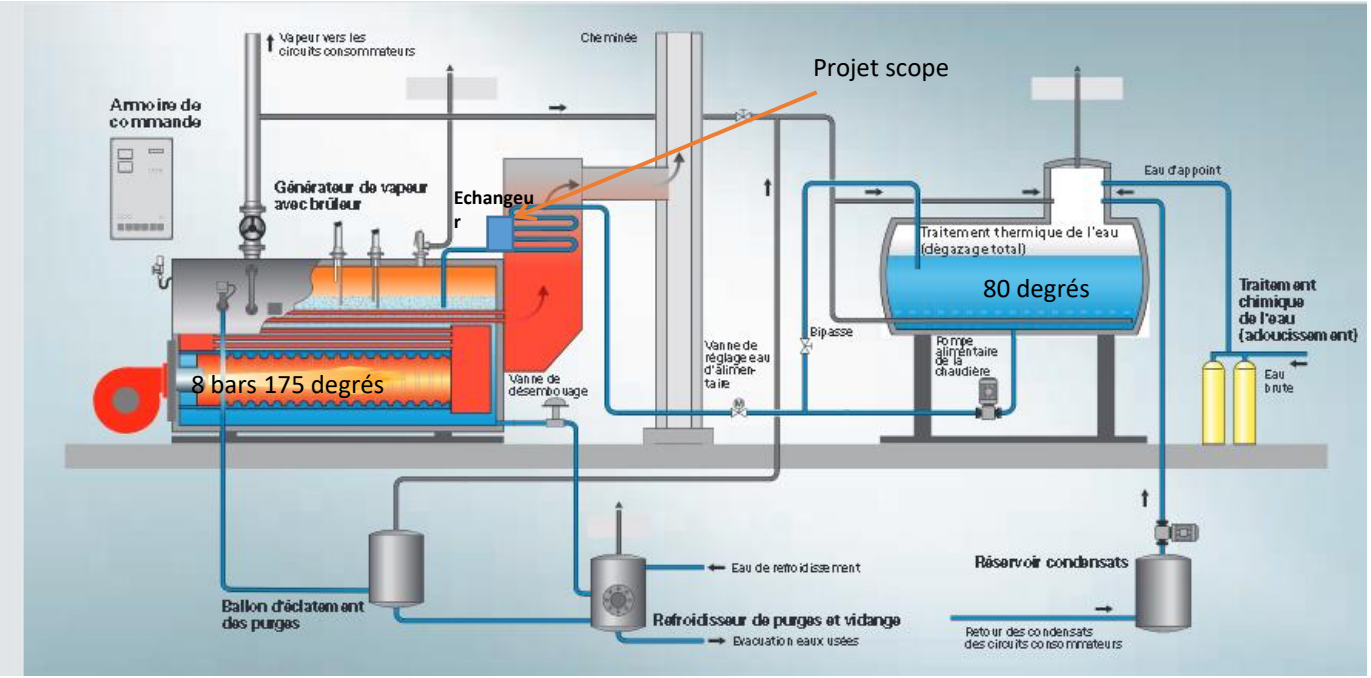


Larnaudie solar field: construction



SHIP2FAIR

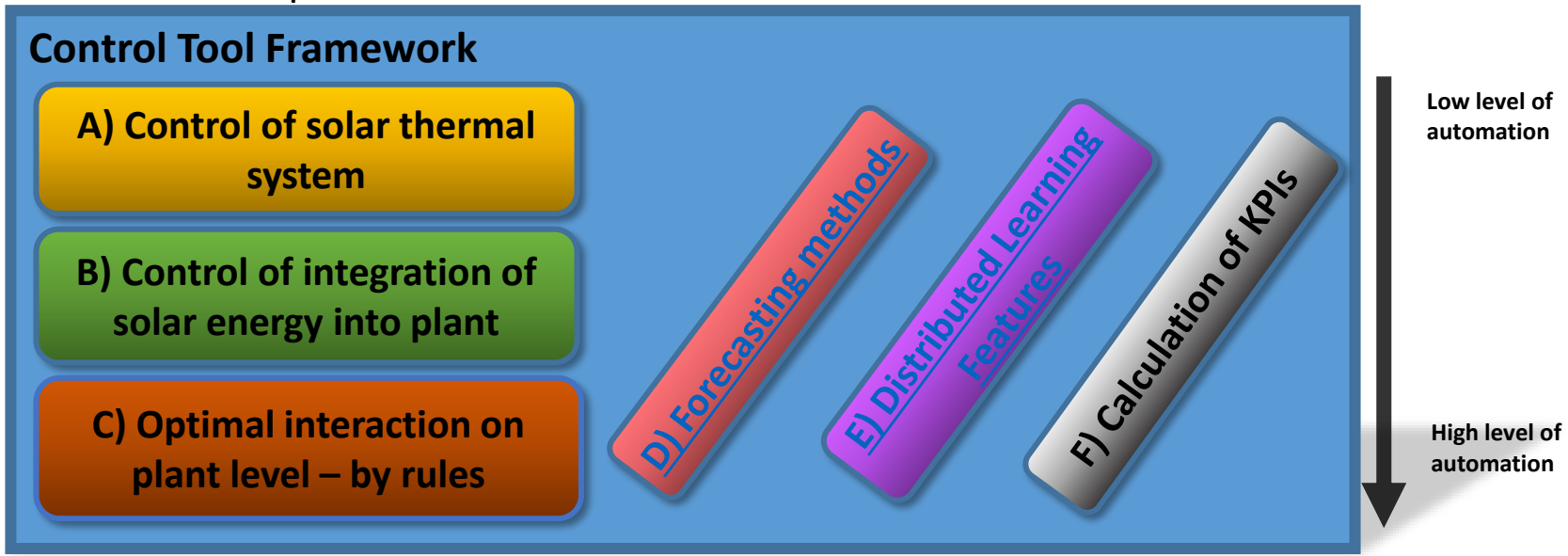
Integration of Solar Heat



Tools & Methods: The Control Tool

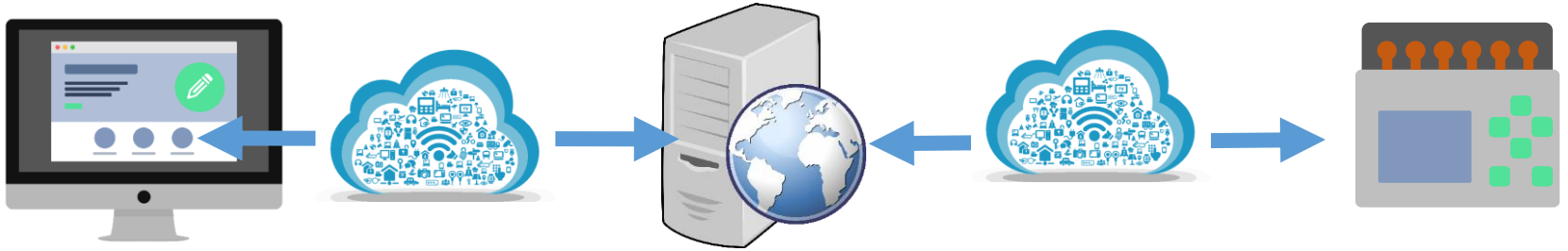
6 MODULES to make the most of the solar production

Tailored to site particularities



SHIP2FAIR

Tools & Methods: Planned integration of Control Tool



Frontend (=Browser)

- *User interface / User experience*

Server / PC

- *High level control aspects / data analysis*

Plant Level (programmable logic controller =PLC)

- *Control of plant in real time*

C) Optimal interaction

D) Forecasting

A) Solar thermal system

E) Distributed Learning

F) KPIs

B) Integration

Indicative Lessons learnt 1/3

Engineering phase:

- Lack of data from the demo site can create delays and/or suboptimal system design; in such cases an energy audit may prove valuable
- Optimal engineering & integration scheme should provide for planned changes in the production processes and/or energy system of the user
- Regulatory bottlenecks and uncertainty: permissions for construction works and the solar thermal system; safety requirements for pressurized equipment
- Language issues may hinter communication and cause delays

