Smart integration of waste and renewable energy for sustainable heat upgrade in the industry (SUSHEAT)

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Introduction:

Moving from fossil fuel-based technologies to renewables technologies in the industry makes it necessary to optimize the resources and the processes, including the excess & waste energy generated by/within them. Heat upgrade technologies are becoming increasingly relevant as one of the ways to meet the high thermal energy demand.

This involves a double benefit: (i) by using Renewable Energy Sources (RES), fossil fuel consumption and emission of pollution and greenhouse gases (GHG) into the atmosphere are reduced; (ii) heat for industrial processes becomes a new market where other renewable-based technologies, like solar, are having limitations for deployment.

The EU has been a leader in the development and deployment of solar heat for industrial processes [1]. However, this solar contribution is currently limited to heat below 150 ºC due to the constraints present in the sector. This temperature threshold coincides with the current limitation of maximum temperatures for heat upgrade technologies based on conventional heat pumps, mainly due to the limitations introduced by the working fluid. Thus, the next step in wide scale introduction of RES at temperatures above 150 °C is to develop heat pumps and integrated technologies for reliable and intensive heat supply in processes above that temperature. Nowadays, commercial technologies (heat pumps) can effectively deliver heat up to 120 °C. However, a wide part of the industrial sector requires higher temperatures (figure to the right) and is currently mostly dependent on fossil fuels.

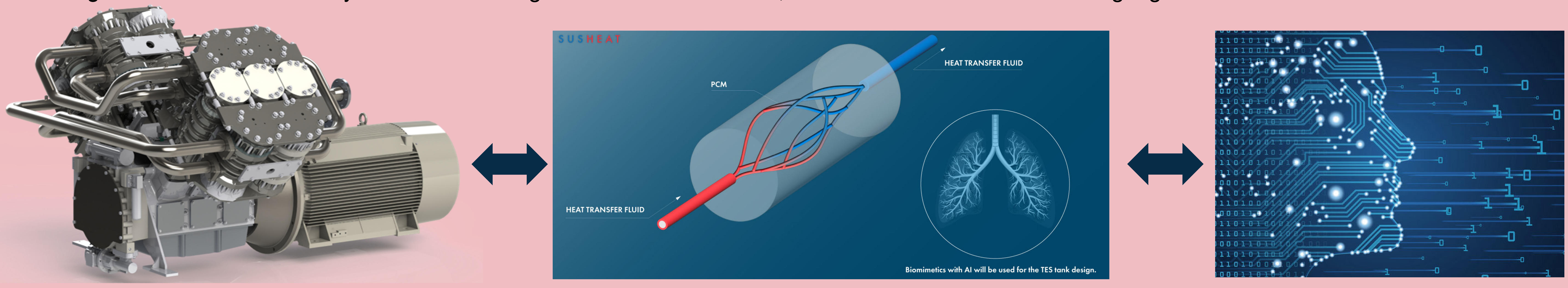
Industry (TWh)	<60 °C	60-150 °C	150-400 °C	>400 °C	Total
Basic metals (iron and steel and non-ferrous metals)	2	12.2	16.6	343.1	373.8
Chemicals & petrochemical	10.4	63.8	95.5	159.1	328.8
Non-metallic minerals	1.6	9.9	11.5	256.5	279.4
Transport equipment	3.2	19.7	5.7	0	28.7
Machinery	10.1	61.5	23.9	0	95.4
Mining & quarrying	1.1	6.5	6.3	0	13.9
Food & tobacco	17.5	106.8	77.6	0	201.9
Pulp & paper	8.2	50.3	31.9	16	106.3
Textile & leather	0.4	2.7	19	0	22.2
Other process heat	10.9	66.5	49.3	22.9	149.6
Total	**65.4**	**400**	**337.2**	**797.5**	**1600**

