# Cascade Heat Pump System for District Heating

## Johnson Controls

**Figure 1: ATEX-compliant enclosure for hydrocarbon heat pump.**

## Summary of technology

The system consists of a cascade heat pump, with R-717 as working fluid in the bottom cycle, and R-600 in the top cycle. The intended application is for district heating. An intermediate cycle with water transfers heat between the two cycles. The heat source for the bottom cycle can be locally available heat sources or, alternatively, an air-cooled evaporator.

The system has reciprocating compressors, which are electrically driven. The compressor design builds on experience from gas transport applications.

The bottom cycle is based on a Sabroe HeatPAC while the top cycle is an ATEX unit with separate enclosure with ventilation and gas detection.

Regarding the lubrication system, an internal oil pump circulates PAG VG 255 oil in the top cycle, while the crankcase optionally can be heated in order to avoid condensation in the compressor suction inlet.

An internal heat exchanger is included to ensure sufficient superheating before the compressor suction side.

**Table 1: Performance.**

| $T_{source,in}$ | $T_{source,out}$ | $T_{sink,in}$ | $T_{sink,out}$ | $COP_{heating}$ |
|---|---|---|---|---|
| [°C] | [°C] | [°C] | [°C] | [-] |
| 50 | 45 | 70 | 120 | 4.3 |

**Figure 2: HeatPAC for $NH_3$ bottom cycle.**

## Project examples

Different working fluids have been identified in a project for working at elevated temperatures up to 250 °C or higher. For temperatures from 90 °C to 130 °C, a hydro-carbon working fluid such as n-Butane (R-600) will be a good solution with high COP, low swept volume and low condensing pressure.

For a specific project in Germany, a 27,000 $m^3$ old coal mine is being explored as a possible heat storage facility. On the surface, different means to heat the water are explored, such as solar heat, which during the summer period is to heat up the water reservoir and use this as a thermal energy storage.

A cascade heat pump system with an ammonia heat pump on the first stage and a Butane heat pump on the second stage is to deliver a high stage temperature of maximum 120 °C at an ambient temperature of -10 °C, and a sink outlet temperature of 80 °C at an ambient temperature of 0 °C.

## FACTS ABOUT THE TECHNOLOGY

**Heat supply capacity:** 0.5 MW (development step 1) to 5 MW (development step 2).

**Temperature range:** Upper limit is 120 °C (however depending on evaporating temperature).

**Working fluid:** $NH_3$ and R-600 (n-Butane).

**Compressor technology:** Reciprocating.

**Specific investment cost for installed system without integration:** n/a (highly dependent on actual circumstances, e.g. customs and taxation).

**TRL level:** $NH_3$ HeatPAC is proven technology (TRL9), and for R-600 top cycle a little lower TRL level (7-8).

**Expected lifetime:** 25 years.

**Size:** Footprint: 6 m long x 1.8 m wide, with a height of under 3 m for each unit ($NH_3$ and R-600 cycle).

## Contact information

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All information has been provided by the supplier without third-party validation. The information was provided as an indicative basis and may be different in final installations depending on application-specific parameters.