



SUSHEAT MAGAZINE



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Public Deliverables ^[1/3]

D2.1 Heat Demand and Requirements

Executive Summary

This report deals with the SUSHEAT deliverable 2.1, which provides information and data related to the energy demand of the industrial sector for high-temperature applications, the temperature specifications for meeting industrial heat demand, the potential for implementing SUSHEAT technologies, focusing on applying the Stirling-based-cycle heat pump and SHIP systems specifically in food and dairy industries, as well as fish meal and oil processing plants. Heat demand data for 2017 is provided for every European Union (EU28) country and industrial sector.

The data reveals that the industrial heat demand for 2017 totalled 1600TWh, accounting for around 50% of the total energy demand in the industrial sector. In 2021, final energy consumption in the European Union (EU) rises to 39,351PJ, a significant increase of 6.2% compared to the previous year. Heat demand in this deliverable has been classified into various temperature ranges, starting from very low (up to 60°), then low to medium (60 to 150°), followed by medium (150 to 400°), and high (above 400°). The Heat pump technology has the potential to convert a significant portion of the existing 175TWh excess waste heat potential into industrial-process heat, covering an estimated demand of 47TWh in the 100–200° output temperature range.

Please follow this [link](#) to read the full report.

D2.2 Analysis of different energy resources (waste, ambient, solar) available in the industries and definition of the operating modes

Executive Summary

The focus of this report is to provide a preliminary analysis of the various available energy sources and operational configurations available for the SUSHEAT system. The energy sources under consideration are: ambient, solar and industrial waste heat. The results show that the use of all 3 resources is feasible.

The report considers a number of different operating configurations, including: a single stage Stirling engine heat pump, a dual-stage Stirling engine heat pump and a 2-stage system involving a vapour compression heat pump, followed by a Stirling engine heat pump. In all cases, the single stage Stirling engine heat pump was shown to be favourable, meaning that the other configurations can be discarded from future analysis in the project.

Integration of solar is considered in 3 separate configurations using 2 collector types: relatively low cost flat plate collectors providing low grade energy to be upgraded in the Stirling heat pump, and relatively expensive linear Fresnel collectors to provide high grade energy to supplement the output from the heat pump. All 3 configurations are shown to be feasible, and none should be discarded from further analysis.

It is expected that future techno-economic analysis will show which configuration is the



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most economically favourable. High COP is expected from the heat pump for all 3 energy sources. When utilizing ambient energy, the mean yearly COP is expected to be 1.58. low-grade waste heat, the COP is expected to be 2.38. Finally, when integrating solar energy into the heat pump the highest expected mean yearly COP is expected to be 1.99.

If these figures are confirmed experimentally in future work packages then the SUSHEAT system will present itself as a key enabling technology in the drive towards Net Zero in the European Process Industries.

Please follow this [link](#) to read the full report.

D2.3 Preliminary laboratory rig design and validation strategy definition

Executive Summary

This report deals with the SUSHEAT deliverable 2.3, which provides the preliminary laboratory rig design and validation strategy definition for implementing SUSHEAT technologies, focusing on the definition of the conceptual design of the laboratory rig and the scale-up to the industrial layout. The description will evidence the flexibility of the concept by showing each possible mode of operation according to the status of electricity price, availability of waste of heat and incident solar irradiance to deliver 200kW for producing steam or drying air.

A total of twenty (20) modes of operation are presented for industrial scalability. It is indicated how the laboratory rig design allows for full

replication of all modes of operation and the case studies (Mandrekas & Pelagia), in which the system can work for charging or discharging the thermal energy storage units or for delivering heat. Key calculations for sizing heat exchangers, pumps, piping, flow heaters and pressure vessels are presented with mass and heat balances.

The preliminary process and instrumentation diagram (P&ID) and the equipment list are reported and are the bases for future detailed engineering. The work considers results from task T2.1 and provides the base ground for the detailed SUSHEAT laboratory rig engineering which will be carried out in T6.1.

Please follow this [link](#) to read the full report.

D4.1 Initial Phase Change Material (PCM) for TES

Executive Summary

This document reports the results of the screening process done to identify viable phase change materials (PCMs) to be integrated in the innovative thermal energy storage (TES) system developed within the SUSHEAT project. The comprehensive review involved an extensive analysis of scientific literature and commercial material datasheets. Materials were specifically collected to cover two distinct temperature ranges: 60-80° for mid-temperature applications and 150-250° for high-temperature applications. A total of 63PCMs for midtemperature applications and 36PCMs for high-temperature applications were identified through this



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extensive search.

Key properties characterizing each material, including latent heat, density, thermal conductivity, and hazard level, were gathered based on available information to support the final selection for the demonstration cases. The work comes out mainly from the wide experience of University of Lleida in material characterization and analysis and with the involvement of personnel of i-TES looking forward to the next step of selection of the suitable material for the project as objective of D4.2.

Please follow this [link](#) to read the full report.

D4.2 Final PCM for TES

Executive Summary

This report shows the experimental characterization of the Phase Change Materials (PCMs) preselected for the SUSHEAT concept. A comprehensive list of suitable PCM was reported in D4.1 submitted in M6.

In this report, experimental techniques including Differential Scanning Calorimetry (DSC), Thermogravimetric Analysis (TGA) and Hot Disk were used to determine the thermal properties of 8 PCMs selected for mid-temperature and 6 PCMs selected for high temperature respectively. The values obtained were compared to the ones found in the available literature and technical datasheets to see potential differences in the thermal behaviour. The next activity to develop the thermal energy storage (TES) concept, will be the definition of the operating temperatures of

the mid-temperature and high-temperature of the TES related to the final application. Indeed, this data is fundamental to define the most suitable PCMs to be integrated in both demo sites and real SUSHEAT applications.

Please follow this [link](#) to read the full report.

D4.3 Bio-inspired TES Rules

Executive Summary

This deliverable is the main outcome of the work carried out in “Task T4.3. Bio-inspired Rules for the Design of TES tanks”. This document details the rules and constraints that the biologically inspired design must adhere to.

The set of constraints is twofold, one subset of those constraints is related to manufacturing constraints (maximum size, thickness, overhang limits, etc.), while the other subset are constraints related to the operation of a thermal energy storage. In this document basis of the genetic algorithm and objective function to achieve optimal design are described.

Please follow this [link](#) to read the full report.



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Phase change materials for **thermal energy storage** in industrial applications

This study reports the results of the screening process done to identify viable phase change materials (PCMs) to be integrated in applications in two different temperature ranges: 60–80° for mid-temperature applications and 150–250° for high-temperature applications. The comprehensive review involved an extensive analysis of scientific literature and commercial material datasheets. A total of 65PCMs for mid-temperature applications and 36PCMs for high-temperature applications were identified through this extensive search. Moreover, an extensive experimental characterization of 14 preselected PCMs is included. Experimental techniques including differential scanning calorimetry (DSC), thermogravimetric analysis (TGA) and hot disk were used. The values obtained were compared to the ones found in the available literature and technical datasheets to see potential differences in the thermal behavior.

