R&D HTHP projects

The Netherlands

IEA Annex 58 – 14th Status Meeting

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High Temperature Heat Pumps projects

- **CATCH-IT**: Industrial pilot demonstration 120°C
- **STEPS**: On-site pilot testing 150°C
- **LowCapex**: On-site full-scale testing up to 2 MW
- **ENCORE**: Lab prototype for cycles and components testing
- **FUSE**: On-site full-scale testing up to 1 MW
- **SCHP**: On-site full-scale testing + Industrial demonstrations
- **KICKSTART**: Innovations in industrial applications for steam generation
- **SPIRIT**: On-site pilot testing of direct steam compression

**TNO Goals**
- 100 – 200°C
- COP > 50% Carnot
- 1, 2, 5 MW
- <5 yrs payback
**CATCH-IT project**

**Objective**

Development and integration of a compression heat pump system into the paper production process for steam generation. On site testing at a paper process site under actual process conditions to establish the reliability, operating range and performance.

- **Duration:** 2012 – 2015
- **Capacity:** 160 kW
- **Oper. cond.:** $T_{source} = 60 \, ^\circ C / T_{lift} < 90 \, K / P_{sink} 0.5 – 2.4$ barg steam
- **Refrigerant:** BUTANE
- **Other:** Cycle + Subcooler / COP: 1.9 – 3.6 (steam) / COP: 4.4 – 5.1 (steam + hot water)
STEPS project

Objective

Development of a two stage compression heat pump prototype for steam generation using natural refrigerants. Optimization of the CAPEX/OPEX to attain max. 5 years payback period.

- Duration: 2015 – 2019
- Capacity: 150 kWth
- Oper. cond.: $T_{source} < 100^\circ C / T_{sink} 150 ^\circ C$ (steam) / $T_{lift} < 90$ K
- Refrigerant: PENTANE, DR2
- Other: Cascade cycle / Steam generation / COP: 2.5 - 3
LowCapex project

Objective

Development of a low CAPEX HTHP for waste heat recovery in industrial applications. Testing and characterisation in laboratory conditions. Identification of non-technical barriers and deliver a commercially viable product (improved CAPEX).

- Duration: 2017 – 2021
- Capacity: 1.5 MWth
- Oper. cond.: $T_{\text{source}} < 90 \, ^\circ\text{C} / T_{\text{sink}} < 120 \, ^\circ\text{C}$
- Refrigerant: HCFO
- Other: Steam generation / Carnot lab test
ENCORE project

Objective

To reach output temperatures of 180 °C and to increase the temperature lift (80 K) of compression heat pumps. Optimization of energy efficiency, performance, flexibility & dynamics.

- Duration: 2019 – 2023 (Ongoing)
- Capacity: 100 kWth
- Oper. cond.: $T_{\text{source}} < 90$ °C / $T_{\text{sink}} 180$ °C
- Refrigerant: NATURAL
- Other: Flexible cycles / Steam generation / Cutomization
**FUSE project**

**Objective**

To develop and test a full-scale HTHP in the range of 1-2 MW capacity using a natural refrigerant. To produce steam at 2 – 5 bar-a using waste heat and the cost target must be <€200/kW.

- **Duration:** 2019 – 2023 (Ongoing)
- **Capacity:** 1 MW<sub>th</sub>
- **Oper. cond.:** T<sub>source</sub> 60-90 °C / T<sub>sink</sub> 120-150 °C
- **Refrigerant:** PENTANE
- **Other:** Closed cycle / IHX / Screw compressor
SCHP project

Objective

Development of a Steam Compression Heat Pump prototype for lab testing/characterisation. Steam generation from vacuum conditions. Identification of technical barriers for scale up to 2 MW\text{th}.

- Duration: 2021 – 2023 (Ongoing)
- Capacity: \(\sim 250\) kW\text{th}
- Oper. cond.: \(T_{\text{source}} < 80\) °C / \(T_{\text{sink}} 150\) °C (5 bar-a steam)
- Refrigerant: Water/Steam
- Other: Semi-open cycle / MVR / Steam generation
KICKSTART project

Objective

Development of HTHPs solutions for industrial heat demand to integrate in brown-field and green-field applications. Identification of non-technical barriers and deliver a commercially viable product (improved CAPEX).

- Duration: 2022 – 2025
- HTHPs: 5 industrial applications
- Oper. cond.: $T_{source} 40-90 \, ^\circ C / T_{sink} 120-200 \, ^\circ C$
- Refrigerant: HFO & Natural
- Other: Advanced cycles / Steam generation / Geothermal
SPIRIT project

Objective

Delivery of full scale demonstrations of HTHP applications in the food and paper industry. Optimization of integration methods. Improvement of CAPEX/OPEX via modularization, standardization and engineering.

- Duration: 2021 – 2025
- Capacity: ~ 1 MWth
- Oper. cond.: \(T_{\text{source}} < 100 \, ^\circ\text{C} / T_{\text{sink}} 135-160 \, ^\circ\text{C}\)
- Refrigerant: NATURAL
- Other: 3 Demo / Advanced cycles / Steam generation
Thermoacoustic Heat Pump developments

AP2013
Piston compressor
Resonator
Oil 110°C
10 kW

HPSEPS
Linear motor
Resonator
Oil 110°C
0.25-10 kW

CRUISE
Industrial piston
Compact
Cost savings study
10 kW

TASTE
Piston compressor
Resonator
Steam 180°C
10 kW

COMTA
Industrial piston
Compact
Steam 110-180°C
10 kW

Scale-up studies
- Full scale design
- Cost reduction studies
- Modular design

- Standardisation
- Business case
- Integration

TNO Spin off

BlueHeart
The design of BlueHeart, our first market product, is completed and the first prototype unit is being built. This unit will be optimized in 2023 and the 0-series of BlueHeart will be available in 2024. Its capacity will be 6 kW.

www.blueheartenergy.com/
TASTE project

Objective

The overall TASTE project objective is to develop and implement an electrically driven thermoacoustic heat pump technology that is able to generate steam in the temperature interval 150-200 °C using waste heat of 80-120 °C. The detailed objectives are:

- Duration: 2015 – 2018
- Capacity: 3 kWth
- Oper. cond.: \( T_{\text{ift}} \) 100 K / \( T_{\text{sink}} \) 110-180 °C
- Fluid: Helium
- Other: Zero GWP / Steam generation
COMTA project

Objective

Design and development of a lab-scale compact electrically driven Thermoacoustic Heat Pump (TAHP) for steam generation. Identification of technical specs for a full-scale modular TAHP.

- Duration: 2019 – 2022
- Capacity: 10 kWth
- Oper. cond.: $T_{\text{ift}}$ 100 K / $T_{\text{sink}}$ 110-180 °C
- Fluid: Helium
- Other: Zero GWP / Steam generation
CARNOT LAB
TNO, Petten, NL

Laboratory for testing and characterization of Industrial Heat Pump systems

• Capability to test multiple setups up to 2 MWth
• Steam and hot water generation
• Open, semi-open & closed cycles
• Operating temperatures up to 200 °C
• Steam pressures up to 20 bar-g
THANK YOU

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