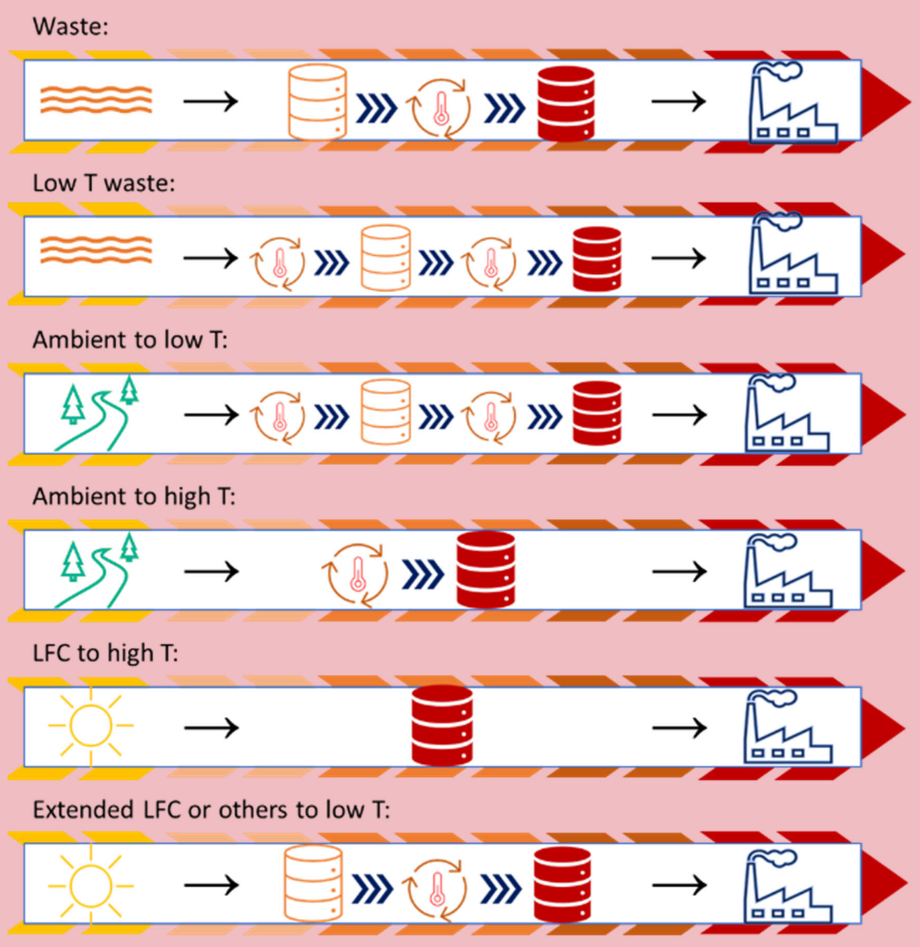
Potential for SUSHEAT concept [2].

SUSHEAT project (www.susheat.eu)

SUSHEAT project proposes an innovative approach enabling a cost-efficient, flexible, user oriented, and reliable heat upgrade concept with a smart integration of all the available resources, targeting a heat delivery temperature in the range of 150 to 250 ºC.

The project has started in May 2023 and will face the main technological challenges to address the development of the key components for a new generation of highly efficient industrial heat upgrade systems fed RES and waste heat recuperation. It develops and validates three novel enabling technologies: HT-HP, PCM bio-inspired Thermal Energy Storage (TES) system, and CIT system. The Stirling-based HT-HP works with helium -non-toxic, inert, zero ozone depletion potential (ODP) and zero global warming potential-, and it is expected a COP higher than 2.8 for a temperature ratio of 1.2, and a long-term production cost (by 2030) of 100 €/kW. The integration of innovative bio-inspired energy storage solutions will ensure a reliable, flexible, and customizable heat delivery with full decoupling from any waste heat recovery and renewables availability. Also, SUSHEAT will provide user-friendly tools and a digital twin for the control system and advising industrial stakeholders, based on smart decision-making algorithms.





The waste energy source/s present in the industry are used to charge the low temperature TES. This energy is restored when decided by the control system, once upgraded by the HT-HP, and stored again in the high temperature TES. The HT-HP is also able to upgrade heat from the ambient either to the low temperature TES, which is later introduced to the high temperature TES once upgraded, or even directly to the high temperature one. The solar collectors can complete the system, introducing heat directly to the high temperature TES or the low one (to be latter upgraded) and, which is later upgraded, extending the Linear Fresnel Collectors operation and feasibility.

The use of any of the three resources (waste, ambient and/or solar energy), allows a decrease of the fossil fuel consumption, emission of GHG & pollutants and release of waste energy to the environment. These benefits will be optimized for each case-study by the CIT.

By developing industry-focused self-assessment tools, SUSHEAT will contribute to identify the target industrial processes and sites which would benefit from the concept and provide solutions to maximize the industrial efficiency while contributing to the sector's decarbonization. The complete SUSHEAT concept will be tested at KTH laboratories to replicate the operational conditions of a dairy (Mandrekas) and fish-oil (Pelagia) industries.

Consortium and project implementation

The consortium is made up of 14 partners, including universities, research centers, SMEs and big companies from 11 different countries: Spain, Sweden, Norway, Romania, UK, Austria, Germany, Hungary, Italy, Slovenia and Greece. UNED (Spain) coordinates the project.

References

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