The paper shows the experimental characterization of the PCMs preselected for the selected temperature ranges. A comprehensive list of suitable PCM is presented and experimental techniques including DSC, TGA/DSC and Hot Disk were used to determine the thermal properties of eight PCMs selected for mid-temperature and six PCMs selected for high-temperature respectively. The main properties measured were the melting enthalpy [J/g], the degradation temperature [°C], and the thermal conductivity at solid state [W/m·°]. These properties are the main

parameters which affects the selection of PCM. The values obtained were compared to the ones found in the available literature and technical datasheets to see potential differences in the thermal behavior. Results show that this analysis was necessary, since differences were found with the data available; the most important differences being in the thermal stability of the materials.

The most difficult parameter to find was the degradation temperature which represent an important material property to define both safety and operational boundaries. The next activity to develop the thermal energy storage (TES) concept, will be the definition of the operating temperatures of the mid-temperature and high-temperature of the TES related to the final application. Indeed, this data is fundamental to define the most suitable PCM since the first property to be selected, when choosing a PCM, is the phase change temperature. After the phase change temperature, the most suitable PCMs will be selected based on the melting enthalpy, and the thermal conductivity. The first property will indeed affect the energy density thus determining the compactness of the TES. Thermal conductivity, corrosiveness, market availability, price, or other criteria, on the other hand, will affect the power of charging and discharging of the storage system.

To read the full publication on *Science Direct* for free, please follow this [link](#).



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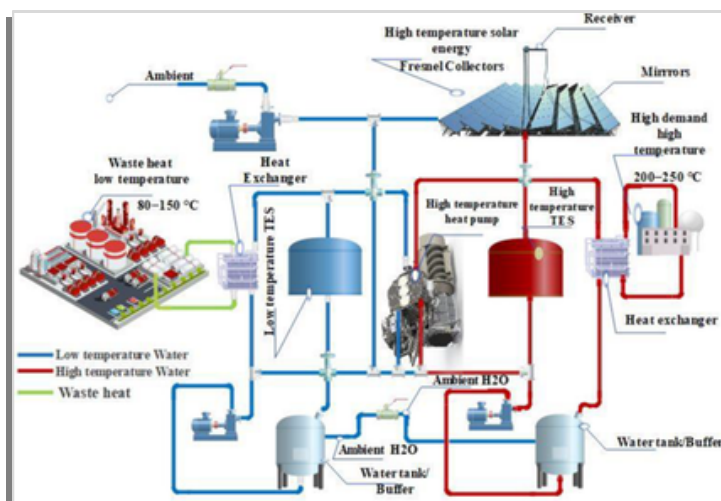
Decarbonizing European Industry: A Novel Technology to Heat Supply **Using Waste and Renewable Energy**

This study examines the potential for the smart integration of waste and renewable energy sources to supply industrial heat at temperatures between 150° and 250°, aiming to decarbonize heat demand in European industry. This work is part of a European project (SUSHEAT) which focuses on developing a novel technology that integrates several innovative components: a Stirling cycle high-temperature heat pump (HTHP), a bio-inspired phase change material (PCM) thermal energy storage (TES) system, and a control and integration twin (CIT) system based on smart decision-making algorithms. The objective is to develop highly efficient industrial heat upgrading systems for industrial applications using renewable energy sources and waste heat recovery.

To achieve this, the specific heat requirements of different European industries were analyzed. The findings indicate that industrial sectors such as food and beverages, plastics, desalination, textiles, ceramics, pulp and paper, wood products, canned food, agricultural products, mining, and chemicals, typically require process heat at temperatures below 250° under conditions well within the range of the SUSHEAT system. Moreover, two case studies, namely the Pelagia and Mandrekas companies, were conducted to validate the effectiveness of the system. An analysis of the annual European heat demand by sector and temperature demonstrated that the theoretical potential heat demand that could be met by the SUSHEAT system is 134.92TWh annually.

Furthermore, an environmental impact assessment estimated an annual significant reduction of 19.40 million tonnes of CO₂ emissions. These findings underscore the significant potential of the SUSHEAT system to contribute to the decarbonization of European industry by efficiently meeting heat demand and substantially reducing carbon emissions.

To read the full publication on *MDPI* for free, please follow this [link](#).



The SUSHEAT system in this study



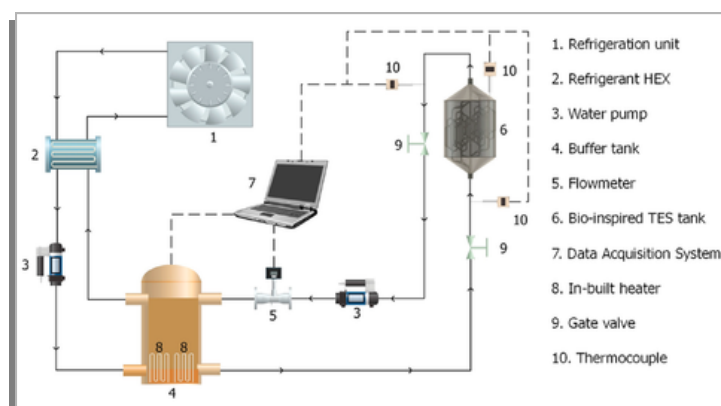
Research & Innovation

Development of a Bio-Inspired TES Tank for Heat Transfer Enhancement in Latent Heat Thermal Energy Storage Systems

This study proposes a novel concept for designing thermal energy storage tanks applying biomimetics to enhance heat transfer without the need for fins.

Thermal energy storage (TES) systems play a very important part in addressing the energy crisis. Therefore, numerous researchers are striving to improve the efficiency of TES tanks. The TES technology has the potential to reach new heights when the biological behavior of nature is incorporated into the design of TES tanks. By mimicking the branched vein pattern observed in plants and animals, the heat transfer fluid (HTF) tube of a TES tank can enhance the heat transfer surface area, hence improving its thermal efficiency without the need to add other enhancements of heat transfer methods. Accordingly, in this study, a unique additive-manufacturing-based bio-inspired TES tank was

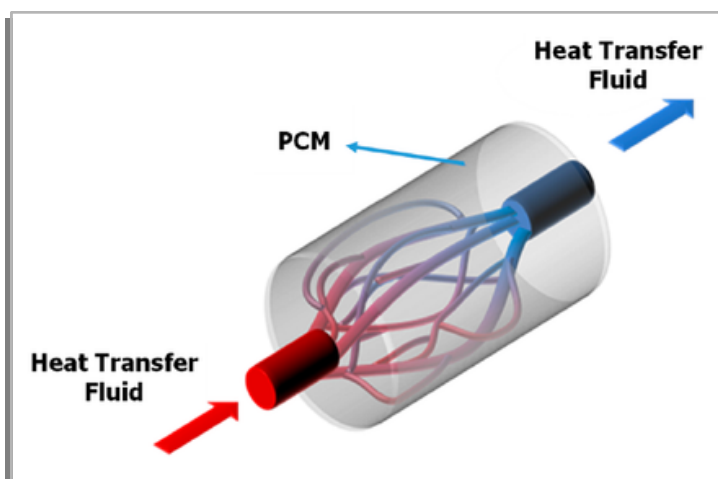
designed, developed, and tested. A customized testing setup was used to assess the bio-inspired TES tank's thermal performance.



