Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

SolairHP Project: First results of summer campaign

Online, November 11th, 2021

L. Gugliermetti, *M. Pieve*, L. Saraceno, R. Trinchieri

IT Workshop for IEA-HPT ExCo Meeting

ENEA-IPSE Lab

ENEA is the Italian National Agency for New Technologies, Energy and Sustainable Economic Development

The **IPSE** laboratory works on the **Process Engineering and Systems for Energy Decarbonization**

The lab is part of the ENEA's Energy Technologies and **Renewable Energy Sources Deparment** and it is inside the **Energy Production, Storage and Use Division**.

It is located inside the Research centre of *"La Casaccia"* in Rome

SOLAIR-HP

Call: Decr. 30/06/2014 ex art. 10, c 2, lett. b) D.I. 26/01/2000 per RdS 2012-2014

Funding: 1.4 M€ (cofunded)

Period: 04/2018 – 03/2022

Partners:

enex
Innovation as energy

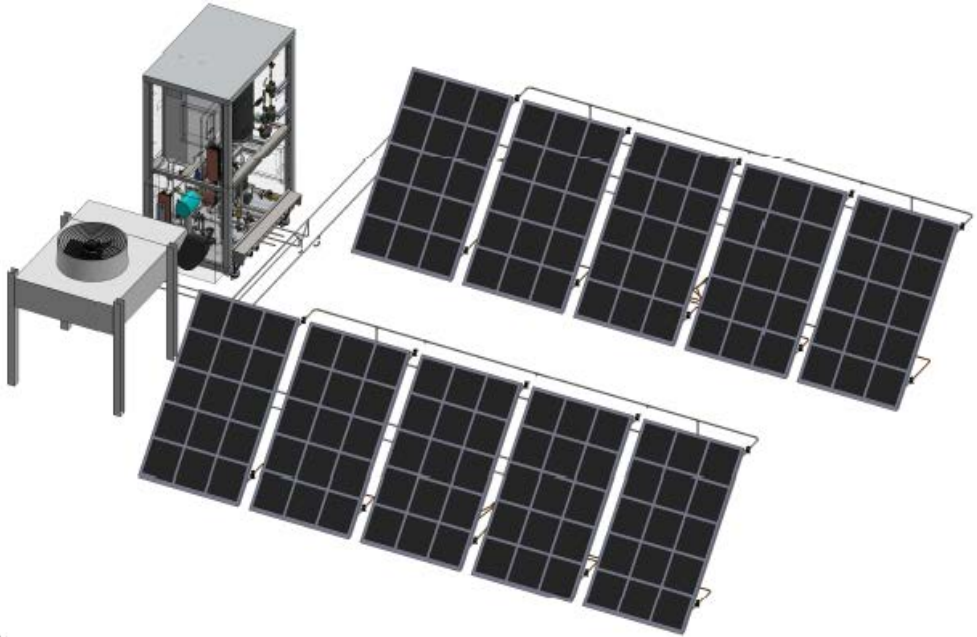
ENEA
Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

Università degli Studi di Padova
Dipartimento di Ingegneria Industriale

SOLAIR-HP: objectives

The project is aimed at developing and testing an innovative transcritical CO2 heat pump. The main features are:

- Air-solar dual source CO2 HP for air-conditioning of buildings and DHW production.
- Photovoltaic Hybrid Solar Panels (PVT) used as thermal exchanger directly connected to refrigerant.
- Six operative modes (cold, heat, DHW and mixed)
- 7÷10 kW of thermal power
- GWP = 1

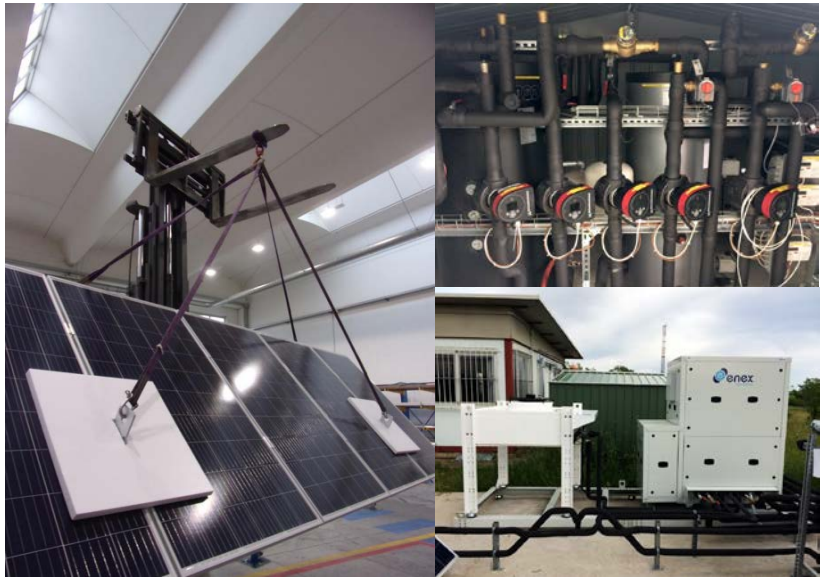


SOLAIR-HP: Placement

Placement:

