# SPIRIT demo case I: Full-scale on-site demonstration of a cascade industrial heat pump producing steam at 145°C

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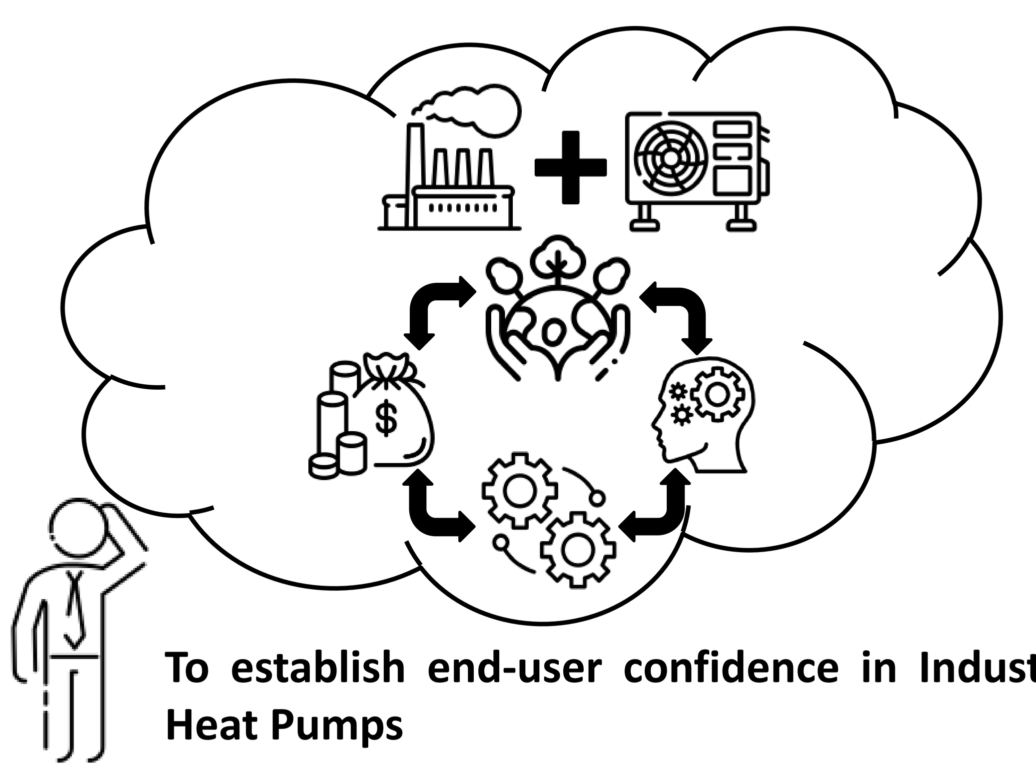
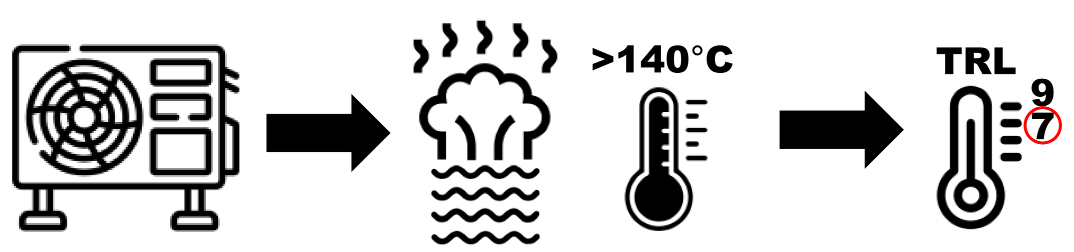
## Context: industrial heat pumps

A critical factor hindering the deployment of high-temperature heat pumps is the end-user hesitation to disrupt existing processes. This hesitation is partially inherent in capital-intensive industrial sites but also concerns the need for more operational experience. Therefore, the SPIRIT-HEU project aims to demonstrate industrial heat pumps at three different process sites demanding heat above 135 °C. "Demonstration site 1" will incorporate a cascade heat pump capable of upgrading waste heat to produce steam above 140 °C into a shrimp processing facility.