Schematic representation of the custom-built experimental setup

A comparison was made between the bio-inspired TES tank and a conventional shell-and-tube TES tank. The latent TES system's thermal performance was significantly enhanced by the biomimetic approach for the design of a TES tank, even before the optimization of its design. The results showed that, compared to the shell-and-tube TES tank, the bio-inspired TES tank had a higher discharging rate and needed 52% less time to release the stored heat.

To read the full publication on *Applied Sciences* for free, please follow this [link](#).



Bio-inspired TES tank concept



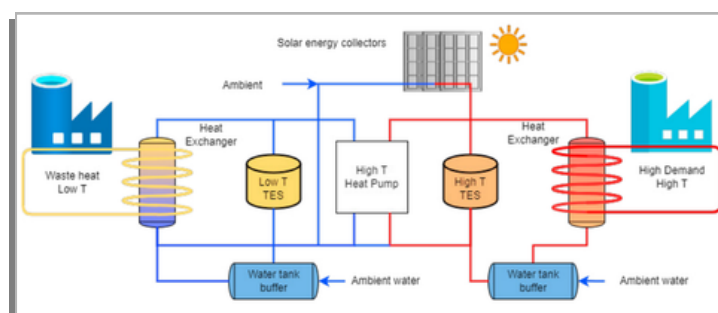
Research & Innovation

A digital twin concept for optimizing the use of high-temperature heat pumps to reduce waste in industrial renewable energy systems

Industry decarbonizing requires a fresh perspective on designing every aspect of the energy supply chain across different sectors. The shift from fossil fuel-based technologies, known for their flexibility in providing energy across wide temperature ranges, to renewable technologies constrained by resource availability and heat temperature, necessitates resource and process optimization, including managing excess and waste energy. Heat upgrade technologies are gaining importance as a solution to meet the high thermal energy demands of industries, offering a dual benefit: reducing fossil fuel consumption and greenhouse gas emissions while creating a new market for renewable-based heat for industrial processes. According to a recent study, non-metallic mineral, food, and paper industries provide the most potential in using the waste heat.

Although the European Union has been a leader in using solar heat for industrial processes, this type of heat contribution is currently limited to temperatures below 150° due to sector-specific constraints such as weather conditions and land availability. This temperature limitation aligns with the maximum capabilities of conventional heat pump-based heat upgrade technologies, largely due to constraints generated by the used fluids. To advance the widespread adoption of renewable energy technologies at temperatures above 150°, the next step is to develop heat pumps and integrated technologies

capable of reliably supplying intense heat for processes above this threshold, regardless of the renewable source or waste sink, thereby expanding exploitation possibilities. Integrating various renewable sources, harnessing available waste energy, and introducing thermal storage systems present a potential pathway for managing energy flows, upgrading available heat in sinks, and optimizing resource dispatchability. Optimizing such a complex process in real-time requires advanced computational resources and methods.



Reference overall architecture of the proposed concept

To be able to achieve this, we are proposing the usage of a digital twin for HT-HP (high temperature heat pumps) optimization to reduce the waste head in industrial renewable energy systems.

To read the full publication on *Science Direct* for free, please follow this [link](#).



Events & Activities

3rd SUSHEAT General Assembly: Progress on Novel Heat Supply Technologies for Industry

From October 24th to 25th, the SUSHEAT consortium gathered in Stockholm for its 3rd General Assembly meeting, hosted by Sweden's [KTH Royal Institute of Technology](#). This two-day event marked an important milestone for the project, bringing together partners from across Europe to review key accomplishments, discuss ongoing challenges, and outline strategic goals for the next phase.

Chaired by the project coordinator, [UNED](#), the meeting reviewed the progress achieved in decarbonizing industrial heat. Over the past 18 months, SUSHEAT has made significant advancements in developing sustainable solutions to capture, recover, and reuse industrial waste heat, boosting energy efficiency across a range of sectors.



SUSHEAT consortium at the 3rd General Assembly meeting, held at the KTH Royal Institute of Technology in Stockholm, Sweden (Photo by RTDS Group)

Key Achievements in the First 18 Months

- **Thermal Energy Storage (TES):** Developed an innovative design for the TES tank, completed lab-scale experimental evaluations, and

reached a significant milestone in advancing efficient energy storage solutions within the SUSHEAT project.

- **Final Phase Change Material (PCM) Selection for TES:** Selected and characterized optimal PCMs for system experimental testing, ensuring thermal efficiency and reliability in the storage system.
- **Heat Demand and Requirements Analysis:** Conducted a comprehensive analysis of heat demand, requirements, and associated challenges across secondary end-users and four additional industries.
- **Laboratory Rig Design and Validation Strategy:** Defined the preliminary design and operational framework for the SUSHEAT prototype laboratory rig, ensuring its replicability across case study applications.
- **Digital Twin Development:** Completed specification, modeling, and simulation of integrated digital systems, processes, and interdependencies, establishing a robust foundation for advanced digital control and data management.
- **Preliminary SUSHEAT Optimization:** Analyzed various energy sources—waste, ambient, and solar—available in target industries and defined optimal operating modes to enhance system efficiency and adaptability.
- **Project Results Dissemination:** The project partners have successfully disseminated their research findings through OpenScience



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platforms, expanding the visibility of the SUSHEAT project's contributions to the field. Recent publications include:

1. Biomimicry-Inspired Design Optimization of a Latent Thermal Energy Storage System Using Phase Change Materials.

Published: September 2024

[Access Publication](#)

2. Integrated High-Temperature Heat Pump and Thermal Energy Storage Laboratory Rig Engineering Considerations and Preliminary Design

Published: June 2024

[Access Publication](#)



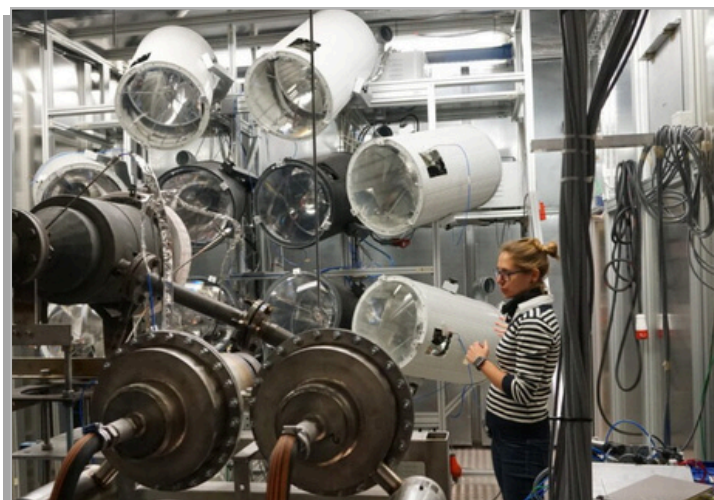
SUSHEAT at the 3rd General Assembly meeting, held at the KTH Royal Institute of Technology in Stockholm, Sweden (Photo by RTDS Group)

3. Decarbonizing European Industry: A Novel Technology for Heat Supply Using Waste and Renewable Energy

Published: October 2024

[Access Publication](#)

These publications showcase our collective efforts and provide valuable insights into innovative energy solutions aimed at industrial decarbonization.



