

SOLINDARITY: DRIVING INDUSTRY DECARBONISATION WITH INNOVATIVE AND SUSTAINABLE HEAT SOLUTIONS

Summary

How can industry decarbonise heat without compromising performance? The SOLINDARITY project offers a compelling answer through an innovative hybrid energy system that combines solar thermal energy, high-temperature heat pumps (HTHP), waste heat recovery (WHR) and thermal energy storage (TES) to deliver sustainable industrial process heat. Designed for medium-temperature applications, SOLINDARITY upgrades renewable and recovered heat to as much as 280°C, significantly reducing CO₂ emissions and reliance on fossil fuels. At the core of the system lies a smart integration of technologies, enhanced by digital twin modelling and artificial intelligence (AI), enabling real-time optimisation and highly efficient operation. Demonstrated across multiple industrial sectors and climates, the project showcases a scalable and replicable pathway for industrial decarbonisation. SOLINDARITY highlights how renewable heat solutions can transform energy-intensive industries, paving the way towards a competitive, resilient and low-carbon future.

Keywords: Industrial decarbonisation, solar thermal energy, High-Temperature Heat Pump, Waste Heat Recovery, Thermal Energy Storage, renewable heat, hybrid energy systems, industrial process heat

Field of application for the findings: Industry

Addressed audience: SEHUS industrial end users, technology developers, scientific community, industrial associations, energy service companies, public authorities.

1. Background and project objectives

The decarbonisation of industrial heat is a critical challenge in the transition towards climate neutrality, as it represents a substantial share of final energy consumption and remains largely dependent on fossil fuels. In the European Union, a significant portion of industrial heat demand lies in the medium-temperature range (100–300°C), which is particularly difficult to decarbonise due to technological limitations and integration constraints.

The SOLINDARITY EU-funded project addresses this challenge by developing, demonstrating and validating an integrated Solar Energy-based Heat Upgrade System (SEHUS). The main objective is to enable deep decarbonisation of industrial processes by efficiently coupling renewable energy sources, waste heat recovery and advanced heat upgrading technologies. The project aims to deliver a flexible, efficient and scalable solution that can be adapted to a wide range of industrial sectors and operational conditions.

2. Technical approach

The SOLINDARITY system is based on a hybrid concept integrating multiple energy technologies into a unified and optimised solution. It combines solar thermal energy, photovoltaic (PV) electricity generation, industrial waste heat recovery (WHR), thermal energy storage (TES) and an innovative high-temperature heat pump (HTHP) operating with air as the working medium.

In the proposed configuration, industrial waste heat, typically available at temperatures between 200°C and 300°C, is combined with high-performance solar thermal collectors to increase the heat source temperature to a range of 90°C to 150°C, depending on solar irradiation conditions. The solar thermal subsystem includes advanced High Vacuum Flat Panels (HVFPS), capable of delivering pressurised hot water at elevated temperatures.

The pre-heated energy stream is then upgraded by a novel reverse Brayton cycle HTHP, powered by renewable electricity generated through high-efficiency PV systems, including advanced configurations with tracking systems and enhanced surface coatings. The heat pump is capable of raising the temperature of the working medium (air) up to 440°C, enabling the delivery of industrial process heat at temperatures up to 280°C.

This configuration allows the system to meet the thermal demands of various industrial applications, including food and beverage processing, pulp and paper production and rubber and plastics manufacturing. The system is designed to operate with different heat transfer media, such as diathermic oil or air, and to accommodate diverse plant configurations, capacities and operational constraints.

3. Demonstration and validation

The SOLINDARITY concept is being validated through three large-scale demonstration sites located in Germany, Greece, and Italy. These sites represent diverse industrial sectors: food and beverage, pulp and paper, and rubber and plastics, as well as a wide range of climatic and operational conditions.

The pilot installations are designed to assess the system under real industrial environments, covering process temperatures ranging from approximately 195°C to 280°C, different heat transfer media, and varying plant capacities and configurations. The demonstrations will evaluate technical performance, system robustness, operational flexibility, safety and economic viability.

In addition, five replication studies (three in Jordan and two in Morocco) are conducted to assess the feasibility and scalability of the SOLINDARITY solution in solar-rich regions outside Europe. These studies aim to demonstrate the adaptability of the system to different geographical, industrial and market contexts.

4. Expected impact

SOLINDARITY addresses the significant decarbonisation potential of medium-temperature industrial heat, which represents a substantial share of industrial energy consumption and associated greenhouse gas emissions. By integrating solar thermal energy, renewable electricity and waste heat recovery, the system is expected to significantly reduce CO₂ emissions and fossil fuel dependency.

Preliminary assessments based on demonstration scenarios indicate strong potential for emission reductions through partial substitution of conventional fuels and increased renewable energy penetration, particularly in configurations with high PV integration.

Beyond environmental benefits, the project contributes to the development of viable business models and financing strategies to support large-scale deployment. By addressing both technical and non-technical barriers, SOLINDARITY aims to stimulate investment, foster market uptake, and accelerate the adoption of solar-driven industrial heat solutions.

SOLINDARITY demonstrates a comprehensive and integrated approach to industrial heat decarbonisation by combining solar thermal technologies, electrification, waste heat recovery, and digitalisation. The project provides a scalable and adaptable solution capable of addressing the challenges of medium-temperature industrial processes.

By validating its concept in diverse industrial and geographical contexts, SOLINDARITY contributes to advancing hybrid renewable energy systems and supports the transition towards a low-carbon, energy-efficient, and competitive industrial sector. Its outcomes are expected to reinforce the role of solar energy as a key enabler of sustainable industrial transformation.