

Heat Pump Awards 2026

Application submission

**MVR4G-DRY: Integrated MVR Heat Pump for Gypsum Board
Drying**

Gyptech AB | Large Heat Pump Award

1. Application overview

Award category	Large Heat Pump
Title of the project	MVR4G-DRY: Integrated MVR Heat Pump for Gypsum Board Drying
Organisation Name	Gyptech AB (project coordinator), with RISE Research Institutes of Sweden AB, KTH Royal Institute of Technology and Knauf Sverige GmbH
Exact address of the project	Knauf Sverige GmbH - Filial (516402-4431), Åhus plant (visiting address: Hamnen, 296 32 Åhus; postal address: 296 80 Åhus), Sweden
Funding	Private; Public; Swedish Energy Agency (Energimyndigheten) grant with industrial co-funding from project partners
Organisations involved in the project	Gyptech AB (556595-6850, coordinator), RISE Research Institutes of Sweden AB (556464-6874), Kungliga Tekniska Högskolan (202100-3054), and Knauf Sverige GmbH - Filial (516402-4431, demonstration site host)
Project ending date	31/08/2028
Project website	https://www.ri.se/sv/energi-och-elektrifiering/energieffektivisering/projekt/en-integrerad-mvr-varmepump-for Please enter a URL
Sector of application	Industrial

2. Applicant & EHPA contact details

Full name	Metkel Yebiyo
Email address	metkel.yebiyo@ri.se
Phone number	460730375702
EHPA member involved	RISE Research Institutes of Sweden AB and KTH Royal Institute of Technology (Kungliga Tekniska Högskolan)
Role of EHPA member	Two EHPA members are partners in MVR4G-DRY. RISE Research Institutes of Sweden AB leads WP4, Data Collection and System Verification. RISE collects and analyses operational data from the MVR heat pump and dryer at the Åhus demonstration site, develops high-fidelity simulation models validated against that data, and

	independently verifies the key performance indicators the system is designed to meet: a COP of at least 2.3, a reduction in specific energy consumption from 0.778 to below 0.389 kWh per kg of water evaporated, and 16,000 tonnes of CO₂ avoided per year. RISE also contributes to WP2 and WP3, and co-leads WP5 on dissemination, where it uses the IEA Heat Pump Technologies TCP platform it hosts to disseminate results internationally. RISE previously led IEA HPT Annex 59, "Heat Pumps for Drying", whose survey of 230 Swedish industries identified the adoption gap this project addresses. RISE budget is MSEK 4.76. KTH Royal Institute of Technology leads WP2, Modelling and Optimisation. KTH develops the models of the drying process and heat pump integration, covering heat and mass transfer, thermodynamics and process kinetics, and runs the simulation-based design optimisation that identifies the most efficient configuration. This includes assessing thermal energy storage integration and capacity enhancement techniques. KTH validates the design-phase models and confirms compliance with pressure vessel codes, electrical safety standards and environmental requirements as the system advances from TRL6 to TRL8. KTH co-leads WP5 on dissemination and supervises a master's thesis aligned with the project. KTH budget is MSEK 6.41. Between them the two EHPA members hold responsibility for all modelling, performance verification and dissemination in the project, independent of the technology supplier. Technical details
--	--

3. Project description and benefits

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

Gypsum board drying is among the most energy-intensive industrial processes, consuming 13 to 35 TWh per year in Sweden. A standard 3 m² board takes 24 kWh to produce, two thirds of it for drying, heat conventionally supplied by a gas-fired burner. The evaporated water then leaves the plant as humid exhaust.

MVR4G-DRY replaces the burner with an integrated mechanical vapour recompression heat pump. Seven steam compressors recompress that vapour in stages, delivering seven temperature levels up to 210°C at a lift of 160°C, beyond the 140 to 180°C typical of industrial MVR systems. The recovered heat passes through a tube condenser and heat exchanger to raise the temperature of the drying air, which in turn dries the boards. An additional n-pentane heat pump recovers further heat from the exhaust.

The 10.5 MWth system achieves a COP of at least 2.3 and cuts specific energy consumption from 0.778 to below 0.389 kWh per kg of water evaporated, an energy saving of over 50%. Working fluids are water/steam (R718) and n-pentane (R601), both natural and non-PFAS.

The demonstration runs on a live production line at Knauf's Åhus plant, advancing the system from TRL6 to TRL8.

Expected or achieved benefits

The project is at demonstration stage, with installation at the Åhus site and verification by RISE and KTH running to mid-2028. The figures below are the design-case values the demonstration is set up to verify.