SUSHEAT at the 3rd General Assembly meeting, held at the KTH Royal Institute of Technology in Stockholm, Sweden (Photo by RTDS Group)

These publications showcase our collective efforts and provide valuable insights into innovative energy solutions aimed at industrial decarbonization.

Guided by the [Energy at KTH](#) team, the consortium partners also toured KTH's cutting-edge laboratories, where the SUSHEAT system will soon be installed for experimental testing. Despite a demanding agenda, we were pleased to capture a group photo to commemorate the occasion and to confirm plans for our next meeting, scheduled for May 2025.



Events & Activities

KTH Presents SUSHEAT Research Results to Decarbonize Industrial Heat at Major Energy Conferences

Decarbonizing industrial heat is crucial for reducing global CO₂ emissions and transitioning towards sustainable energy systems. [KTH Royal Institute of Technology in Sweden](#), a key partner in the [SUSHEAT project](#), is actively contributing to this mission. At two recent conferences, [SolarPACES 2024](#) and [Enerstock 2024](#), KTH presented distinct aspects of their research, each targeting innovative solutions to decarbonize industrial heat generation. These research results represent significant milestones for the SUSHEAT project.

SolarPACES 2024: KTH Highlights Economic Benefits of Solar Energy Solutions for Better Industrial Heating

From October 8 to 11, the KTH team, including [Mateo Sanclemente](#), [Silvia Trevisan](#), and [Rafael Guedez](#), presented their research at the [30th SolarPACES 2024 Conference](#) in Rome, Italy. The event, which focused on Concentrating Solar Power, Thermal, and Chemical Energy Systems, brought together over 500 researchers and industry experts to address global energy challenges. At this collaborative platform, KTH demonstrated their techno-economic assessment of a solar hybrid system with a high-temperature heat pump for industrial heat generation. Their research examined the use of pressurized water as a heat transfer fluid (HTF), an innovative approach for generating industrial heat. In the context of SUSHEAT project, this hybrid system uses solar energy to heat water

and generate steam at 175°. A high-temperature heat pump (HT-HP) helps when there's not enough solar energy, making the system more efficient. KTH's model tests how well the system works in real industrial settings, taking into account factors like waste heat quality, electricity costs, and how much energy is stored.



KTH team at SolarPACES 2024 Conference in Rome, Italy. (Photo by KTH)

The research is applied to a [case study in a dairy factory in Greece](#), demonstrating how renewable energy solutions can reduce dependency on fossil fuels in industrial processes. The study's results are promising for industries looking to meet heat demand while minimizing costs and emissions.

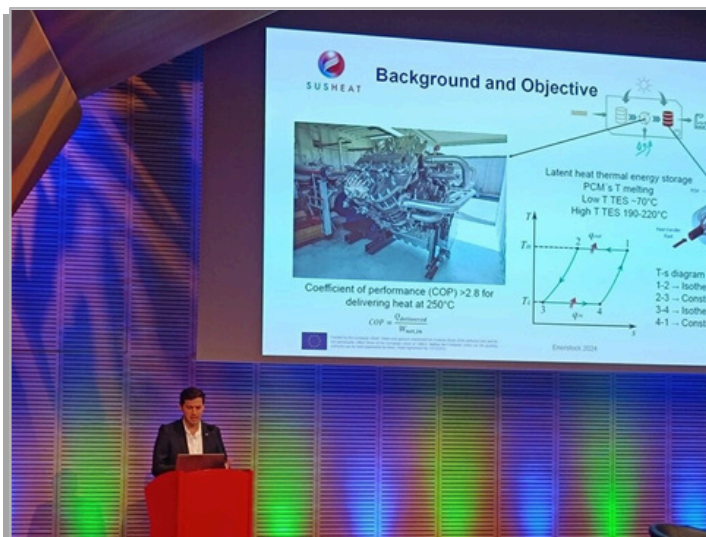
To explore the conference discussions and access the research papers in detail, please visit the [SolarPACES 2024 Conference Proceedings](#).



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Enerstock 2024: KTH Unveils Advanced Lab Rig Design to Transform Industrial Heat Generation

Earlier this year, KTH shared another key aspect of the SUSHEAT project at the [Enerstock 2024 Conference](#), held from June 5-7 in Lyon, France. Focused on innovative energy storage solutions, the conference provided a strategic platform for KTH to showcase their research work on designing and engineering a laboratory rig that integrates a high-temperature heat pump and thermal energy storage for industrial heat generation.



KTH doctoral student Mateo Sanclemente Lozano presenting at Enerstock 2024 in Lyon, France. (Photo by KTH)

Led by KTH doctoral student [Mateo Sanclemente Lozano](#), the presentation detailed the development of this lab rig, designed to test the combined performance of the heat pump and [Phase Change Material \(PCM\)](#) thermal energy storage. These technological innovations are essential to SUSHEAT project's mission of decarbonising industrial heat generation. The lab

rig simulates real-world industrial conditions, allowing researchers to validate how these technologies perform in fluctuating heat demand and availability scenarios. The goal is to create a system capable of operating efficiently at temperatures up to 250°, a critical requirement for industrial applications like manufacturing and food production.



SUSHEAT partners from the University of Leida (UDL) and KTH Royal Institute of Technology, at Enerstock 2024 in Lyon, France. (Photo by UDL)

This laboratory rig serves as a testing ground for innovations that could transform how industries approach heat production, integrating waste heat recovery with renewable energy sources. For more details, read the [KTH Conference Paper](#), and explore the [Enerstock 2024 Conference Proceedings](#).

Both presentations highlight the multifaceted approach of the SUSHEAT project to decarbonizing industrial heat. While the SolarPACES presentation focused on techno-economic modelling of hybrid solar-heat pump systems for industrial steam generation, the Enerstock presentation emphasized the experimental validation of these systems in a controlled lab environment.



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Recap of the **SUSHEAT General Assembly Meeting: Strengthening Partnerships and Progress Updates**

From May 29 to 30, the [SUSHEAT](#) project's 2nd General Assembly Meeting took place in the historic city of Lleida, Spain, hosted by the [University of Lleida \(UDL\)](#). Bringing together 14 project partners, the meeting was a pivotal opportunity to assess progress, share insights, and outline the next steps as we continue developing innovative solutions for integrating waste and renewable energy for sustainable heat production in industry.



SUSHEAT Consortium at the 2nd General Assembly meeting, hosted by the University of Lleida, Spain. (Photo by UDL)

Project Progress Updates

Twelve months into the project, the consortium presented significant milestones achieved since the last meeting. The University of Lleida team highlighted advancements in designing a novel Thermal Energy Storage (TES) unit using phase change material (PCM), while [KTH Royal Institute of Technology](#) presented the Laboratory Test Rig design that will simulate waste heat for testing

purposes. A 3D model of the thermal energy storage unit was showcased to demonstrate the novel heat exchange system design.



