

Heat Pump Awards 2026

Application submission

Tervakoski Heat Upgrade System

Turboden S.p.A. | Large Heat Pump Award

1. Application overview

Award category	Large Heat Pump
Title of the project	Tervakoski Heat Upgrade System
Organisation Name	Turboden S.p.A.
Exact address of the project	Tervakoski OY, Vahikkalantie 1, 12400 Tervakoski, Finland
Funding	Public; EU funds
Organisations involved in the project	Turboden S.p.A., delfortgroup AG
Project ending date	21/08/2026
Project website	https://www.turboden.com/case-histories/5278/delfortgroup?utm_source=youtube&utm_medium=organic_video&utm_campaign=delfort_case_history
Sector of application	Industrial

2. Applicant & EHPA contact details

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EHPA member involved	Turboden S.p.A.
Role of EHPA member	Equipment Supplier and System Integrator

3. Project description and benefits

Project description (goal, problem addressed, and solution provided by the heat pump)

At delfort's paper mill in Finland, the project aimed to support the decarbonization of steam generation while maintaining the reliability, responsiveness, and steam quality required for paper production. A key challenge was ensuring stable operation under demanding process conditions, including sudden load changes such as paper sheet breaks, which can cause rapid fluctuations in heat demand and waste heat availability. The solution also needed to provide steam at the temperatures required by the manufacturing process without relying on fossil-fuel boilers. To address these requirements, Turboden developed a customized Heat Upgrade system combining a Large Heat Pump (LHP) and a Mechanical Vapor Recompression (MVR) unit. The system recovers low-grade waste heat from the paper mill and upgrades it using CO₂-free electricity to produce more than 12 MWth of superheated steam at 3.4 barA, at temperatures ranging from 170°C up to 185–190°C, with an attenuator controlling the final steam

temperature delivered to the mill's network. The project demonstrates how high-temperature heat pumps can support the electrification of industrial heat and significantly reduce CO₂ emissions in energy-intensive industries.

Expected or achieved benefits

The project avoids approximately 19,000 tonnes of CO₂ emissions per year while delivering performance above the contractual guarantees. During the Final Acceptance performance tests, the system achieved a COP of 1.901 under winter conditions and 1.873 under summer conditions, against guaranteed values of 1.81 and 1.87 respectively, and a steam output of up to 20.0 t/h against the 19 t/h guaranteed, delivered at 183–187 °C against a guaranteed 170 °C. In commercial operation the plant delivers 20–21 t/h of steam and has repeatedly reached a COP of about 2 at full load. Technical availability over the period from Provisional to Final Acceptance was 98.3 %, against a 95 % contractual guarantee. The system has also proven its ability to handle process transients, ensure a stable steam supply and resume operation within approximately 10 minutes after interruptions, supporting both production continuity and long-term sustainability goals.

Obstacles/barriers encountered during development

One of the main challenges was integrating a first-of-a-kind heat pump system into an operating paper mill while meeting demanding process requirements. The available installation space was limited, requiring a highly customized plant layout and a close collaboration between Turboden and delfort throughout the design and commissioning phases. During commissioning, additional fine-tuning was needed to optimize system integration and control strategies under real operating conditions. Another key challenge was managing the variability of the waste heat source. The quantity and temperature of the available waste heat fluctuate with production rates and process conditions, requiring the system to maintain stable performance despite changing inputs. Finally, the solution had to provide the same level of reliability, steam quality, and operational flexibility traditionally delivered by fossil-fuel boilers. This was particularly important in a paper mill environment, where events such as paper sheet breaks can cause sudden changes in heat demand. Advanced control strategies were therefore developed to ensure stable steam generation and continuous operation even during rapid process transients.

Why should this project win an award?

This project represents a major milestone in industrial heat electrification. It is the world's largest steam-generating heat pump in operation and a true first-of-a-kind installation, combining a large hydrocarbon-cycle heat pump and a steam compressor in a novel series configuration capable of achieving steam conditions that neither technology could reach independently. The system uses natural refrigerant R600a (isobutane), with very low environmental impact (GWP 3, ODP 0), and a highly customized thermodynamic cycle optimized for high-temperature steam production. Beyond its innovative design, the plant has exceeded its contractual performance guarantees, achieving COP values above target and steam production up to 20 t/h. It has demonstrated exceptional operational flexibility, including rapid warm restarts within minutes and the ability to withstand major process disturbances, such as a 40% drop in thermal output during a paper break, without tripping. The project also delivers tangible environmental and operational benefits, avoiding approximately 19,000 tonnes of CO₂ emissions per year, achieving 98.3% technical availability, and fully electrifying steam generation under normal operation. Furthermore, it was successfully retrofitted into a paper mill with limited installation space, demonstrating the flexibility of large-scale heat pump solutions even where space availability is limited.