Energy. The MVR heat pump has a thermal capacity of 10.5 MWth, built from seven steam compressors delivering seven temperature levels up to 210°C at a lift of 160°C. This is well beyond the 140 to 180°C and 40 to 100°C lift typical of industrial MVR systems recorded in IEA HPT Annex 58. At a COP of at least 2.3 it cuts the dryer's specific energy consumption from 0.778 to below 0.389 kWh per kg of water evaporated, an energy reduction of over 50%. Compared with an electric boiler of the same duty it avoids roughly 5 MW of electrical demand.

Emissions. Replacing the gas-fired burner removes 16,000 tonnes of direct CO₂ per year at the demonstration site. That is 0.45% of Sweden's entire 2030 emission reduction target from a single production line.

Economics. At Sweden's 2024 carbon tax of SEK 1,450 (EUR 125) per tonne, the avoided emissions are worth MSEK 23.0 (MEUR 2.0) per year, before the value of the fuel displaced.

Refrigerants. The system runs on R718 (water/steam) with a supporting R601 (n-pentane) heat pump. Both are natural, low-GWP and non-PFAS, so the installation is already compliant with where refrigerant regulation is heading and carries no risk of TFA contamination in the event of a leak.

Scale of the opportunity. Drying consumes 13 to 35 TWh per year in Sweden. One standard 3 m² gypsum board takes 24 kWh to produce, 16 kWh of it for drying, enough to heat a Swedish home for 6 to 9 hours in winter, against a European gypsum board market exceeding 3,400 million m². IEA HPT Annex 59, led by RISE, surveyed 230 Swedish industries and found only one respondent in 71 using a heat pump for anything beyond low-grade sanitary hot water. The technology is absent from the sector, not unsuitable for it.

Replication. The concept transfers to sludge and wastewater treatment, dairy and food processing, textiles and timber. The project targets at least 25 engaged stakeholders, five dissemination events, peer-reviewed and conference publications, and outreach through the IEA HPT TCP platform hosted by RISE.

Obstacles/barriers encountered during development

Three barriers shaped the project.

Technically, the dryer exhaust is not clean steam. It carries gypsum dust, starch and additive residues, so compressor and heat exchanger design had to tolerate fouling and particulates while maintaining the tight stage efficiencies the multi-stage cycle depends on. Achieving high pressure ratios in a single train without compromising reliability required iteration between modelling at KTH and design work at Gyptech.

Operationally, the installation sits on a live production line. Board quality is highly sensitive to the drying curve, so the heat pump had to be integrated without disturbing product specification, and downtime for retrofit had to fit within scheduled plant stops.

Commercially, the investment competes against an incumbent gas burner with very low capital cost. The gas-to-electricity price ratio in Sweden means the case rests on carbon pricing, grid tariffs and long-run fuel exposure rather than on fuel cost alone, which makes the techno-economic assessment central to convincing other plant owners to replicate.

Why should this project win an award?

Everyone assumes industrial drying is too hot and too dirty for heat pumps. The evidence says the sector agrees: IEA HPT Annex 59, led by RISE, surveyed 230 Swedish industries and found exactly one respondent in 71 using a heat pump for anything beyond heating sanitary water. An entire process class, consuming 13 to 35 TWh a year in Sweden alone,

has been written off.

MVR4G-DRY proves the assumption wrong, and it does so using the fuel that was there all along. Every gypsum board dryer already generates the working fluid its own heat pump needs, as vapour evaporated from the boards and vented up the stack. Seven steam compressors in series refuse to let it leave, recompressing it to 210°C at a lift of 160°C. Industrial MVR systems typically reach 140 to 180°C with lifts of 40 to 100°C, so this sits well outside what the technology is currently assumed capable of, with water and n-pentane as the only working fluids and no PFAS anywhere in the system.

The surprising part is the scale of what one machine does. Replacing a single gas burner on a single production line removes 16,000 tonnes of CO2 per year and delivers 0.45% of Sweden's entire 2030 emission reduction target. Specific energy consumption halves, from 0.778 to below 0.389 kWh per kg of water evaporated. At the 2024 carbon tax rate, that one line is worth MSEK 23 a year in avoided tax alone.

It is also a genuine commitment rather than a subsidised experiment. Of the MSEK 204 total, industry is funding MSEK 145. Knauf is putting a 10.5 MWth prototype into a working plant where board quality depends on the drying curve holding steady and where the line cannot simply be stopped. That is what makes the result credible to the next plant owner, in gypsum, dairy, wastewater or timber.

