

Heat Pump Awards 2026

Application submission

**High-Temperature Transcritical CO₂ Heat Pump Retrofit for an
Existing Residential Building in Zuchwil, Switzerland**

NIK SYSTEMS | Innovation Award

1. Application overview

Award category	Innovation
Title of the project	High-Temperature Transcritical CO ₂ Heat Pump Retrofit for an Existing Residential Building in Zuchwil, Switzerland
Organisation Name	NIK SYSTEMS
Exact address of the project	AMSELWEG 25, 4528 ZUCHWIL SO, SWITZERLAND
Funding	Private
Organisations involved in the project	BUILDING SOLUTIONS AG
Project ending date	01/06/2026
Project website	No answer provided.
Sector of application	Residential

2. Applicant & EHPA contact details

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EHPA member involved	DANFOSS
Role of EHPA member	Danfoss/BOCK is the manufacturer and supplier of the CO ₂ compressor used in the NIK Systems transcritical R744 heat pump installed in the Zuchwil project. The heat pump technology, system architecture, control strategy and overall design were developed by NIK Systems.

3. Project description and benefits

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

The project demonstrates the decarbonisation of an existing 35-apartment residential building in Zuchwil, Switzerland, where the existing heating infrastructure requires high water temperatures and cannot easily be converted to a conventional low-temperature heat pump system.

NIK Systems developed and installed a high-temperature transcritical CO₂ (R744) heat pump designed to provide both space heating and domestic hot water while working with the building's existing hydronic heating system. The system operates at supply temperatures of approximately 70–80°C, enabling the building to reduce its dependence on fossil-fuel boilers without requiring a complete replacement of radiators or major changes to the internal heating network.

The solution uses natural refrigerant CO₂/R744 and a proprietary transcritical system architecture developed by NIK Systems. The project also provides real operating data from an occupied residential building under European climatic conditions.

The main objective is to demonstrate that existing high-temperature buildings can be decarbonised efficiently with a heat pump, overcoming one of the major barriers to heat-pump deployment in Europe: the need for high-temperature heating in existing building stock.

Expected or achieved benefits

The project demonstrates that high-temperature heat-pump technology can significantly reduce the use of fossil-fuel boilers in existing buildings without requiring a complete reconstruction of the heating system.

Key achieved benefits include:

- * High-temperature space heating at approximately 70–80°C together with domestic hot water production.
- * Use of natural refrigerant CO₂ (R744), with very low global warming impact and no dependence on HFC refrigerants.
- * Strong real-world efficiency: during optimised operating periods, the system has demonstrated SOR values reaching approximately 4.5 even at very high supply and return water temperatures.
- * Reduced gas consumption, operating costs and associated CO₂ emissions.
- * Retention of the building's existing radiators and hydronic distribution system, avoiding a costly full heating-system retrofit.
- * Demonstration of a scalable solution for the large European market of existing apartment buildings, hotels, hospitals and other facilities requiring high-temperature heating and domestic hot water.

The project therefore demonstrates a practical pathway for replacing fossil-fuel heating in existing European buildings that are difficult to decarbonise using conventional low-temperature heat pumps.

Obstacles/barriers encountered during development

One of the main challenges was to integrate a high-temperature heat pump into an existing residential building without changing the existing heating infrastructure.

No radiators were replaced, no changes were required to the existing hydronic distribution system, and no additional low-temperature heating system was installed. The NIK Systems transcritical CO₂ heat pump was connected in parallel with the existing gas boilers.

The system had to provide approximately 70–80°C water temperatures while maintaining high efficiency, which is a demanding operating condition for conventional heat pumps.

Another challenge was the simultaneous production of space heating and domestic hot water under continuously changing outdoor temperatures and building loads. This required

optimisation of NIK Systems' proprietary transcritical CO₂ system architecture, control strategy, heat-exchanger configuration and operating parameters.

The project was implemented in an occupied residential building while maintaining normal heating and domestic hot-water service.

Since commissioning of the NIK Systems heat pump, the existing gas boilers have not been required for normal operation. The building continues to use its original high-temperature heating infrastructure, now supplied by the CO₂ heat pump.

Extensive real-world monitoring and optimisation were essential to achieve stable operation, high water temperatures and strong system efficiency.

Why should this project win an award?

What makes this project special is that an existing high-temperature residential building was decarbonised without replacing its radiators, without rebuilding the hydronic heating system, and without installing a new low-temperature distribution system.

The NIK Systems transcritical CO₂ heat pump was integrated in parallel with the existing gas boilers. Since commissioning, the gas boilers have not been required for normal operation. The system supplies approximately 70–80°C water for space heating and domestic hot water. This represents an extremely demanding operating condition for a heat pump and, in particular, for a transcritical CO₂ system, because very high supply and return water temperatures normally make it extremely difficult to maintain high efficiency.

