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Main Characteristics of the Ocean Thermal Energy Conversion Onshore Prototype in La Réunion

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► **To cite this version:**

Alexandre Dijoux, Frantz Sinama, Olivier Marc Marc, Bertrand Clauzade, Jean Castaing-Lasvignottes. Main Characteristics of the Ocean Thermal Energy Conversion Onshore Prototype in La Réunion. OTEC Symposium 2017, Sep 2017, Saint-Pierre, Réunion. 2017. <hal-02999789>

HAL Id: hal-02999789

<https://hal.science/hal-02999789v1>

Submitted on 11 Nov 2020

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Main Characteristics of the Ocean Thermal Energy Conversion Onshore Prototype in La Réunion

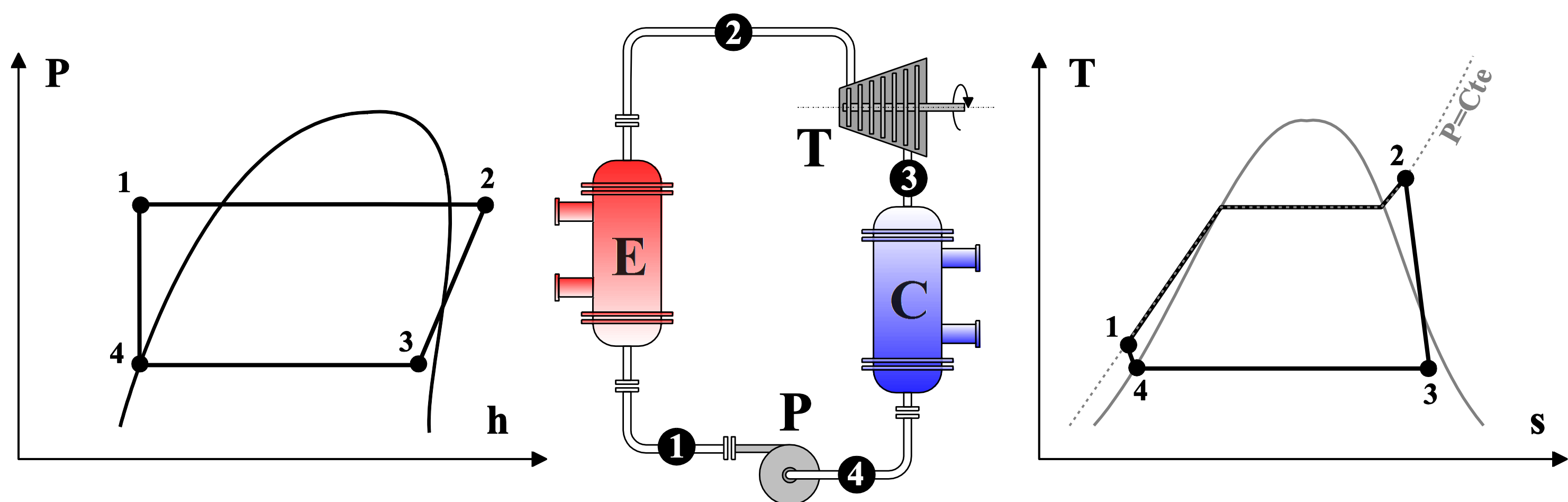
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Introduction

Closed Cycle OTEC (Ocean Thermal Energy Conversion)

Resources : { Warm Seawater (25 - 28 °C)
Cold Seawater (5 °C at 1000 m deep) } ⇒ Electricity production with an ORC (Organic Rankine Cycle)

1 → 2: A working fluid in subcooled liquid state enters the evaporator where it will be heated and then evaporated using the warm source
2 → 3: The high pressure gas thus obtained is expanded in a turbine, providing a mechanical work convertible into electricity
3 → 4: The low pressure steam then enters the condenser to return to the liquid state thanks to the cold source
4 → 1: The liquid leaving the condenser is returned to the initial state by a pump



OTEC Onshore Prototype (named PAT ETM)

- Experimental installation in Reunion Island, co-funded by Naval Energies and Région Réunion.
- Located in the site of the IUT of Reunion Island