Your information

4. Technical specifications

Capacity of unit(s)	10,500 kW thermal (10.5 MWth) nominal heating capacity. The system comprises seven steam compressors in series, delivering seven temperature levels with a maximum supply temperature of 210°C at a temperature lift of 160°C. An auxiliary n-pentane heat pump provides additional heat recovery from the dryer exhaust.
Energy sources used	Electricity and recycled waste heat. The heat pump is driven entirely by electricity and upgrades waste heat recovered from the gypsum board dryer's own exhaust vapour, which is currently vented to atmosphere. It replaces a natural gas-fired burner, so the drying process moves from fossil fuel to electricity, and on the Swedish grid mix becomes effectively fossil-free. No gas is used in the heat pump itself.
Coefficient of Performance (COP)	COP of at least 2.3. This is the overall system COP at the design operating conditions: heat source is the dryer's humid exhaust vapour, supply temperature up to 210°C, temperature lift 160°C, 10.5 MWth output. The COP is the design target the demonstration at Åhus is set up to verify, with measurement and independent verification carried out by RISE in WP4. For context, a COP of 2.3 at a 160°C lift is well outside the range of conventional industrial MVR systems, which typically operate between 140 and 180°C at lifts of 40 to 100°C according to the case studies collected under IEA HPT Annex 58. Against the

	gas boiler it replaces (efficiency 0.95 to 0.97) and an electric boiler alternative (0.99 to 1.0), the system halves specific energy consumption for drying, from 0.778 to below 0.389 kWh per kg of water evaporated.
Service provided	Industrial process heat. The heat pump supplies the drying stage of gypsum board manufacturing, heating the drying air that removes water from freshly formed boards on a continuous production line. It provides no space heating, cooling or domestic hot water.
Refrigerant type	R718 (water/steam) as the primary refrigerant in the MVR cycle, with R601 (n-pentane) in the auxiliary heat pump that boosts heat recovery from the exhaust. Both are natural refrigerants with negligible GWP and no PFAS content, so the system carries no risk of trifluoroacetic acid or other persistent breakdown products in the event of a leak or during maintenance.

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

Configuration. A seven-stage mechanical vapour recompression cycle. Seven steam compressors operate in series, each applying a modest pressure ratio so that the train as a whole reaches a supply temperature of 210°C at a lift of 160°C while keeping stage efficiencies high. The staging produces seven distinct temperature levels, which allows heat to be matched to the different zones of the dryer rather than supplied at a single temperature. Nominal capacity is 10.5 MWth.

Compressors. Steam compressors operating on R718, based on Gyptech's patent-pending design (European patent application EP24179188.8). The build draws on steam screw compressor work with a long track record in industrial applications.

Heat exchange. A tube condenser recovers heat from the recompressed vapour, and a heat exchanger transfers it to the drying air, which in turn dries the boards. Flash tanks recover further steam to raise overall cycle efficiency. The steam loop includes an air separator, steam traps, control and safety valves, vacuum breakers, non-return and wedge gate valves, condensate pump, water fill system and water storage tank.

Second cycle. A separate n-pentane (R601) heat pump operates alongside the MVR train, recovering additional heat from the dryer exhaust that the steam cycle cannot reach economically. So the installation is a combination: seven steam stages in series, plus a parallel auxiliary cycle on a different working fluid.

Integration. The system is retrofitted to an existing dryer at the Knauf Åhus plant, including an upgrade to the dryer's final zone, rather than being installed as part of a new line.

5. Renewable energy integration and grid response

Integration of renewable energy sources

The heat pump runs on the Swedish electricity grid, which is predominantly hydro, nuclear and wind, so electrification of the drying process is itself the decarbonisation step: it removes 16,000 tonnes of direct CO₂ per year. Direct on-site renewable generation is not part of the

demonstration scope, but the system is designed so that the electrical load can be offset by renewable generation where a site has it. Knauf has done this elsewhere in the group, for example at its Mendoza plant in Argentina, where 2,000 solar panels supply half the factory's energy demand and avoid 540 tonnes of CO₂ per year.

Response to energy demand / smart grid integration

The dryer runs continuously and board quality depends on the drying curve holding steady, so the heat pump's first obligation is stable delivery rather than load following. Flexibility comes from three features of the design. The seven-stage configuration allows individual compressor stages to be modulated, so heat output can be turned down without shutting the system off. Flash tanks and the water storage tank provide a buffer of thermal inertia between compression and delivery, decoupling the two over short periods. And the project investigates thermal energy storage integration under WP2 (Subtask 2.2.2) specifically to widen this flexibility.