4. Technical specifications

Capacity of unit(s)	The Delfort heat pump system has a nominal thermal output of 12 MWth, equivalent to 12,000 kWth.
Energy sources used	The system is powered by CO ₂ -free electricity and uses recovered low-grade waste heat from the paper manufacturing process as its heat source.
Coefficient of Performance (COP)	COP: up to 2, repeatedly reached at full load in commercial operation. The certified reference values are 1.901 under winter conditions and 1.873 under

	summer conditions, measured at the contractual test points during the Final Acceptance performance tests, against guaranteed values of 1.81 and 1.87 respectively. Operating conditions: the heat source is a pressurised water loop that aggregates the low- grade waste heat streams recovered at several points of the paper-making process, with a flowrate of 150 ± 15 kg/s and an inlet temperature that varies seasonally — 16.7 ± 3 °C in the winter reference case and 30.1 ± 3 °C in the summer reference case. The heat sink is superheated steam fed into the mill's steam header at 2.4 barG (about 3.4 barA). The winter acceptance test, over 55.5 hours of continuous stable operation, gave a COP of 1.901 with a steam output of 19.0 t/h at 183.5 °C; the summer test, over 123.5 hours, gave a COP of 1.873 with 20.0 t/h at 187.3 °C. Both figures refer to the combined heat pump and steam compressor system at the specific contractual test points; in commercial operation at full load the system has repeatedly reached a COP of about 2.
Service provided	The heat pump system is used for an industrial process application, specifically the generation of high-temperature steam for paper manufacturing.
Refrigerant type	LHP working fluid: natural hydrocarbon refrigerant, Isobutane (R600a)

Heat pump details (compressor technology, heat exchanger, system configuration)

The system features a two-stage, series configuration consisting of a Large Heat Pump (LHP) operating on a hydrocarbon refrigerant cycle and a Mechanical Vapor Recompression (MVR) unit. Both systems use centrifugal compressor technology. The heat pump is equipped with a Mitsubishi Heavy Industries Compressor Corporation (MCO) compressor featuring in-line centrifugal compression stages, derived from proven oil and gas applications and selected for its high efficiency, robustness, and reliability. The MVR unit is equipped with an integrally geared centrifugal steam compressor. The thermodynamic cycle was specifically customized for this application to maximize overall system performance and efficiency. The heat transfer equipment includes a shell-and-tube evaporator, an internal heat exchanger, and a condenser, all manufactured in carbon steel, ensuring robustness, durability, and reliable operation in demanding industrial environments.

5. Renewable energy integration and grid response

Integration of renewable energy sources

Finland's electricity mix is characterized by a high share of renewable energy sources, including wind, hydropower and biomass, complemented by nuclear power, enabling the use of low-carbon electricity for industrial applications. The project leverages this CO₂-free electricity together with low-grade waste heat recovered from the paper manufacturing process. Rather than being released to the environment, this waste heat is captured and upgraded by the Large Heat Pump to produce high-temperature steam for the mill's operations. By combining electrification with waste heat recovery, the system significantly improves overall energy efficiency, reduces the amount of electricity required for steam generation, and supports the decarbonization of industrial heat production.

Response to energy demand / smart grid integration

The operating regime of the heat pump is driven by the customer's steam demand. The system is designed to rapidly and efficiently modulate its thermal output, maintaining high performance even at partial loads. It can also be shut down and restarted quickly, enabling it to effectively manage process transients and sudden changes in demand, such as paper sheet breaks. Turndown capability was verified during the minimum-load acceptance test, in which the system kept delivering steam at 183.5 °C with a thermal input to the heat pump reduced to 4.55 MW. In addition, the heat pump constitutes a large and modulable electrical load: its consumption can be increased when renewable generation is abundant, and electricity prices are low and reduced during periods of scarcity. The

experience gained in managing rapid load changes on the process side is directly applicable to grid-responsive operation, making the system a natural candidate for demand response and grid flexibility services.

6. Innovation, monitoring and replicability

General (all awards)

Why the project is innovative *(all awards)*

This project is innovative because it is the first installation to combine a large-scale hydrocarbon-cycle heat pump with a steam compressor in series, delivering 12 MW of thermal power in the form of high-quality process steam; a configuration for which no precedent existed at this scale or in this operational context. It is, to date, the largest steam-generating heat pump in commercial operation, and it demonstrates the viability of large-scale industrial heat electrification. It uses a natural hydrocarbon refrigerant and a highly customized thermodynamic cycle, specifically designed to achieve the high temperature lift required for steam production. Further innovative aspects lie in the engineering solutions developed during commissioning. A dedicated control architecture was developed to manage the surge risk that arises when the waste heat input collapses suddenly during a paper break, based on real-time interaction between the pressurised hot water loop and the heat pump control logic, together with a careful mapping of the compressor operating envelope at partial load. A warm start sequence was engineered to exploit the residual thermal energy stored in the hot water loop and in the heat pump circuit, restoring stable steam delivery within minutes of a restart. Finally, the waste heat recovery loop itself aggregates distributed and highly variable waste heat streams into a single stable heat source, which was a precondition for stable steam production. These control strategies and design models did not exist before this project and are directly transferable to future high-temperature heat pump installations.