What is especially important is that the high COP was achieved specifically at these demanding high-temperature operating points. During recent optimised operation, the system demonstrated COP values reaching approximately 4.5 while operating with very high supply and return water temperatures.

This result demonstrates the effectiveness of NIK Systems' proprietary transcritical CO₂ system architecture and control strategy, and shows that R744 can be used not only for domestic hot water, but also for highly efficient high-temperature space heating in existing buildings.

The project therefore challenges the common assumption that existing buildings with high-temperature heating require major renovation or complete conversion to low-temperature heating before fossil-fuel boilers can be replaced by heat pumps.

Using natural refrigerant R744, the project demonstrates a practical and scalable pathway for decarbonising a large part of Europe's existing high-temperature building stock.

4. Technical specifications

Capacity of unit(s)	300 kW nominal heating capacity
Energy sources used	The heat pump is electrically driven and uses ambient air as the renewable heat source. The existing gas boilers remain connected in parallel only as backup; since commissioning of the NIK Systems CO ₂ heat pump, they have not been required for normal operation.
Coefficient of Performance (COP)	Measured operating COP reached approximately 4.25–4.45 during recent optimised operation, with heating water entering the heat pump at approximately 70°C and leaving at

	approximately 79°C, while outdoor air temperature was around 12°C during night-time operation. This is an exceptionally demanding operating point for a high-temperature transcritical CO₂ (R744) heat pump, because both the supply and return water temperatures are very high. The result was measured under actual operation of the residential building, not under laboratory conditions.
Service provided	High-temperature space heating and domestic hot water production for an existing 35-apartment residential building, using the existing radiators and hydronic distribution system without conversion to a low-temperature heating network.
Refrigerant type	Natural refrigerant CO₂ (R744), with GWP = 1 and ODP = 0.

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

The project uses one 300 kW NIK Systems high-temperature transcritical CO₂ (R744) heat pump.

The complete heat-pump technology, refrigerant-system architecture, heat-exchanger arrangement, control strategy and system integration were developed by NIK Systems. The system uses a Danfoss/BOCK semi-hermetic reciprocating compressor designed for transcritical CO₂ operation.

On the water side, high-pressure stainless-steel brazed plate heat exchangers are used for heat transfer, while ambient heat is collected through a high-pressure air evaporator designed for R744 operation.

The proprietary NIK Systems configuration is specifically designed to maintain high efficiency while simultaneously producing high-temperature space heating and domestic hot water. Only one heat-pump unit is installed. Hydraulically, it is connected in parallel with the building's existing gas boilers. No radiators or existing hydronic distribution system were replaced. Since commissioning of the NIK Systems heat pump, the gas boilers have not been required for normal operation.

5. Renewable energy integration and grid response

Integration of renewable energy sources

The primary renewable energy source is ambient outdoor air.

Electricity is used to drive the compressor, fans and pumps, while the majority of the useful thermal energy delivered to the building is extracted from the ambient air.

At measured operating COP values of approximately 4.25–4.45, around 76–78% of the

useful heat delivered by the heat pump originates from ambient environmental energy, with only approximately 22–24% corresponding to electrical input.

This allows the system to provide high-temperature heating and domestic hot water while substantially reducing dependence on fossil fuel.

The use of ambient renewable heat together with natural refrigerant CO₂ (R744) provides both an energy-efficiency and decarbonisation benefit.

Response to energy demand / smart grid integration

The system automatically adapts its operation to changes in building heating demand, domestic hot-water demand and outdoor temperature.

Compressor capacity, air-side operation, water temperatures and system operating parameters are continuously controlled to match the actual thermal load while maintaining the required high supply-water temperatures.

The control strategy also manages the interaction between space heating and domestic hot-water production and continuously optimises the transcritical CO₂ operating conditions.

The existing gas boilers remain hydraulically connected in parallel as backup capacity; however, since commissioning of the NIK Systems heat pump, they have not been required for normal operation.

The current installation is not operated as part of a utility smart grid. However, the control architecture allows load-management strategies and external operating commands to be incorporated where required, enabling future integration with demand-response systems, renewable electricity or time-dependent electricity tariffs.

6. Innovation, monitoring and replicability

General (all awards)

Why the project is innovative *(all awards)*

The innovation lies in the proprietary NIK Systems transcritical CO₂ (R744) system architecture and control strategy, developed specifically for high-temperature heating of existing buildings.

Unlike conventional heat pumps, the system is able to operate efficiently with very high return and supply water temperatures. In the Zuchwil project, the heat pump operates at approximately 70°C return and 79–80°C supply temperatures — one of the most demanding operating conditions for a transcritical CO₂ system.

Despite these conditions, measured real-world COP values reached approximately 4.25–4.45 at these specific high-temperature operating points.