Replacing a gas burner with a 5 MWe electrical load makes the plant a significant new grid participant, and the real-time monitoring installed under WP4 records electrical consumption continuously alongside thermal performance. This gives the operator the data needed to shift load within the constraints of the production schedule and to respond to price signals on the Swedish spot market. Verifying how far a continuous industrial dryer can participate in demand response without compromising product quality is one of the questions the demonstration is designed to answer.

6. Innovation, monitoring and replicability

General (all awards)

Why the project is innovative *(all awards)*

Temperature and lift. Industrial MVR systems typically deliver 140 to 180°C at lifts of 40 to 100°C, according to the case studies gathered under IEA HPT Annex 58. This system reaches 210°C at a lift of 160°C, which places it beyond the current envelope of the technology. The seven-stage arrangement is what makes it possible: each stage takes a modest share of the lift, so high stage efficiency is preserved across a total lift that a smaller number of stages could not deliver economically.

Protected design. The compressor and cycle configuration is covered by European patent application EP24179188.8, held by Gyptech AB.

Working fluids. R718 and R601 only. No HFCs, no HFOs, no PFAS. As the sector moves toward natural refrigerants ahead of 2030, this system is already there, and a leak or maintenance event carries no risk of trifluoroacetic acid contamination of soil or water.

The source is the process itself. The refrigerant is the water evaporated from the product. A gypsum board dryer generates its own working fluid and currently discards it. The design turns the largest loss in the process into the input for the machine that replaces the fuel.

Scale and setting. At 10.5 MWth this is not a pilot skid. It is retrofitted into a working production line at Knauf Åhus, including an upgrade to the dryer's final zone, and must hold the drying curve that board quality depends on while the line keeps running. Demonstrating at that scale, in that setting, is what advances the technology from TRL6 to TRL8 and what makes the result credible to the next plant owner.

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

Monitoring is a dedicated work package (WP4), led by RISE with KTH, Gyptech and Knauf, with a budget of MSEK 4.7 and independence from the technology supplier built into the structure.

Collection. Sensors, meters and control systems are installed and calibrated during the

installation phase to record temperature, pressure and energy consumption in real time across the MVR unit and the dryer. Data collection runs continuously from commissioning through the remainder of the project, with checks on data integrity and consistency.

Metrics. The parameters tracked are system capacity, coefficient of performance, specific energy consumption in kWh per kg of water evaporated, electrical consumption, and the resulting CO2 emissions. These map directly onto the targets: COP of at least 2.3, SEC below 0.389 kWh/kg against a 0.778 baseline, and 16,000 tonnes of CO2 avoided per year.

Use. The measured data feeds high-fidelity simulation models of the demonstration site, which validate and refine the models built during the design phase under WP2. That closes the loop between prediction and measurement, and it is what allows the performance claims to be extended to other sites and other sectors rather than remaining specific to Åhus.

Continuous data also surfaces inefficiencies, maintenance needs and deviations from optimal operation as they appear, supporting predictive maintenance and corrective action.

Reporting. Results are published as project deliverables (D4.1 and D4.2), in peer-reviewed and conference papers, and through the IEA Heat Pump Technologies TCP platform hosted by RISE, so the verification is available to the wider industry rather than held internally.

For Large Heat Pump or Building Solutions Award

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

The demonstration is deliberately structured to be copied rather than admired. It is a retrofit, not a new build. The MVR unit is integrated into an existing dryer on an operating production line at Knauf Åhus, with the final zone of the dryer upgraded to suit. Most industrial decarbonisation has to happen this way, on assets already in the ground, so a result obtained under retrofit conditions transfers where a greenfield result would not. It runs under real production constraints. Board quality depends on the drying curve, the line cannot be stopped at will, and the exhaust the heat pump draws on carries dust and process residues. The demonstration has to hold performance under those conditions, which is precisely what a plant owner considering the same investment needs to know.

Verification is independent. RISE leads WP4 and verifies performance separately from Gyptech, which supplies the technology, and from Knauf, which hosts the site. The COP, specific energy consumption and CO2 figures are measured and published rather than asserted by the vendor.

The evidence is published. Results go out as project deliverables, peer-reviewed and conference papers, open-access case studies, and through the IEA Heat Pump Technologies TCP platform hosted by RISE. The project targets at least 25 engaged stakeholders and five dissemination events, plus presentation at the Global Gypsum conference and publication in Global Gypsum magazine, reaching the plant operators who would make the next investment.

The barrier it addresses is confidence, not capability. IEA HPT Annex 59, led by RISE, surveyed 230 Swedish industries and found one respondent in 71 using a heat pump for anything beyond low-grade sanitary hot water. Annex 59 also found strong interest alongside that low adoption: the industry will invest if suppliers can prove reliability at scale. This demonstration is that proof.