3D model of the Thermal Energy Storage unit – a novel heat exchange system designed to efficiently store and release thermal energy, being developed within the SUSHEAT project by the University of Lleida. (Photo by RTDS Association)

[WIZ Research](#) reported progress on the development of a data-driven digital twin system, which will be integrated into SUSHEAT technologies. This system will enable detailed simulations, allowing the project to test multiple scenarios in a controlled environment, saving time and resources while enhancing productivity. A Data Analysis Workshop was also held to discuss the various data types required for the digital twin system.

Additionally, candidates for the External Advisory Board were nominated during the meeting to provide strategic guidance. The consortium reviewed exploitation and knowledge management activities to ensure that



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the research outputs not only remain theoretical but also transition into practical applications.

These updates showcased the collective efforts of the consortium in advancing the project towards its objectives.

Tour of UDL's Laboratories

One of the highlights of the meeting was a visit to

UDL's laboratories at the Centro de Investigación en Energía Aplicada (CREA), where the consortium observed firsthand the ongoing development of the Thermal Energy Storage (TES) unit.

The tour provided valuable insight into the innovative work being carried out to bring SUSHEAT's vision to life.



Researchers at the University of Lleida demonstrate the design of the Thermal Energy Storage (TES) system, which utilises Phase Change Materials (PCM) to effectively store and release heat in response to demand. (1/2) (Photo by RTDS Association)



Researchers at the University of Lleida demonstrate the design of the Thermal Energy Storage (TES) system, which utilises Phase Change Materials (PCM) to effectively store and release heat in response to demand. (2/2) (Photo by RTDS Association)



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SUSHEAT at **Technology Talks 2024**: Energy-Intensive Sectors Key to Europe's Triple Transition



From September 12 to 13, Vienna became a hub of visionary discussions on the future of research, technology, and innovation (RTI) at [Technology Talks 2024](#), organized by the [Austrian Institute of Technology \(AIT\)](#). The event convened leading innovators, researchers, industry stakeholders, policymakers, and European Commission representatives to examine how RTI can drive Europe's green, digital, and human-centered transition.

High-level discussions conveyed the importance of RTI for the European economy and society, with a special focus on the role of technology in the green and digital transitions, policy development, and the transformative potential of AI in science.

SUSHEAT project partner [RTDS Group](#) participated in the event, highlighting the essential role of industrial decarbonization in meeting Europe's climate goals and advancing the green transition. Many [keynote speakers](#) emphasised how energy-intensive sectors can

spearhead the development of standards crucial to Europe's Triple Transition—a holistic shift towards ecological sustainability, technological innovation, and human-centered progress.

Throughout the event, there was a clear call for cross-sector collaboration to tackle the urgent challenges facing European industries, society, and the environment, positioning energy-intensive sectors as key drivers of Europe's sustainable and competitive future.

Integrated Triple Approach to Europe's Green Transition

Technology Talks Austria 2024 shed a spotlight on the critical role of research, technology, and innovation (RTI) in advancing Europe's 'Triple Transition—a green, digital, and human-centered' transformation crucial for sustaining competitiveness and technological leadership. At the heart of these discussions was the urgent need for adopting innovative technologies that will help Europe transition beyond fossil fuels.

Austria's Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation, and Technology, [Leonore Gewessler](#), emphasised that “energy-intensive sectors will be instrumental in shaping the frameworks necessary to realise the triple transition.”

These industries, which include chemicals, steel, textiles, and cement, are not only significant contributors to greenhouse gas emissions but also heavy energy consumers. Innovations in



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energy efficiency, waste heat recovery, and the integration of renewable energy within these sectors hold the potential to dramatically reduce emissions and overall energy consumption, making them essential drivers of Europe's sustainable future.



Leonore Gewessler, Austria's Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation, and Technology, speaking at the opening of Technology Talks 2024 in Vienna. (Photo by AIT)

The Heat Pump Revolution: A Key Technology for Industrial Decarbonization

Decarbonizing industrial production demands significant reductions in energy consumption and CO₂ emissions, along with a transition to renewable energy sources. With rising energy costs, dependence on fossil fuels, and growing energy demands, industries worldwide are seeking strategies to decarbonise process heat.

Thomas Novak, Vice President of Quantum and former Secretary General of the European Heat Pump Association (EHPA), delivered a compelling message about the transformative potential of heat pumps in driving industrial decarbonisation. He emphasised the link between heat pumps and

the core principle of the circular economy – a continuous cycle of resource use. “When we connect the concept of cycle to heat pumps, we see that they provide both heating and cooling, allowing waste heat from one (cooling) process to serve another’s heating needs,” Novak explained.

He also highlighted the need for social and policy shifts to fully utilize this clean energy technology, stating, “Policymakers often overlook the importance of heating and cooling in energy discussions. Cities, municipalities, and regions are sitting on untapped energy resources—they just need to harness them.”

Novak’s call to action brings to light the role of heat pumps as a critical solution for reducing industrial emissions and achieving Europe’s climate goals.



Thomas Novak, Vice President of Quantum and former Secretary General of the European Heat Pump Association (EHPA), discusses the role of research, technology, and innovation (RTI) in the green transition at Technology Talks 2024 in Vienna. (Photo by AIT)

The SUSHEAT Project: Innovative Technology for Heating Solutions Utilizing Waste and Renewable Energy

Projects like SUSHEAT are crucial to this agenda.



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The EU-funded SUSHEAT initiative aims to decarbonise heat demand in European industry by integrating waste and renewable energy sources to provide industrial heat at high temperatures. This project develops novel technology that incorporates several innovative components, including a Stirling cycle high-temperature heat pump (HTHP), a bio-inspired phase change material (PCM) thermal energy storage (TES) system, and a control and integration twin (CIT) system that utilizes advanced decision-making algorithms.

Involving leading European research institutions and industry stakeholders, SUSHEAT seeks to deliver efficient, low-carbon heat technologies

tailored to the needs of energy-intensive industries. These innovations not only facilitate industrial decarbonization but also play a vital role in establishing the frameworks necessary for Europe's Triple Transition. Ultimately, the successful integration of heat pump technology can significantly accelerate the transition toward a sustainable and low-carbon industrial future.

By aligning with the [EU's 2050 net-zero](#) targets, SUSHEAT contributes to a cleaner, more sustainable future, offering practical solutions for energy efficiency and resource optimization. It's not just about meeting heat demand; it's about transforming our approach to industrial energy use.

Watch the [SUSHEAT animation video](#) to discover the innovative approaches being implemented in the project for the smart integration of waste and renewable energy sources.



Video by RTDS Group



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Industrial Heat Pumps to Pave Europe's Path to Net Zero



Screenshot of webinar (Photo by RTDS Group)

In Europe's journey toward decarbonisation, heat pump technologies stand out as a leading solution for heating and cooling, promising a sustainable industrial energy transition. Heat accounts for a significant portion, approximately 60%, of energy consumption in Europe's industrial sector. Compelling success stories showcased at the webinar "[Sustaining Success of Industrial Heat Pumps – A Call to Action!](#)" hosted by the [European Heat Pump Association](#) on 14 March make a strong case for adopting high-temperature industrial heat pumps.