Monitoring approach (performance, cost, and carbon targets) *(all awards)*

The plant was designed and validated using advanced simulation software, and key operating parameters such as temperatures, flow rates, steam production, and electrical consumption are continuously measured and recorded. Turboden's Service team remotely monitors the system in real time to ensure that performance, efficiency, reliability, and decarbonization targets are met. The collected operational data is used to support predictive maintenance, enabling early identification of potential issues and maximizing plant availability. Performance reports and historical data analyses are also leveraged to optimize system operation and to develop new strategies, engineering solutions, and best practices for future heat pump projects.

For Large Heat Pump or Building Solutions Award

Why the project serves as a model for others *(Large Heat Pump or Building Solutions Award)*

This project serves as a real-world, commercially available reference case for companies seeking to decarbonize industrial steam generation. It demonstrates that high-temperature heat pump technology is no longer a future concept but a market-ready solution capable of delivering reliable steam for demanding industrial processes.

Potential for expansion to other locations/industries *(Large Heat Pump or Building Solutions Award)*

The project has strong replication potential and can be implemented at other delfort production sites, as well as across the broader pulp and paper industry, where high-temperature steam and recoverable waste heat are commonly available. The solution can also be adapted to a wide range of energy-intensive industrial sectors, including refinery & petrochemical, chemical & pharmaceutical, and food & beverage applications. By tailoring the system design to specific process requirements and site conditions, high-temperature heat pumps can support the decarbonization of industrial steam generation across multiple industries. This project demonstrates that large-scale heat pump technology is a scalable and flexible solution for reducing CO₂ emissions while maintaining the performance and reliability required by demanding industrial processes.

Barriers to replication elsewhere *(Large Heat Pump or Building Solutions Award)*

The main barriers to replicating this project are both technical and financial. From a technical perspective, generating high-temperature steam with a heat pump requires achieving a very high temperature lift while maintaining efficiency and reliability. In addition, integrating large heat pump systems into existing industrial facilities can be challenging, particularly when installation space is limited and plant layouts must be adapted to complex site constraints. From a financial perspective, these technologies still involve a relatively high upfront investment (CapEx). Furthermore, in many markets, electricity prices remain less competitive than natural gas prices, which can affect the business case for industrial heat electrification projects. These barriers can be overcome through a combination of national and European funding schemes, subsidies, and decarbonization incentives, which help reduce investment costs and improve project economics. On the technical side, dedicated engineering efforts, such as the development of customized thermodynamic cycles, advanced control strategies, and tailor-made plant layouts, can enable high-temperature operation and facilitate integration even in facilities with limited available space.

Business opportunities for expansion, licensing, or commercial production *(Large Heat Pump or Building Solutions Award)*

The project has direct and immediate commercial value. Turboden offers the Heat Upgrade system as a commercially available product line, and the Tervakoski plant now acts as the operating reference for industrial customers evaluating the decarbonisation of their steam supply. Its primary contribution is to de-risk the category: until now, the absence of a reference installation for large steam-generating heat pumps in industrial service was a significant barrier to new project development, since prospective clients and their financing partners had no operational evidence that such a system would perform as designed under real process dynamics. That evidence now exists, which makes comparable projects more credible to clients, more attractive to investors and more financeable on competitive terms. The design models, control algorithms and operational insight developed for this plant can be applied directly to the next projects, reducing engineering effort, shortening commissioning timelines and allowing performance guarantees to be issued with greater confidence. Replication is being pursued within the delfort group and, more broadly, across the pulp and paper, food and beverage, chemical and pharmaceutical, refinery and petrochemical and district heating sectors, where variable waste heat and demanding steam requirements share the characteristics of this project. The architecture is scalable in capacity and adaptable in temperature level and is supported by a long-term service and remote monitoring offering.

For Innovation Award

Technology/technique developed solely for this project *(Innovation Award only)*

No answer provided. (Innovation Award section — not applicable to this application.)

Differentiation from state-of-the-art solutions & market maturity *(Innovation Award only)*

No answer provided. (Innovation Award section — not applicable to this application.)

Regional benefits (energy savings, emissions, jobs, infrastructure) *(Innovation Award only)*

No answer provided. (Innovation Award section — not applicable to this application.)

Commercial potential *(Innovation Award only)*

No answer provided. (Innovation Award section — not applicable to this application.)