The system also provides both space heating and domestic hot water, while using the building's existing radiators and hydronic distribution network. No conversion to a low-temperature heating system was required.

The heat pump was connected in parallel with the existing gas boilers, but since commissioning, the gas boilers have not been required for normal operation.

This demonstrates a new practical approach to decarbonising existing high-temperature buildings using natural refrigerant R744, without major reconstruction of the building's heating infrastructure.

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

The NIK Systems heat pump is controlled and remotely managed by NIK Systems, including the operating parameters, water temperatures and optimisation of the transcritical CO₂ cycle.

However, the measurement of electrical energy consumption and delivered thermal energy is carried out independently in Switzerland by an external company using separate energy metering equipment.

The system COP is calculated from these independent measurements of thermal energy output and electrical energy input. Therefore, the reported performance values, including the measured COP of approximately 4.25–4.45 at the high-temperature operating points, are based on independent field measurements rather than calculations made by NIK Systems. The collected data are used to verify system performance, evaluate energy efficiency and operating costs, and assess the reduction in fossil-fuel consumption and associated CO₂ emissions.

This independent measurement approach provides transparent verification of the heat pump's real-world performance in an occupied residential building under actual operating conditions.

For Innovation Award

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

The core transcritical CO₂ (R744) technology was developed by NIK Systems as a proprietary high-temperature heat-pump platform and was not created solely for this individual building. However, the Zuchwil project required specific engineering, control optimisation and hydraulic integration to operate with the building's existing high-temperature heating infrastructure, while simultaneously providing space heating and domestic hot water.

The system architecture and control strategy were further optimised under real operating conditions, particularly for the extremely demanding operating point of approximately 70°C return water and 79–80°C supply water.

The project therefore represents both a commercial application of NIK Systems' proprietary technology and an important real-world development and validation stage for high-temperature European retrofit applications.

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

The project differs from conventional heat-pump retrofit solutions because it does not require the existing building to be converted to a low-temperature heating system.

The NIK Systems transcritical CO₂ heat pump operates directly with the building's existing high-temperature radiators and hydronic network, at operating conditions around 70°C return and 79–80°C supply.

At these demanding operating points, independently measured real-world SOR values have reached approximately 4.25–4.45.

The system was connected in parallel with the existing gas boilers, without replacing the radiators or rebuilding the heating distribution system. Since commissioning, the gas boilers have not been required for normal operation.

In addition to the environmental benefit of replacing fossil-fuel heating with a natural-refrigerant CO₂ system, the building's heating energy cost has been reduced by approximately 64% compared with the previous gas-based operation.

The solution therefore combines three benefits that are rarely achieved together: very high-temperature operation, strong real-world efficiency, and substantial operating-cost reduction. This is not a laboratory prototype or theoretical concept. The Zuchwil installation is a commercially deployed system operating in an occupied residential building under real European climatic conditions. The technology is therefore already at the commercial-deployment stage and is designed for replication in other high-temperature retrofit applications.

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

The project directly benefits the Zuchwil region by substantially reducing the building's dependence on natural gas, fossil-fuel consumption and associated CO₂ emissions. At the same time, the project demonstrates that an existing residential building can be decarbonised without replacing its radiators or reconstructing the complete heating distribution system. This significantly reduces infrastructure changes, material use, disruption and investment normally associated with conversion to low-temperature heating. The use of ambient air as the renewable heat source and natural refrigerant CO₂ (R744) further improves the environmental performance of the project. Beyond this individual building, the installation provides a real European reference for apartment buildings, hotels, hospitals, care facilities, public buildings and other facilities with similar high-temperature heating requirements. The project therefore has value not only for Switzerland, but for the wider European market, by demonstrating a practical and replicable pathway for decarbonising the large existing building stock that still depends on high-temperature fossil-fuel heating systems.

Commercial potential *(Innovation Award only)*

The commercial potential is significant because a very large part of Europe's existing building stock was designed for high-temperature radiator heating and cannot easily or economically be converted to conventional low-temperature heat-pump systems. The NIK Systems solution addresses this market directly by allowing high-temperature space heating and domestic hot water to be supplied using the existing hydronic infrastructure. The technology is already manufactured commercially by NIK Systems and the Zuchwil project demonstrates its operation in a real European residential building. The same approach can be scaled and applied to apartment buildings, hotels, hospitals, care facilities, public buildings and industrial facilities requiring high-temperature heating and domestic hot water. Commercial expansion can be achieved through direct system sales, local engineering and installation partners, distributors and strategic cooperation with European companies. The Zuchwil project therefore provides not only a successful individual installation, but a replicable commercial model for replacing fossil-fuel heating across a large segment of the European retrofit market.

For Large Heat Pump or Building Solutions Award

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

No answer provided.

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

No answer provided.

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

No answer provided.

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

No answer provided.