Best Practices

- Emphasis on the quality and granularity of data collected
- Use of local engineering companies for regulatory requirements & civil works

Lessons learnt 2/3

Civil works & installation phase:

- A large time gap between decision making and implementation may end up in revised decisions
- Low familiarization of the industrial users and their local contractors related to solar thermal posses further challenges; Unexpected events occur more often (pandemic, supply chain disruptions, natural disasters); production and EPC systems should embed resilience

Best Practices

- Clear allocation of responsibilities & scope of work need to be agreed between the involved parties (per demo site)
- Apply a systemic approach to training of involved actors
- Insuring the whole system (installation & operation) against natural disasters or other unexpected events can be proved critical

Lessons learnt 3/3

Commissioning phase

- Commissioning and troubleshooting requires time and causes delays particularly where there is no local physical presence of the tech provider (direct or indirect)
- Operation of the solar thermal system close at the edge of its capabilities may reveal design failures; this should be reflected in the risk assessment
- Data exchange solutions may not be straightforward
- Coordination challenges & delays due to multi-party involvement (demo site owners; solar thermal technology providers; control tool developers & cloud infrastructure operators; local contractors)

Best Practices

- Use of local contractors / integrators
- Agree on the architecture of the data exchange infrastructure and mechanism early enough
- Employ experienced technical project managers to coordinate actors involved

SHIP2FAIR

Thank you!

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 792276.

SUSTAINABLE PLACES 2023

zhenit

Workshop short title

Workshop long title

Date, 2023 - Madrid, Spain

sustainableplaces.eu

R2M RESEARCH TO MARKET SOLUTION

POLITÉCNICA

zhenit

alessia.peluchetti@rina.com – RINA Consulting

Funded by
the European Union

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ZHENIT IN A NUTSHELL

Zero waste Heat vessel towards relevant ENergy savings also thanks to IT technologies

- Call: HORIZON-CL5-2021-D5-01-10 -> Innovative on-board energy saving solutions

- Research and Innovation Action (RIA) – 100% Funding
- Duration: 1 June 2022 - 30 November 2025
- Current Month: M13 June 2023 (about 30%)

ZHENIT CONSORTIUM

The consortium is composed by 11 partners and 2 affiliated entities from 7 countries

ZHENIT CONSORTIUM

RINA

NATIONAL TECHNICAL UNIVERSITY OF ATHENS

KYMA

tecnalia
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

ANEK LINES
www.anek.gr

Consiglio Nazionale delle Ricerche

ITAE

Sorption Technologies

bound4blue

ENCONTECH B.V.
ENERGY CONVERSION TECHNOLOGIES

esperienza ed innovazione
Gruppo SIGLA
RELATECH GROUP

UNIVERSITY OF BIRMINGHAM

AMBITION

- The International Maritime Organization (IMO) has adopted a global strategy to reduce greenhouse gas (GHG) emissions from international shipping by at least 50% by 2050 (compared to 2008)
- This has been even “reinforced” in terms of ambition by EC which is committed to cut all transport emissions by at least 90% by 2050.

The goals are very challenging and require radical actions to be taken by all relevant stakeholders -> Optimization solutions like WHR and energy management optimization can play a key role

ZHENIT aims to the validation and rapid market roll-out of WH-to-X systems, as key technology for 2030 shipping decarbonization targets achievement.

AMBITION

ZHENIT aims to promote WHR as key and "ready-to-scale up" solutions to contribute to 2030 decarbonization targets achievement.

To do so, ZHENIT project will:

- Develop novel WasteHeat-to-X (WH-to-X) solutions to recovery WH at different T° and from different sources (TRL 5)
- Couple WH-to-X solutions with alternative propulsion systems (wingsail), ICT monitoring and management solutions and thermal energy storages
- Validate WH-to-X solutions both in the lab and on-board

These solutions straight forward to making the shipping sector more sustainable, accessible and clean.

