

High-Temperature Heat Pump

A solution for electrification heat sources in
the food industry



Lelystad, Netherlands

PUBLIC



CONTENT

CONTENT	1
Project details	2
Project number.....	2
Project title.....	2
Project period	2
Summary of the principles and the objective of the project and the (possibly) collaborating parties.....	2
Description of the contribution of the project to the objectives of the scheme (sustainable energy management, strengthening the knowledge position);	4
Spin-off inside and outside the sector;.....	4
Overview of public publications about the project and where to find or obtain them;	5
Indication where additional copies of this report can be ordered;	5
Listing contact person(s) for more information;.....	5
Mention of the subsidy obtained in the following way:.....	5



Project details

Project number

Subsidy project: DEI121011

Project title

Electrification of high-pressure Steam thanks to heat recovery, DEI121011

Project period

September 2021 to January 2023

Summary of the principles and the objective of the project and the (possibly) collaborating parties.

The project aims to electrify high-temperature heat up to approximately 220°C or 20 bars (a) steam in order to reduce CO₂ emissions while maintaining competitive costs. To achieve this objective, the project has been divided into three technological steps.

The first step focuses on recovering heat from the existing manufacturing process. By maximizing the recovery of heat at the highest quality possible. To accomplish this, Ammonia is utilised as a working fluid. Depending on the temperature of the heat source, different ammonia compressors are utilised to raise the temperature to an evaporating temperature of 64°C. This allows the generate steam at a pressure below ambient pressure.

In the second step, a shell and tube heat exchangers is utilized to convert the compressed Ammonia vapour from step one into steam. The high condensation temperature of the Ammonia vapour facilitates the creation of steam in this process.

The third step involves the recovery of all the steam generated in step two. By employing a series of blowers and piston compressors to recompress the steam to the required pressure for various processes.

By following these three steps, high-temperature heat can be effectively electrified by generating steam, to meet the specific pressure and temperature requirements for the manufacturing processes.

The primary achievement of this project is the successful demonstration of available technological solutions to electrify heat requirements for this specific use case. The key findings indicate that we can attain a Coefficient of Performance (COP) of 2 across all



three steps of the process, which proves to be economically feasible under certain conditions. Specifically, this is viable when the ratio of electricity-to-gas prices remains below 2, and when the Carbon tax is established at a minimum of 125 €/TCO₂ starting from 2030..

The main bottlenecks in the system are:

Technically

- The total heat demand required
- The delivered pressure and temperature of the heat demand (if you have a very high heat demand but small quantities, technological challenges will be faced with the current technology available on the market)
- The amount of spare heat available in the factory, if there are not sufficient heat sources of good quality, the heat pumps will not be able to deliver the heat required
- Operating complexity due to multiple steps as well as risk of downtime for maintenance
- Increased maintenance knowledge, extra resources and cost needed

Economically

- Future Carbon tax pricing
- Price of green electricity
- Price of natural gas

From a broader perspective, the food industry requires heat for various processes, each with different temperature and quantity requirements. Often, this industry releases excess heat into the environment, which could instead be harnessed. By utilizing green electricity, this waste heat stream can be transformed into a valuable heat source for the factory.

There are multiple potential applications for this concept. In cases where it may not be feasible for a company to directly reuse the recovered heat in their own processes, the heat can be upgraded to higher temperature by using green electricity and sold to fulfil district heating needs or cater to nearby industrial heat demands.

It is important to note that while this concept can be applied across various industries, there are significant challenges to overcome. The first challenge is re-evaluating the existing processes to incorporate this new approach. Additionally, it is crucial to secure a long-term vision regarding the ratio between electricity and gas prices, as well as the implementation of high CO₂ taxes. The financial viability of such systems is paramount for large industrial players, and their decision-making is strongly influenced by long-



term market prices. Considering the 20-year lifespan of such systems, long-term planning and assurance are vital.

Description of the contribution of the project to the objectives of the scheme (sustainable energy management, strengthening the knowledge position);

This project has successfully demonstrated the feasibility of electrifying heat, even at high temperatures, utilizing readily available technologies and green electricity. It specifically showcased the potential for an industrial group within the food sector, operating under the Emissions Trading Scheme (ETS) carbon tax system, to significantly decarbonize its industrial processes by up to 60% through the implementation of a comprehensive and sustainable energy management system.

Furthermore, the project highlighted the interest and involvement of major engineering and energy companies in these technologies. Their expertise and capabilities are instrumental in designing, constructing, and operating the complex technological solutions required for this project.

Importantly, the project emphasized the existence of technical solutions that can unlock substantial market opportunities. On one hand, the renewable energy sector stands to benefit from the increased demand for green electricity, which is necessary for producing decarbonized high-temperature heat sources. On the other hand, the construction and industrial sectors have the opportunity to participate in building and delivering the equipment needed for these systems.

However, it is crucial to ensure a clear and long-term perspective on pricing and tax mechanisms. This is essential to de-risk the economic complexities associated with such systems and provide industrial players with the confidence that adopting these solutions will not compromise their cost competitiveness, particularly in industries with narrow profit

Spin-off inside and outside the sector;

The proposed solution, which can be summarized as a cascade of heat pumps, holds potential for application both within and outside the food industry sector. Wherever there is waste heat available and a need for heat within industrial processes, the proposed system can be considered as a potential solution.

While it may not be straightforward to directly copy and paste the solution to other industries, as a detailed mass balance is required, this project has successfully demonstrated its capability to deliver steam at a pressure of 20 Bars(a), which represents a substantial steam requirement due to the significant temperature differential that needs to be overcome. As a result, there is potential for this solution to



be replicated in many industries that do not require such high temperatures, as the challenges related to high-temperature heat can be effectively addressed by this system.

Overview of public publications about the project and where to find or obtain them;

European Heat pump association has publications around HTHP but not this project

Indication where additional copies of this report can be ordered;

McCain Continental Europe

Listing contact person(s) for more information;

McCain Continental Europe

Walter van Genderen

(Senior Project Manager/Sustainability Engineering Lead)

Rue Heracles 41

59650 Villeneuve d'Ascq

France

+33-359-360500

E-Mail: CE.Communications@mccain.com

Mention of the subsidy obtained in the following way:

- Grant 2021(from 1st of April until May 31st , 2025): "The project was carried out with subsidy from the Ministry of Economic Affairs, a subsidy scheme for energy and innovation (SEI), Top Sector Energy carried out by the Netherlands Enterprise Agency."