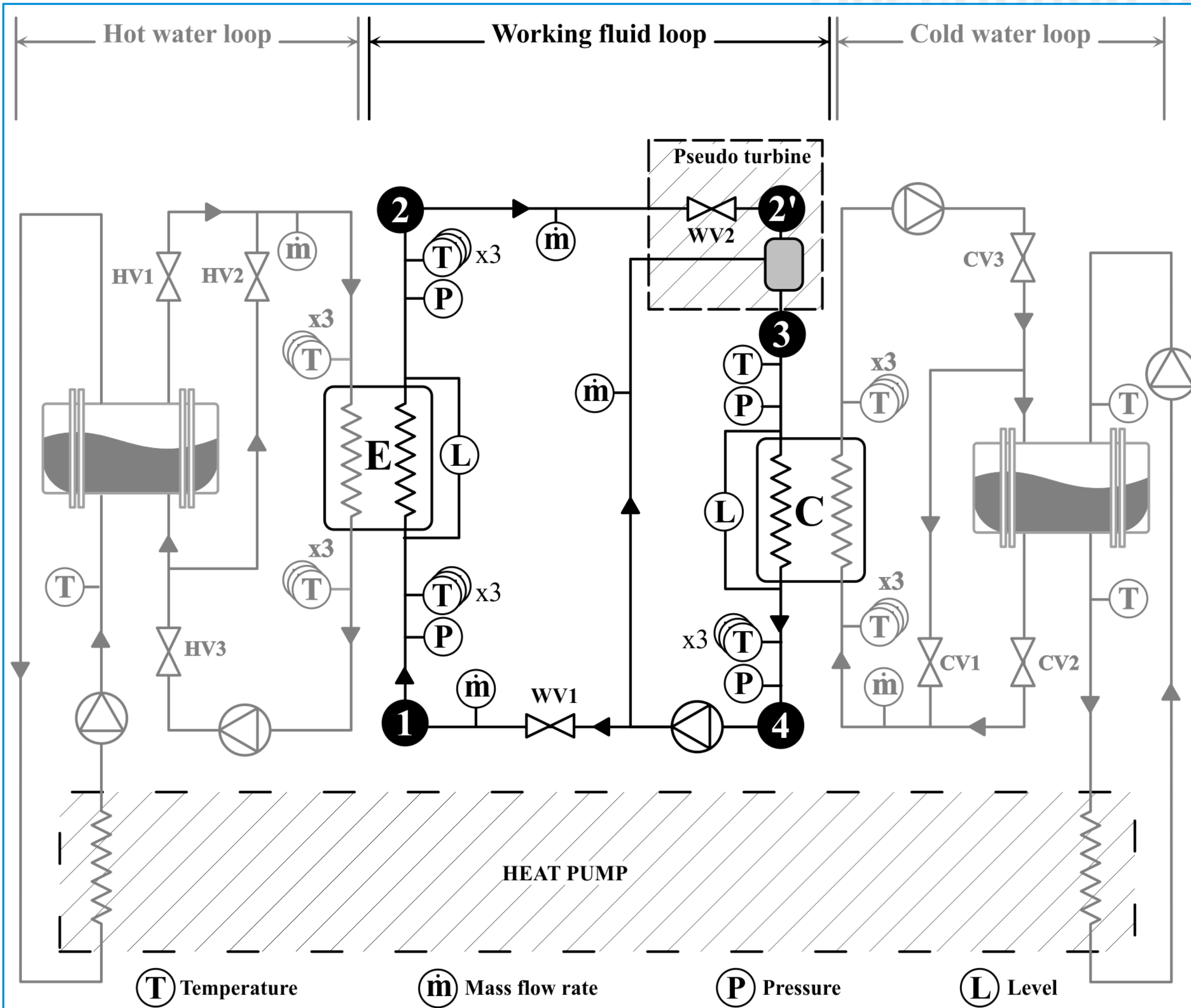
Installation in 2012.

Objectives:

- Test of different heat exchangers technologies
- Reduced but representative scale (1/125) of a real system



Description of the Prototype



Heat sources:

- Use of a Heat Pump: power of 500 kW (sub-system ZA)
- Hot Water Loop: from 23 to 37 °C (sub-system ZB)
- Cold Water Loop: from 3 to 9 °C (sub-system ZC)