### Impact of SPIRIT demonstrations



**To establish end-user confidence in Industrial Heat Pumps**

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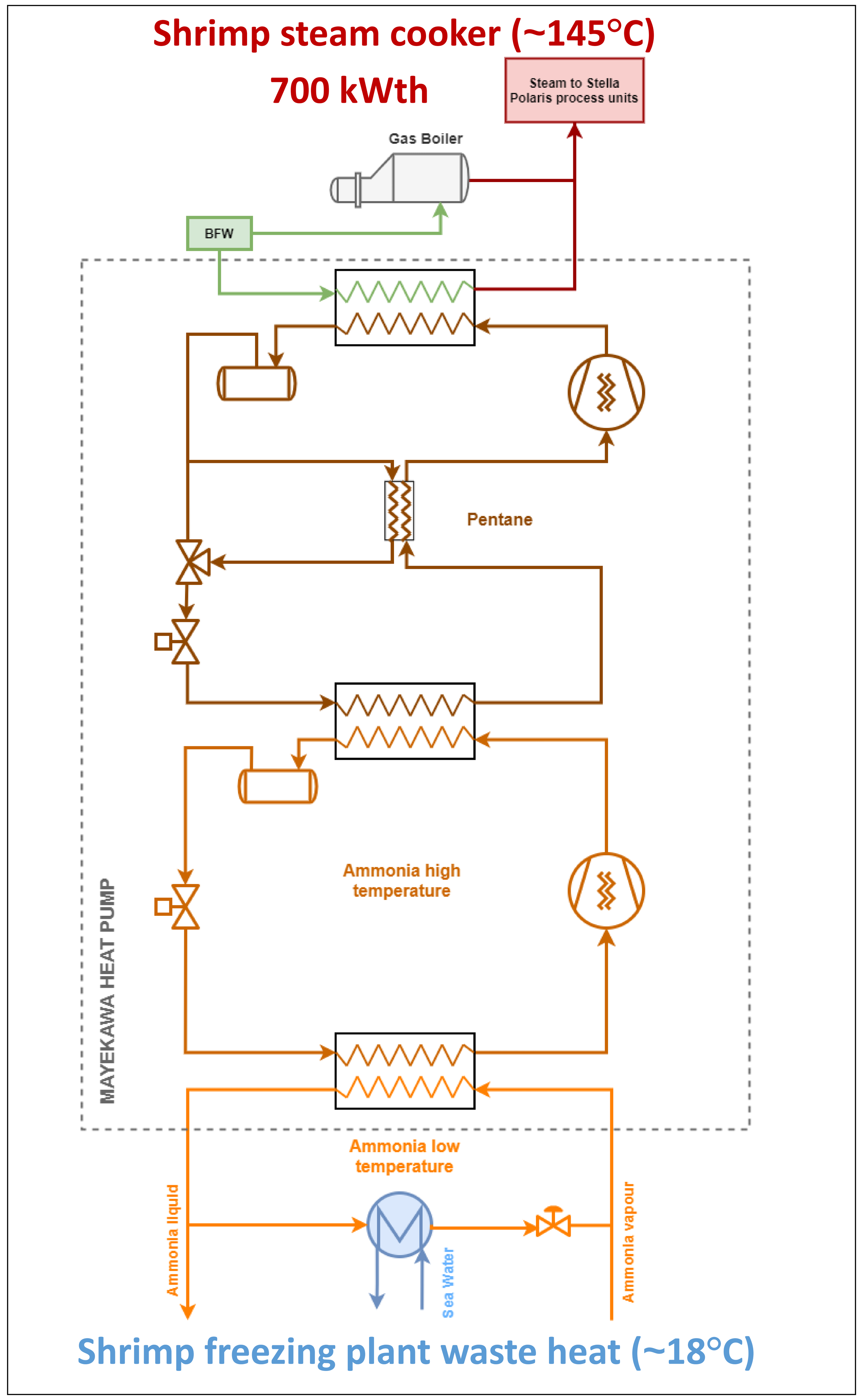
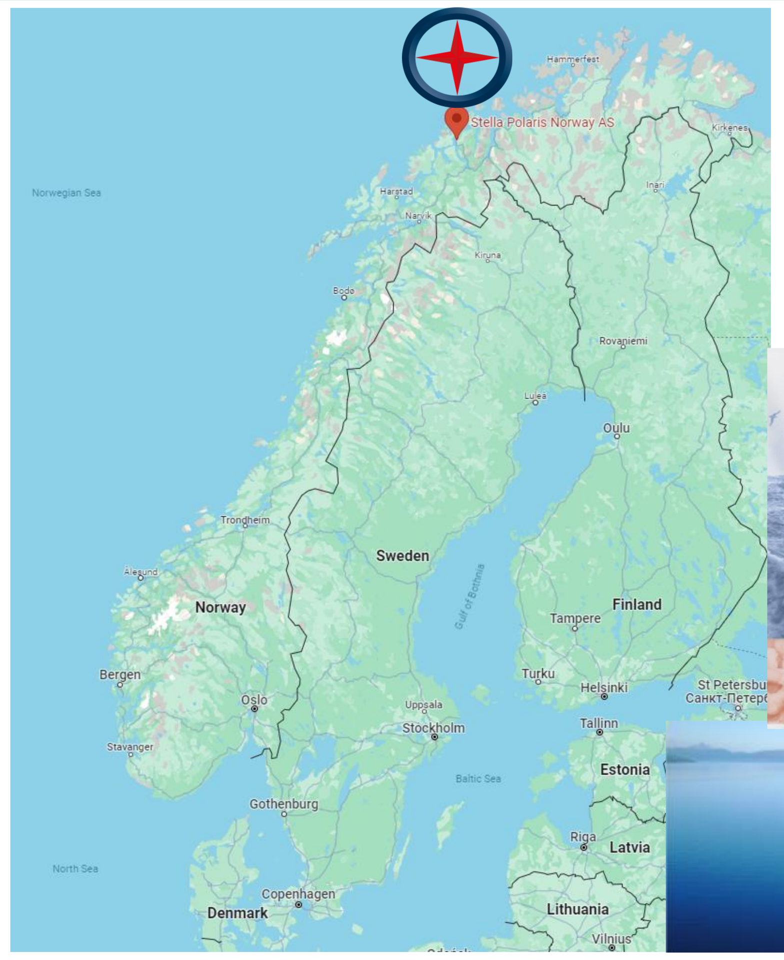
## Process and industrial heat pump