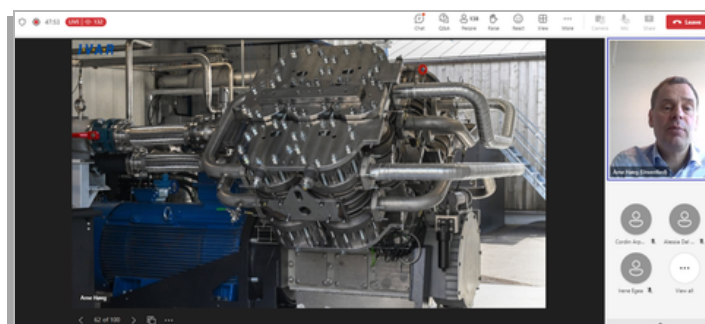
This online event was orchestrated as part of three EU-funded initiatives: [SUSHEAT](#), [PUSH2HEAT](#), and [SPIRIT](#), which are financed by Horizon Europe. These projects aim to foster the adoption of high-temperature heat pumps (HTHP) within the industrial sector.

Gathering top industry experts alongside an impressive turnout of 140 online participants, the webinar revealed ground-breaking developments in industrial heat pumps. It delved into the challenges and opportunities surrounding the integration of heat pumps in Europe, offering

insights from both technology providers and end-users.

Arne Høeg, CEO of SUSHEAT partner [Enerin](#), a pioneering manufacturer of high-temperature heat pumps from Norway, showcased at the webinar its [novel HT-HP systems](#) being developed under the SUSHEAT project. These innovative systems promise to revolutionize the technology by providing heating and cooling capacities of 400kW to 800kW, utilizing either steam or hot water with a supply temperature reaching 250°. It's worth noting that, as of now, no company has produced high-temperature heat pump systems with such capabilities and versatility in operation conditions.

If deployed on a large scale, this leading-edge technology holds immense potential to accelerate industrial decarbonisation.



Arne Høeg, Enerin's CEO presents the High-Temperature Heat Pump (HT-HP) technology during the webinar.

In addition to exploring innovative heat pump technology by Høeg, Alessia Del Vasto, Senior Policy Officer at EHPA, shed light on the broader policy framework supporting decarbonisation efforts.



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"We have tested a heat pump with a steam generator for temperatures up to 200° on the water output. A new tester for HTHP will be constructed at [KTH Royal Institute of Technology](#) in Stockholm, enabling us to handle temperatures of up to 250°".

Arne Høeg, CEO of Enerin, SUSHEAT partner

However, despite these evident benefits, the heat pump sector grapples with various barriers. A significant hurdle in Europe's journey towards widespread heat pump deployment is the existing regulatory framework, which poses challenges such as high electricity prices and initial uptake costs.

Addressing these challenges is paramount, as Del Vasto emphasized, "Reducing upfront costs and electricity prices is crucial to accelerating industrial heat pump deployment." Additionally, challenges like complex integration into existing infrastructure, limited knowledge and trust in new technology, and the need for training and education also hinder the pace of heat pump adoption," as Del Vasto pointed out.

"Momentum for heat pumps is gaining traction. They are recognized as a key technology for industrial decarbonisation under the [EU Net-Zero Industry Act](#) published in 2023," highlighted Del Vasto. "They provide highly efficient methods for harnessing renewable energy sources and recovering waste heat, particularly in sectors that have long relied on fossil fuels."

Alessia Del Vasto, Senior Policy Officer at EHPA

Building on Del Vasto's insights, Cordin Arpagaus, Senior Research Engineer at [OST–Eastern Switzerland University of Applied Sciences](#), offered a detailed overview of the latest developments in the European industry. He confirmed the expanding global market for high-temperature heat pumps driven by high energy demand and decarbonisation efforts.

"Currently, 37% of the process heating demand in the European industry is met by low-temperature heat pumps with a maximum capacity to supply temperatures up to 180°. There is a noticeable shift in demand towards high-temperature heat pumps capable of delivering temperatures above 200° while maintaining a low GWP (global warming potential)."

Cordin Arpagaus, Senior Research Engineer
OST–Eastern Switzerland University of Applied Sciences

To meet this market demand, Enerin's HoegTemp heat pump, which can deliver reliable and flexible industrial heat up to 200° (250° in the future), will undergo testing and validation under the SUSHEAT project in 2025. Several sectors, including the chemicals, paper, and food industries, have already been benefiting from Enerin's high-temperature pumps, albeit at lower temperatures. While addressing the growing demand for high-temperature heat pumps, companies like Pelagia are actively implementing innovative solutions to reduce CO₂ emissions and improve energy efficiency. [Pelagia](#), a leading producer of pelagic fish products and a partner of the SUSHEAT project, is one of the



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end-users of Enerin's heat pumps in producing a wide range of products, from frozen fish to fish meal and fish oil.

"At Pelagia, our objective is not only to minimize costs and energy consumption in our fish meal factories but also to significantly reduce CO₂ emissions."

Eirik Anfinsen Solberg
Technical Manager at Pelagia

"We are currently finalising the installation of an HT-HP system, which is set to decrease Pelagia's

annual CO₂ emissions by 3,500 tonnes while improving energy efficiency," Solberg concluded." The SUSHEAT project, uniting [14 partners](#) specializing in energy, AI, equipment manufacturing, and academia, is geared towards enabling the practical application of its expected low-carbon heat solutions for commercial success.

The recording of this webinar is available [here](#), and you can find the slides from the speakers [here](#).

Watch the Webinar Recording

Sustaining success of industrial heat pumps – a call to action!

14 March 2024 | 10:00 - 11:30 CET | Teams webinar

SPIRIT

Push2Heat

SUSHEAT

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Watch on YouTube



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SUSHEAT's STEM Star



The United Nations 9th International Day for Women and Girls in Science Assembly took place on 8-9 February, 2024 at the United Nations headquarters in New York. The day is celebrated on 11 February.

The Assembly examined topics around gender equality across the fields of Science, Technology, Engineering and Mathematics (STEM). More female talent needs to be harnessed globally to achieve the goals of sustainable development. The United Nations reports that, so far, we “have not achieved gender equality in STEM”.



SUSHEAT interviewed EU Climate Ambassador, Professor Luisa F. Cabeza, from the GREiA Research Group and the Department of Industrial Engineering and Buildings at the University of Lleida (UdL), which is situated in Lleida, Catalonia, close to Barcelona.

Luisa F. Cabeza is a highly cited researcher. Google her and you will see that she has won many awards and has received an unusually high number of citations for her work, with much of it in the fields of energy and energy storage.

The feature and profile, below, documents her journey into engineering; her impressive academic history; her participation in international energy bodies; and her work as an EU Climate Ambassador. On SUSHEAT, GREiA Research Group from the UdL will collaborate with partners from i-TES to design a new thermal energy storage tank, using an approach never attempted before.

But, if you asked fifteen-year-old Luisa what she wanted to study after school, she would have told you: “Anything but engineering. Because I never liked physics. Although now,



“I always wanted to do medicine. My Dad was a medical doctor and I found that was very exciting. But as time went by in school, I got closer to chemistry.”