FUNDAMENTALS

T<C°100
Isobaric Expansion (IE) Engine
WH-to-mechanical work

70°<T<100°C
Adsorption System WH-to-cooling and Desalination

T>100°
Innovative ORC integrated with HP with ejector WH-to-Trigenetayion

INTEGRATED CONTROL FOR WHR MAXIMISATION

HYBRID PROPULSION (WINGSAIL)

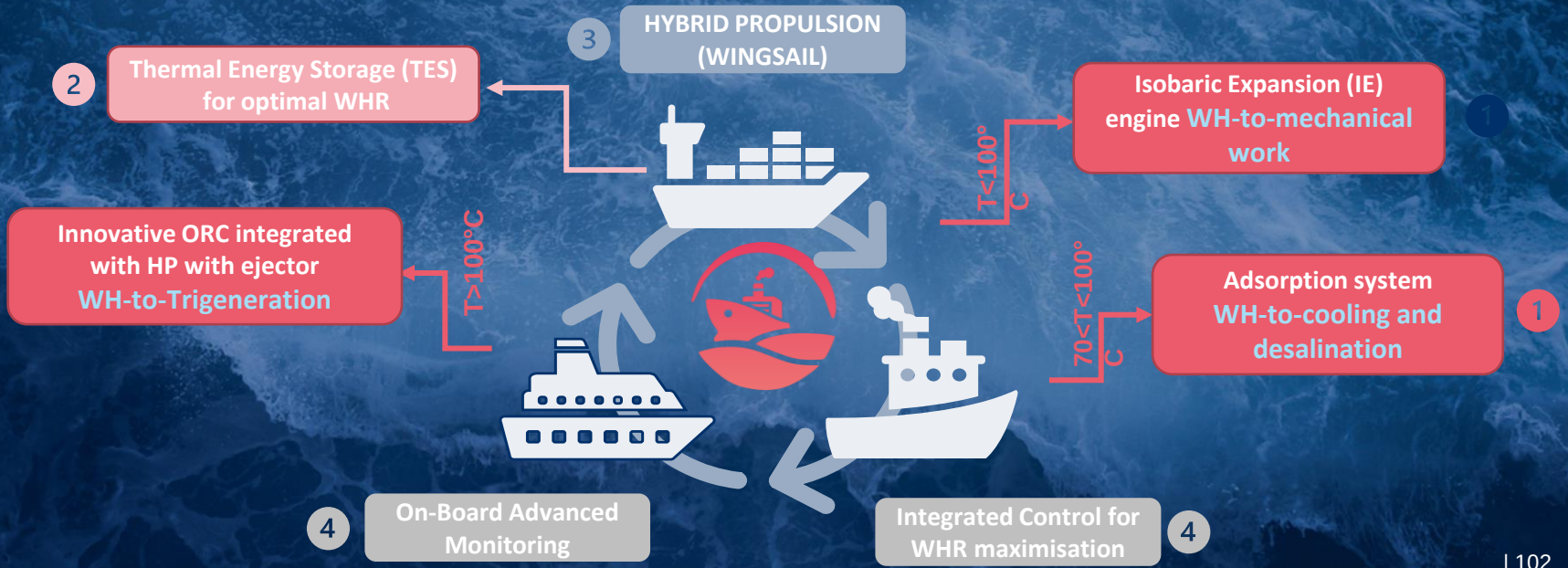
ON-BOARD ADVANCED MONITORING

THERMAL ENERGY STORAGE (TES) FOR OPTIMAL WHR

ZHENIT TECHNOLOGIES

1 3 WH-to-X technologies coupled with

2 Thermal energy storage
3 Hibrid propulsion systems
4 Digital solution



APPROACH

1 VESSEL ENERGY / WH AUDIT AND MODELING

Promotion of new approaches and models (thermoeconomics, dynamics) to assess on-board energy and thermal needs.

Detailed thermal - energy balance of the vessel as a whole to drive WH-to-X development and proper management-prioritization of the WH valorisation.

2 TECHNOLOGY DEVELOPMENT

Development of prototypes (starting from existing application) and considering insights collected from on-board energy/WH assessment and from stakeholders.

3 VALIDATION

Prototypes validation in:

TECNALIA Thermal systems lab

On board of La Naumon vessel

4 REPLICATION

Project impacts assessment from an environomics approach, to understand replication potential

also considering regulatory and stakeholders' acceptability aspects

ZHENIT VALIDATION

Validation campaign at two different levels:

TECNLALIA Thermal Energy Systems LAB

Possibility to operate with working water T° between -10ºC and 150ºC

it embeds a multi-purpose climatic chamber with controlled environment.