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

Within gypsum. The Knauf Group operates over 320 production facilities worldwide and has committed to a 50% reduction in CO2 emissions across its operations by 2032. A verified result at Åhus is directly transferable to Knauf's other board plants, and to competitors' plants, since the drying process is fundamentally the same everywhere. The European gypsum board market alone is expected to exceed 3,400 million m² and every square metre passes through a dryer.

Beyond gypsum. Any continuous process that evaporates water and vents humid exhaust is

a candidate. The project explicitly targets three distinct sectors for scalable versions of the system, with sludge and wastewater treatment, dairy and food processing identified as the nearest, and textiles and timber drying as further applications. Drying accounts for 13 to 35 TWh per year in Sweden alone.

Why it transfers. What moves between sectors is not the machine but the principle that the evaporated water is the working fluid. The staging, compressor design and integration approach adapt to different capacities and temperature requirements. The 210°C capability matters here: a system that only reached 140 to 180°C would be limited to the lower-temperature end of the drying sector, whereas this one covers processes that were previously out of reach for heat pumps altogether.

What makes it credible. The modelling work in WP2 produces validated simulation models rather than a single point design, so the configuration can be re-optimised for a new site's temperatures, capacity and exhaust conditions without repeating the full development.

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

Technical. Dryer exhaust is not clean steam. It carries gypsum dust, starch and process additives, so compressors and heat exchangers must tolerate fouling and particulates while holding the stage efficiencies that a seven-stage train depends on. Overcome through iteration between modelling at KTH and design at Gyptech, with the demonstration providing real fouling data over extended operation rather than laboratory assumptions.

Financial. This is the dominant barrier. The MVR system represents 50 to 60% of total project cost, and Annex 58 puts the manufacturing cost of a 1.0 MWth MVR unit at EUR 0.8 to 1.0 million before installation, commissioning and grid connection. It competes against an incumbent gas burner with very low capital cost. In Sweden the gas-to-electricity price ratio means the case rests on carbon pricing rather than fuel cost alone: at SEK 1,450 per tonne, the avoided carbon tax alone is worth MSEK 23 per year at this one site. Overcoming it requires public co-funding for first-of-a-kind installations, which is what Energimyndigheten's 29% share provides here, and a stable carbon price signal. Each subsequent installation needs less support as the technology cost curve falls and the performance risk premium disappears.

Operational. Retrofitting into a live line means the work must fit scheduled plant stops, grid connection capacity must be available for a load of this size, and the drying curve must be preserved through the transition. These are site-specific and are best addressed by the kind of structured pre-study the project runs in WP3, covering infrastructure, space constraints and utility connections before any procurement.

Regulatory. Pressure vessel codes, electrical safety standards and environmental requirements all apply to a high-temperature steam system, and compliance is verified during the first project year. The refrigerant choice removes one regulatory barrier entirely: with R718 and R601 there is no F-gas exposure and no PFAS liability, so replication is not threatened by tightening refrigerant rules.

Market. The deepest barrier is that the sector does not know this is possible. Annex 59 attributed low adoption largely to lack of awareness of what heat pump technology can now do in drying. A published, independently verified full-scale result is the direct remedy.

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

The technology is owned by Gyptech AB, a Swedish SME, and protected under European patent application EP24179188.8, so there is a clear commercial route rather than an orphaned research result.

Direct sales. Gyptech supplies equipment to the gypsum board industry and already has the customer relationships. A verified installation at Knauf Åhus is a reference plant for the rest of the Knauf group's 320-plus facilities and for the wider board industry.

Sector adaptation. The project aims to develop scalable versions of the system for three distinct sectors beyond gypsum, opening markets in sludge and wastewater treatment, dairy and food processing.

Supply chain. Deployment at scale pulls demand through to Swedish manufacturers of compressors, heat exchangers and steam system components, domestically and for export. Positioning. TRL8 by project end means the system is ready for full-scale commercial deployment rather than requiring a further development stage. The project also strengthens Gyptech's ESG profile, which matters for access to green finance and investment. Market timing. Demand is being created by policy rather than waiting on it: Fit for 55, REPowerEU, the Energy Efficiency Directive (EU) 2023/1791, the EU ETS at around EUR 100 per tonne, and Sweden's carbon tax at SEK 1,450 per tonne all improve the business case each year. Swedish industry is expected to need 45 to 133 TWh of additional energy as electrification proceeds, so efficiency at this scale has value beyond the individual plant.

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.)