Prior to enrolling in engineering there were a lot of comments from both her grandmothers. “One of my grandmothers was super happy and was encouraging me, and told me ‘Yes, do it’. So, when Luisa went with her Mum to enrol in university, she decided to do engineering.

“After starting the engineering course, I knew



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I had made the right choice. I ended up doing chemical and mechanical engineering. You see, my grandfather was an engineer. I always liked having conversations with him, and I think that's also what made me interested in the subject."

"Also, my favourite subject at school was mathematics. Now I understand that it's maths that leads you to engineering, so it's logical. At that time, I didn't really see the link".

Professor Luisa F. Cabeza

An engineer – that is a male subject!

As soon as she had enrolled in engineering her Mother received a call from her paternal Grandmother telling her: "You must stop this! If Luisa becomes an engineer, she will never get married! Engineering is a male subject!".

Thankfully, she had the support of both her parents and continued with her studies. Plus, she had two brothers, and was constantly in male company with them and their friends, who became her friends. But how did she negotiate her way through a male-dominated environment in her professional life? It is well-known that engineering is a highly competitive, traditionally male domain. Did she feel alone?

"I felt alone at times. Yes. But I didn't feel like I needed to have other women around me. I have already mentioned my brothers, and I was close in age to them, so I was used to being around boys.

"But at the same time, I did feel that being one of few women in the engineering tutorials – that was a challenge. But this gave me more interior power, you know. To fight, to get things done."

Professor Luisa F. Cabeza

Are there now more female enrolments in engineering at University? "No, unfortunately not – it doesn't look different. But we cannot force equality."

"So, I tell young people, either girls or boys, that you must do what you love. If a man wants to be a nurse, be a nurse, and if a girl wants to be an engineer, be it."

Professor Luisa F. Cabeza

Fathers can be the best role models for women

"I suppose it's important to say, though, that my father was a super good role model for me. And when he decided to do his PhD in medicine, when I was in high school, I helped him. That was my first introduction to research, and I liked it very much."



In fact, years later one of her proudest moments was when she completed her PhD in 1996 from the University Ramon Llull, Barcelona, Spain. "That was really a landmark moment for me, like most people when they finish their PhD, it's a big achievement. Also, my family felt proud of me, right. And I could feel that."



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The completion of a PhD often is a major decision-making crossroad. Luisa first wanted to get a job in industry, but after she finished her post doc in the USA, she decided to stay in the world of academia. Not long afterwards, she broke the glass ceiling when she was granted a full professorship at UdL.

"I was very young when I was granted my professorship, 39 years old, and in engineering, being a woman, well, that was also an honour I guess."

Professor Luisa F. Cabeza

Women are given feeling that **their words count for less**

Did she have to prove herself more in a crowd of men? For example, publish more, work more, have more stage presence? Were there any sacrifices?

"Honestly, I did not have to work more, or publish more. I felt it more when I was in a meeting with, say, ten men. You sometimes felt that they didn't let you talk. And when you talked, you were kind-of dismissed. It's like they gave you the feeling that your words did not have the same power as theirs."

Professor Luisa F. Cabeza

(That was the late eighties, nineties? Things have changed – or have they?)

"No, actually, because today my name is known, so it's the opposite." People listen to what Luisa F. Cabeza has to say. "But, generally, I am not so sure that we have achieved the change for

women in professions and science that we would have hoped for".

GREiA Research Group:

The GREiA Research Group, which, was founded by Cabeza, has impressive competences in thermal energy storage; building energy efficiency; energy use optimisation; artificial intelligence; and sustainable tannery processes, and is involved in many research collaborations and projects.

Decreasing CO2 emissions is not as expensive as claimed

Did she have to prove herself more in a crowd of men? For example, publish more, work more, have more stage presence? Were there any sacrifices?



Cabeza spends a lot of time away from home, at airports, travelling for many EU-funded projects and networking with other international universities and companies working in the energy industry.



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It was because of her initiative to invite companies to UdL to participate in a workshop to showcase their sustainability targets, that the spotlight was placed on her. She caught the attention of the European Commission that grants the climate ambassadorial roles.

“The companies came to the EU-funded SWS-Heating workshop and they explained how they had reduced their CO₂ emissions and what they had done in their production processes to reach that, and what it had cost them”.

Professor Luisa F. Cabeza

“What we realised from this workshop is that the companies present agreed that decreasing CO₂ emissions is possible, and it is not as expensive as it is sometimes claimed.”

Cabeza proud to be EU Climate Ambassador



“What we realised from this workshop is that the companies present agreed that decreasing CO₂ emissions is possible, and it is not as expensive as it is sometimes claimed.”

“Well, to tell the truth, when I was named an EU Climate Ambassador for the first time, I was very proud. You always think that people who are acting as brand ambassadors of such things, in the name of the European Commission, that it should be someone with another profile to that of mine.”

Obviously, it is a recognition of the work she has achieved. The drive she has, her commitment and thirst for knowledge, her temerity in pushing for workable renewable energy solutions for society. For speaking up. For linking actors in emerging renewable energy sectors that are sometimes fragmented due differing policies within EU countries that affect funding, and the market penetration of renewables. As a result, in November 2023, she had her Climate Ambassadorial role renewed. Her work is not complete.

“The idea is that we do as much as we can to make society better. We need to also make policy makers understand the urgency of the climate change problem. As citizens we can decrease heating levels at home and work, use public transport, or even consider our emissions when we travel for leisure.”

Professor Luisa F. Cabeza

Energy is a complex topic that requires massive levels of investment. Finding ways to deal with intermittent renewable energy supplies means that we must work hard to improve the storage solutions of renewable energy; target energy efficiency and improve supply so that it's reliable.



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Elsevier journal gives a history of Professor Cabeza's work

“Luisa F. Cabeza received her PhD in Industrial Engineering in 1996 from the University Ramon Llull, Barcelona, Spain. She also holds degrees in Chemical Engineering (1992) and in Industrial Engineering (1993), as well as an MBA (1995) from the same University.

Dr Cabeza joined UdL in 1999 where she created the research group GREiA and started her research on thermal energy storage (TES). Her interests include the different TES technologies (sensible, latent and thermochemical), applications (buildings, industry, refrigeration, CSP, etc.), and social aspects.

Dr Cabeza is very active in the storage implementing agreement (ECES IA) of the International Energy Agency and the International Panel on Climate Change (IPCC). She also acts as subject editor of the journals Renewable Energy, and Solar Energy and today is the editor-in-chief of the Journal of Energy Storage.”

Separately, Dr Cabeza is the co-ordinator of the RedTES network. The Spain-based RedTES focuses on the collaboration between research groups and companies in the advancement of TES nationally and internationally. The collaboration is expanding very fast, where the number of industry involvement is growing. Spain is one of the

leading countries, globally, in the field of TES which has been enabled by research, development and innovation collaborations.