WH-to-X solutions are already present in the lab

La Naumon Vessel

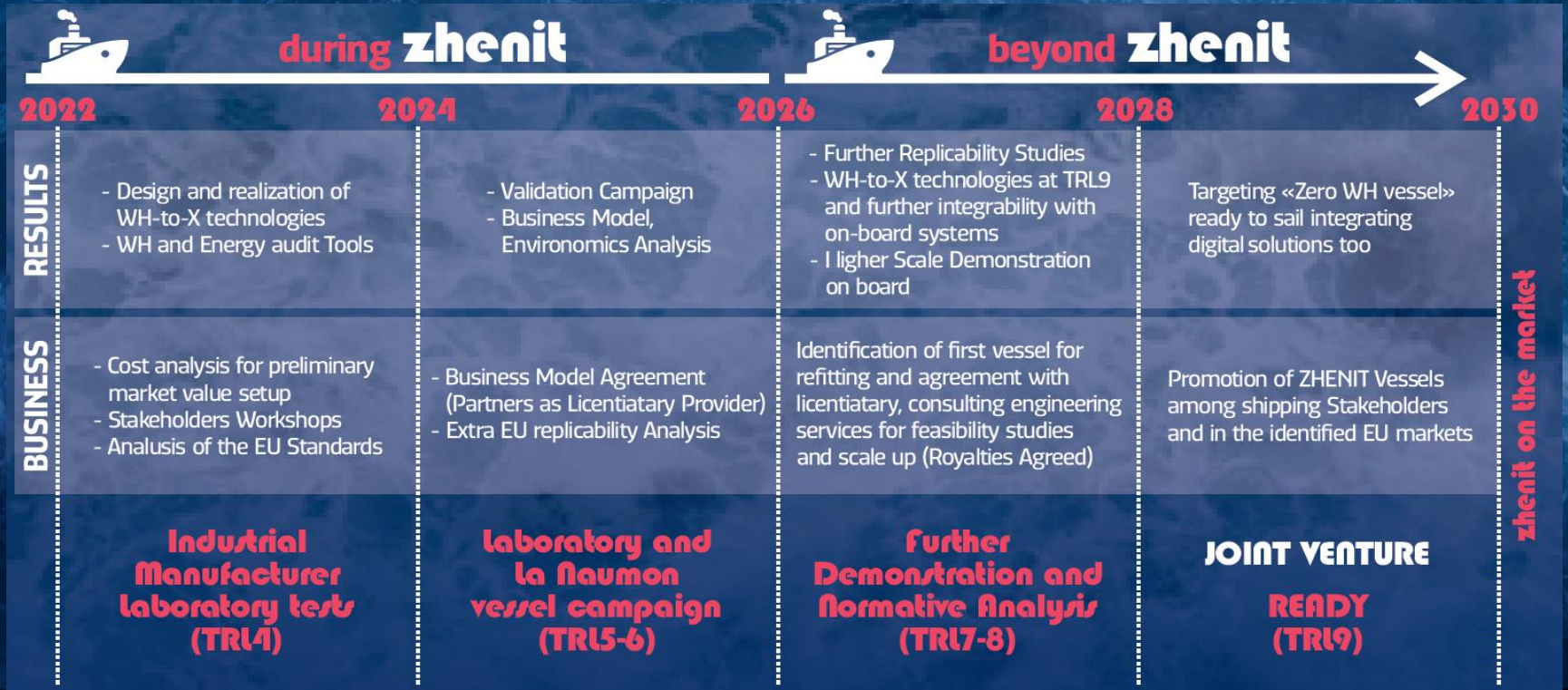
Probably based in Spain and route in EU

Owened by theater company as living stage and green shipping lab" to travel all around EU

To be installed on board: Waste-to-Cooling/Desalination Adsorption Chiller, B4B wingsail, KYMA monitoring system, SIGLA Controller

ZHENIT roadmap

Demonstrate that WH-to-X if properly integrated with Digital Solutions and hybrid propulsion (wingsail) can bring **up to a 25% reduction** of vessel energy consumption.