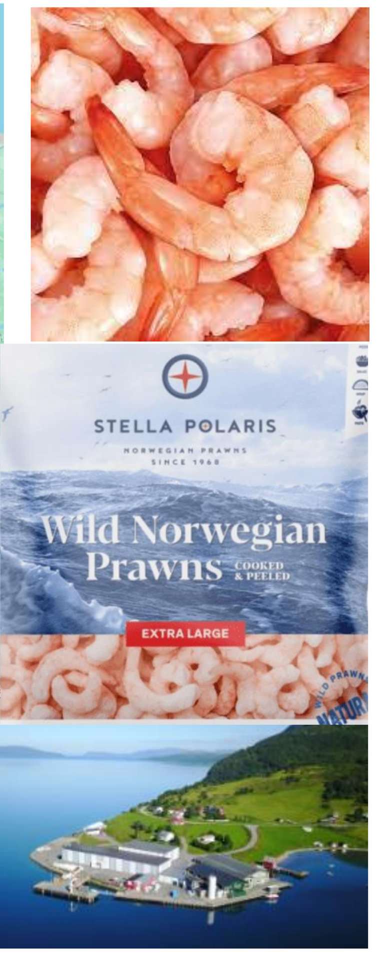
**Location:** Stella Polaris AS, Finnsnes Norway

**Type of production:** Food/beverage - cooked and peeled shrimps (annual production: 15,000 metric tons of shrimp)

**Technology involved:** cascaded high-temperature heat pump (ammonia and pentane cycle at the bottom and top, respectively) from Mayekawa Europe to overcome the 130 K temperature lift. The heat duty of the heat pump is 700 kWth.




### Process modifications:

- **Shrimp freezing plant:** heat currently rejected to sea. The heat of condensation of the freezing plant (single-stage ammonia system) is the heat source of the cascade heat pump.
- **Steam network for shrimp cooker:** currently steam is being produced by a propane boiler.

### Heat pump design and performance

- **Ammonia cycle:** Upgrading the heat from the freezing plant to an intermediate temperature of approx. 80°C. Components: piston compressor and flooded evaporator.
- **Pentane cycle:** upgrading from the intermediate temperature to steam conditions. Components: internal heat exchanger to superheat the suction gases to the screw compressor, and the condenser is a shell and plate heat exchanger where pentane is condensed on the plate side and steam is generated on the shell side.
- Expected **Coefficient of performance (COP)** of the heat pump is 1.8 and 2.5 for heating and combined heating/cooling, respectively. The expected primary energy consumption and CO2 savings with using an industrial heat pump instead of a Propane boiler is of 1043 MWhr/year and 621 ton/year, respectively.

| | Overall cascade heat pump | Bottom cycle (ammonia heat pump) | Top cycle (pentane heat pump ) |
|---|---|---|---|
| COP heating and cooling | 2.53 | 6.04 | 3.92 |
| COP heating | 1.78 | 3.52 | 2.48 |
| COP cooling | 0.75 | 2.52 | 1.45 |

## Status of the design and implementation

### Milestones

1. **Freezing plant modifications** have been finalized. Enabling the redirection and utilization of waste heat for the heat pump, previously dissipated to seawater.
2. **Basic engineering** completed: outlining the system's configuration, identifying/ordering key components, and determining the overall operational parameters.
3. **Detailed engineering** completed. Comprehensive examination of various components, system integration, operational details, risk assessment, definition of control narrative, among others.
4. Comprehensive **ATEX risk assessment** has been delivered considering the toxicity and flammability of both refrigerants, ensuring the safety of the end-product and personnel.
5. **Order placement** of major components of the industrial heat pump have been successfully concluded (i.e., heat exchangers, compressor, etc).
6. **Completion of detailed skid** (which houses and supports the various components of the heat pump system) has been finalized.
7. **Assembly** of the heat pump skids is currently taking place at Mayekawa's workshop.

### Moving forward:

- **Delivery** of the heat pump skids, comprising of both heat pumps, is planned for April 2024.
- **Integration** phase schedule for April to August 2024. Thereafter, the **Commissioning** of the integrated system will be performed. This critical stage involves fine-tuning to ensure optimal performance/functionality of the integrated system.
- **Experimental testing** of the industrial heat pump consists of: a short and long-term testing. (1) Short-term testing investigates part load operation and cycle parameter variations. (2) The target of the long-term testing is for the heat pump to run more than 2,000 hours/year.

## References

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SPIRIT

A project fostering the decarbonisation of industry through high-temperature heat pumps

Funded by the European Union



SPIRIT is a 42-month EU project aiming to enable industrial heat pumps to become the reference climate-neutral technology for covering heat demand for temperatures up to 160ºC by 2030.