⇒ Optimal pilotability of test conditions

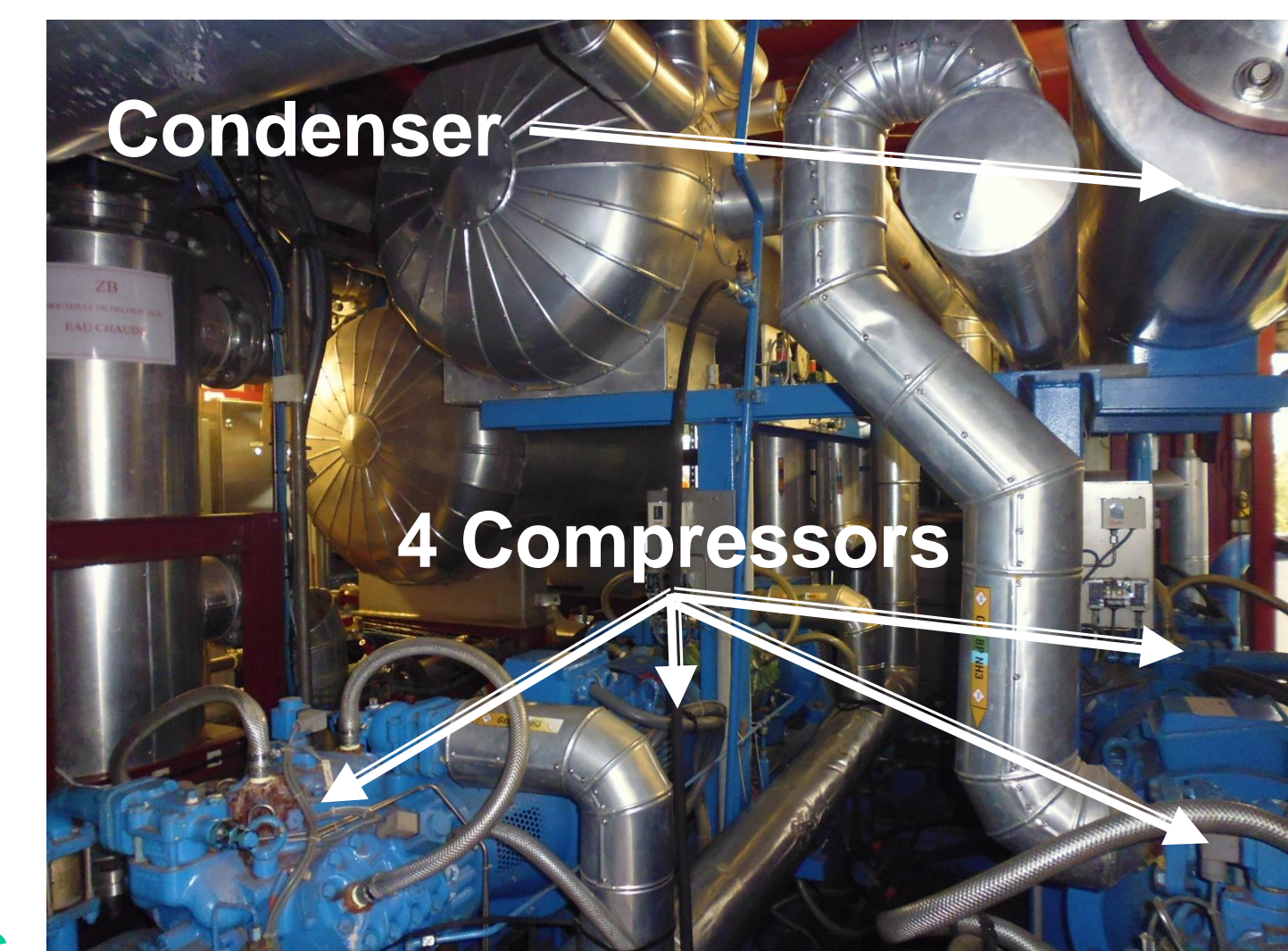
Working fluid:

- Ammonia
 - Total mass in the installation: 680 kg (included the heat pump)
 - Security: fluid B2L (toxic and slightly flammable)

⇒ Closed shoes, long sleeves clothes and helmet are mandatory.

⇒ Contact lenses prohibited.

- Environmental Monitoring



The security shower in case of contact with ammonia

Measurements

Many sensors are installed for test considerations but for security and environmental issues as well

Sensor	Description	Number	Type	Accuracy
T	Temperature	60	Three wires PT-100	0,02° C / 0.15 ° C
P	Pressure	17	0 – 16 bar	1 mbar / 32 mbar
ṁ	Mass Flow Rate	9	Coriolis	0,5%
L	Level	5	Bypass level indicator with Level transmitter	0,2 mm

Key figures

Temperature: $T_F=5^\circ\text{C}$ / $T_C=23-37^\circ\text{C}$
Equivalent power production: 15 kW
Mass NH_3 : 680 kg
Power of the Heat Pump: 500 kW

ORC: (sub-system ZP)

- Expansion process:
 - Simulated by an expansion valve followed by a desuperheater, constituting the pseudo-turbine
 - 15 kW of equivalent power production
- Heat exchangers:
 - 6 types of heat exchangers technology tested:
 - EVAP1:** Horizontal Smooth shell-and-tube
 - EVAP1bis:** Horizontal Enhanced shell-and-tube
 - EVAP2:** Horizontal shell-and-tubes falling film
 - EVAP3:** Vertical plate
 - EVAP6:** Vertical Smooth Shell-and-tube
 - COND1:** Horizontal Smooth Shell-and-tube



Flooded shell-and-tube evaporator



Smooth shell-and-tube Condenser