TECHNOLOGIES DEVELOPMENT

The technologies development phase follows the following steps:

- System modelling (M1-M12) ✓
- Material definition and conceptual design (M1-M12) ✓
- Detail design of the IE Engine (M12-M18) ↻ → Solutions are ready for the testing phase

ZHENIT Renewable Heating and Cooling Solutions are

Adsorption system

Which develop the innovative concept of combined desalination and cooling system for medium temperature (70<T<100°C) waste heat recovery and conversion.

ORC Integrated with ejector system

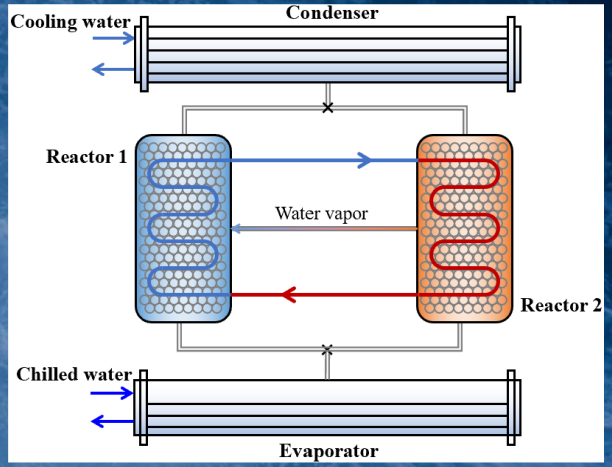
Which Develop, design and test a recuperated ORC integrated with an ejector able to valorise WH at T>100°C for trigeneration (Heating, cooling, power) production while exploiting different WH sources at various T ranges and guaranteeing high operational flexibility/versatility according to vessel energy demands

WH-to-cooling / desalinate water via adsorption system

A basic AD cycle consists of (1) a reactor packed with sorbents, (2) an evaporator and (3) a condenser.

It accomplishes the water purification function by

1. extracting water vapor from saline water into the sorbents during the sorption process
2. and then ejecting the water vapor to condenser where it condenses to liquid potable water during the desorption process.



The driving force of the whole cycle is the sorption/desorption reaction between sorbents and water vapor.

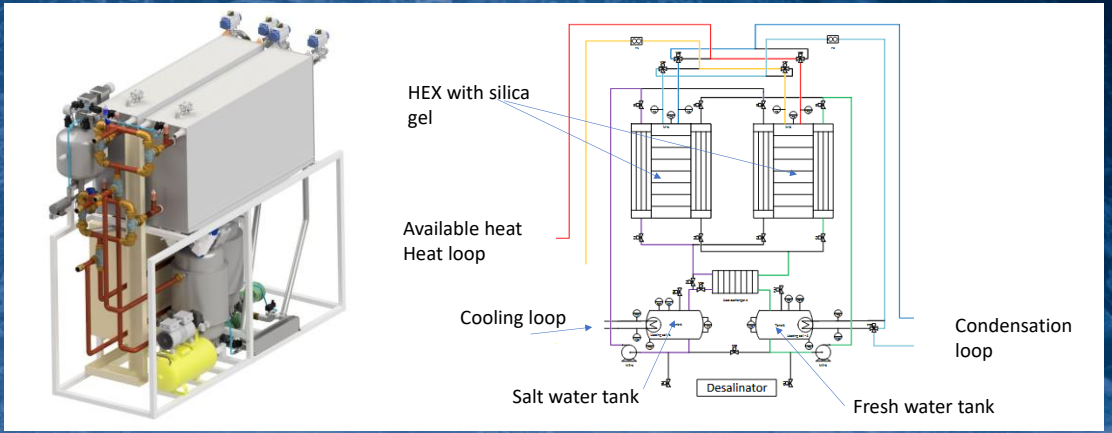
This cycle is flexible enough to produce either desalinated water or cooling, by varying the operating boundary temperatures.

It can also accomplish both services at the same time, thus satisfying more requests on board.