On SUSHEAT, GREiA-UdL will explore a highly innovative approach for the design of the project's (Make sure this is linked) Thermal Energy Storage (TES) tank, exploring the most suitable Phase Change Material. GREiA-UdL will work with the Italian start-up company from Torino, i-TES that specialises in innovative thermal storage solutions, particularly in PCMs. The SUSHEAT technologies will approach will attempt designing a very different thermal energy storage tank using artificial intelligence and 3-D printing which, if successful, will be a breakthrough. The commencement of this work will be showcased in the project over the next months.



Media Highlights

SUSHEAT animation video

Watch the SUSHEAT animation video to discover the innovative approaches being implemented in the project for the smart integration of waste and renewable energy sources.



Video by RTDS Group

WEBINAR: Industrial Heat Pumps to Pave Europe's Path to Net Zero.

Watch the recording of the webinar below:



Article on SUSHEAT in 'We Don't Have Time', the world's largest media platform for climate action

Breakthroughs in Reusing European Industry's Wasted Heat

By Nick Nutall

A little-known Europe-wide effort is underway to develop a range of high temperature, industrial heat pumps and novel energy storage systems, that could make significant cuts in the energy use of sectors like food and drink to paper and petrochemicals.



Industry world-wide is responsible for up to 20% of global climate pollution and in Europe over 65% of the energy is used for heating in processes such as drying and bleaching up to sterilization and distillation.

Yet many of Europe's industrial processing plants are still heavily reliant on fossil fuels like gas—and most of this valuable heat is lost after being vented to the surrounding air.

The new push, called [SUSHEAT](#) aims to recover, upgrade and re-use 75% or more of the



Media Highlights

heat wasted in industrial processes.

A recent paper on SUSHEAT in [Applied Sciences](#), led by Professor Jose Daniel Marcos of the National University of Distance Education (UNED) in Madrid, Spain, estimates heat pumps providing temperatures of up to 250°, could cut industry related emissions by well over 19 million tonnes of carbon dioxide annually.

And play a “significant” role in the European Union’s 55% emission reduction targets for 2030 and net zero by 2050.

[Silvia Trevisan](#) and [Mateo Sanclemente Lozano](#) are two researchers at KTH, the Royal Institute of Technology in Stockholm, Sweden.



Photo by RTDS Group

KTH is one of the 14 companies and universities taking part in SUSHEAT located in countries including Romania and Italy to Austria and the UK.

Together they are working with a new generation Stirling Engine that can take waste heat and transform it to hit temperatures up to 250°. It

has been built by [Enerin](#), a Norwegian company in the partnership.

Heat Storage System Mimics Human Lung

The KTH researchers are linking the heat pump to a storage system that works in part by mimicking the shape and function of the human lung.

It has been developed by the [University of Lleida](#), Spain and can store heat for several hours providing further flexibility and heat on demand.

The advanced industrial heat pump and heat storage technologies link to a concentrated solar plant and an artificial intelligent (AI) management system to add even more flexibility and performance.

The overall goal is to not only re-use of as much waste heat as possible but to ensure there is a tech package relevant to different countries with, for example, different electricity prices and conditions.

“You can also achieve temperatures between 200° and 250° with concentrated solar. In a country like Italy where electricity is expensive but there is a lot of sun, you will use more concentrated solar heat and produce less from the heat pump,” said Dr Trevisan.

“In a country like Norway, where there is less sun but electricity is cheap and green, you can deploy the industrial heat pump more,” added Dr Trevisan.

Will this industrial revolution happen?

Commercial high temperature industrial heat pumps hitting 250° could be ready in the next



Media Highlights

one or two years.

“The integrated system will take more time as the management is more complex—maybe 4 to 5 years,” said Dr Trevisan.

Perhaps the biggest challenge will be the capital costs for the new technologies and the incentives provided by governments.

“The technology could be a game changer, but a lot of the challenge is probably more related to the capital costs and payback periods industry is prepared to accept,” added Dr Trevisan.

The [European Heat Pump Association](#) agrees. Most EU countries plus Norway, Switzerland and the UK, have some government incentives available. But there are still barriers to take-up including lack of awareness of their potential.

It is calling on the European Commission to put these new technologies at the heart of its soon to be published [‘Industrial Decarbonisation Accelerator Act’](#).

Click [here](#) to read the article on ***We Don’t Have Time***

(A version of this article originally appeared in Climate Table, part of [Table Media](#))

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To Watch Out For

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Upcoming Events in 2025

Name of Event:

14th National and 5th International Conference in Engineering Thermodynamics

Date:

4-6 June, 2025

Location:

Zaragoza, Spain

Find out more:

[Conference Website](#)



Name of Event:

International Congress on Sustainable Energy and related Technologies

Date:

June 22-26, 2025

Location:

Lipari, Italy

Find out more:

[Conference Website](#)



Name of Event:

Webinar on Heat Pump Day with EHPA, Push2Heat and SPIRIT sister projects

Date:

October 21, 2025

Location:

Online

Find out more:

[EHPA Website](#)





Beyond SUSHEAT

RELATED EU PROJECTS



Push2Heat aims at addressing the technical, economic, and regulatory barriers that prevent heat upgrading technologies to be widely deployed. It will do so by scaling up four different technologies (whose supply temperatures range from 90 °C to 160 °C) to optimise their efficiency and economic performance.

In addition, it will focus on integrating them into the relevant industrial sectors such as the paper and chemical industries.

The project will also work towards demonstrating suitable business models and dedicated exploitation roadmaps for higher market penetration of heat upgrading technologies.

Find out more [HERE](#).



The industrial sector is one of the largest users of energy and one of the biggest CO2 emitters. The largest share of energy used by the industry concerns the production of process heat.

SPIRIT aims at implementing sustainable heat-upgrade technologies for industry.

In this context, high-temperature heat pumps would reduce energy use and allow for electrification. These technologies are a sustainable, still unexploited, way to lower the dependence of the EU industry on fossil fuel, to achieve greater performance levels and to turn waste heat into new energy, thus saving money while preventing energy loss.

Find out more [HERE](#).

PLATFORMS & INITIATIVES



The European Heat Pump Association (EHPA) is the voice of the European heat pump sector in Brussels. They work to shape EU policy that allows the heat pump sector to flourish, and heat pumps to become the number one heating and cooling choice by 2030.

EHPA advocates, communicates and provides expert policy, technical and economic input to European, national and local authorities, and to their members.

EHPA organises high level events and manages or partners in multiple EU projects.

All their activities aim to speed up the market development of heat pumps for heating, cooling and hot water production.

Find out more [HERE](#).



European
Commission

CORDIS Results Pack: Heat pumps promoting clean and energy efficient solutions for households

The 'CORDIS Results Pack: Heat pumps promoting clean and energy efficient solutions for households' is the European Commissions' new publication for the promotion of heat pumps in the European Union.

It showcases seven projects managed by CINEA and funded under the Horizon 2020 research and innovation funding programme, which demonstrate the EU's firm commitment to expanding the heat pump sector.

The EU's [Heat Pump Action Plan](#) to accelerate roll-out across the EU includes the Heat Pump Accelerator partnership bringing together the Commission, EU Member States, industry experts, financial institutions and training providers from across the heat pump value chain.

Find out more [HERE](#).



Beyond SUSHEAT



SUSHEAT Project Partners

Please click on partner logo to find out more



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