WH-to-cooling / desalinate water via adsorption system

The system will provide WH-tocooling/fresh water, reducing the electricity load for a wide range of ship types (particularly for space cooling and on-board electro-driven reverse osmosis desalination).

The target is to demonstrate the increasing in specific water production **at least up to 30% compared to the SoA**



Activation temperature: up to 100 ºC

Vessels cooling loop: 20 to 30 ºC.

→ COP 0.6-0.7 → 2 prototype of 10 kWcool

WH-to-cooling / desalinate water via adsorption system

First prototype has been realized for testing under controlled conditions, it has just arrived and has been installed in CNR ITAE lab

Silica gel about 42.3 kg per module

Max volume between fins 84.7 liters

About 64% fill in with silica gel

WH-to-trigeneration via ORC

This advanced trigeneration unit (electricity, H&C) will be able to recover medium/high (over 100 oC) and low (≈60 oC) T WH.

The coupling of the innovative ORC and activated ejector cooling cycle-heat pump (ECC-HP) in a cascade configuration with multiple and different Temperature enables

- WH sources optimization and smart utilization
- the production of diverse useful products (electricity, heating and cooling) at high efficiency

Activation temperature: > 100 ºC
Vessels cooling loop: 10 to 30 ºC.

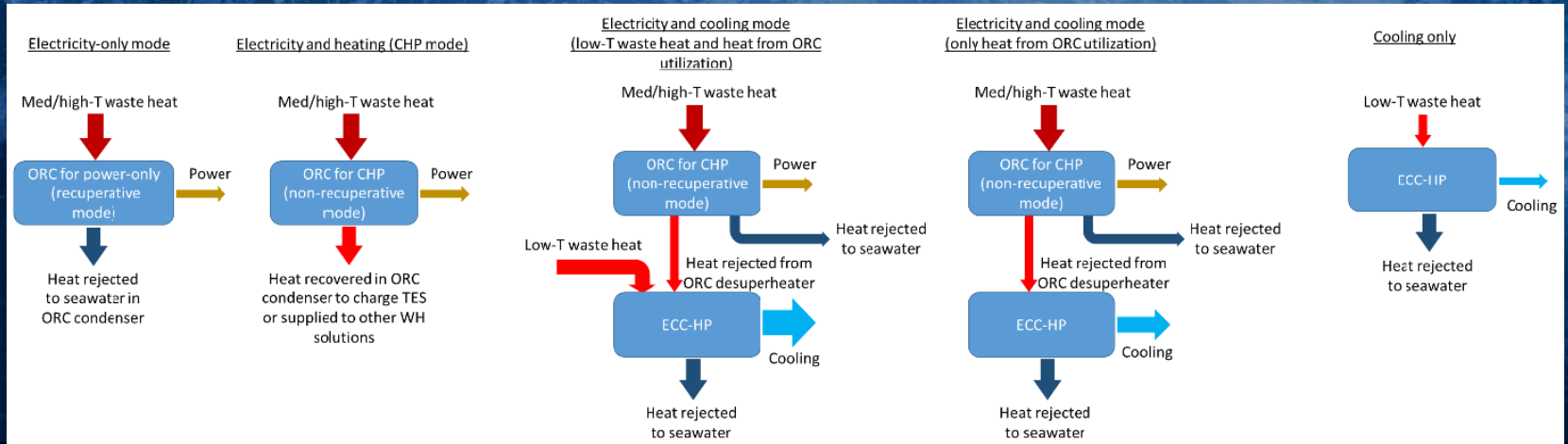
→ **12% Efficiency** →

4 operation modes 10 kWe
up to 40 kWc

WH-to-trigeneration via ORC

The system can alternate among various trigeneration modes according to WH availability and vessel real time needs.

- Scenario 1: ORC with recuperator – Electricity production
- Scenario 2: ORC without recuperator – Electricity and heating production (CHP)
- Scenario 3: ORC with preheater & ECCHP – Electricity and cooling production (CCP)
- Scenario 4: ECCHP only – Cooling production



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ZHENIT Project

ZHENIT Project

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SUSTAINABLE PLACES 2023

Thank You!

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15th of June 2023, Madrid, Spain

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