ENEA Casaccia - Roma

The Heat Pump is located at the Research Centre of «La Casaccia» in Rome.
The system is installed in an open environment to simulate the real operative conditions.



Auxiliaries:

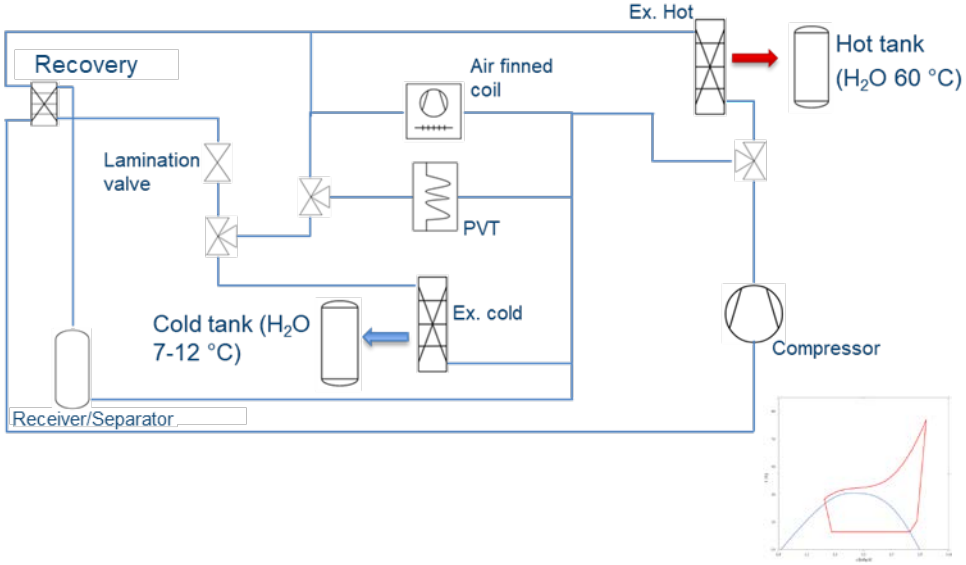
The heat pump is supported by auxiliaries system able to:

- Dispose up to 7/10 kW of thermal power (cold/hot),
- Cold and Hot tanks (300 and 500 l),
- Fine control of mass flow rate by means of bypasses and pumps inverters.

SOLAIR-HP: Schematics

The schematic of the SOLAIR-HP is visible in figure. By using the three-way valves it is possible to switch the operative mode of the heat pump. The system is composed by several components:

- Heat Recovery Exchanger: to increase the superheating of the fluid before the compressor
- Lamination valve: to control the upper system pressures
- PVT exchanger: to improve system efficiency using the sun irradiation
- Air finned coil: alternative to PVT exchanger
- Cold and hot storage tank: for thermal storage purposes
- Inverter controlled compressor: to control the system power and efficiency



SOLAIR-HP: Operations

The heat pump can be operated in 6 different modes depending on what it is wanted to produce.

#1-2 «Winter» Heating with DHW → H_2O at T_{max} 60 °C

#3-4 «Winter with PVT» Heating with DHW → H_2O at T_{max} 60 °C using the PVT

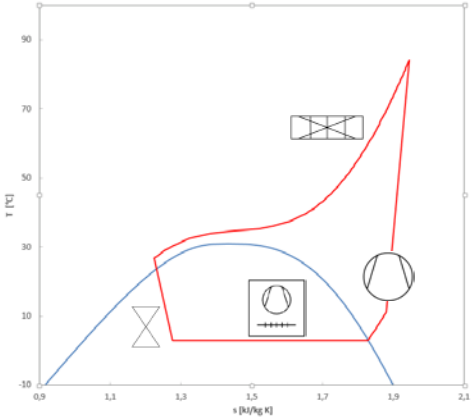
#5 «Summer» Cooling with water at 12-7 °C

#6 «Heating and Cooling» Cold and Hot water T_{max} 60 °C and T_{min} 7 °C

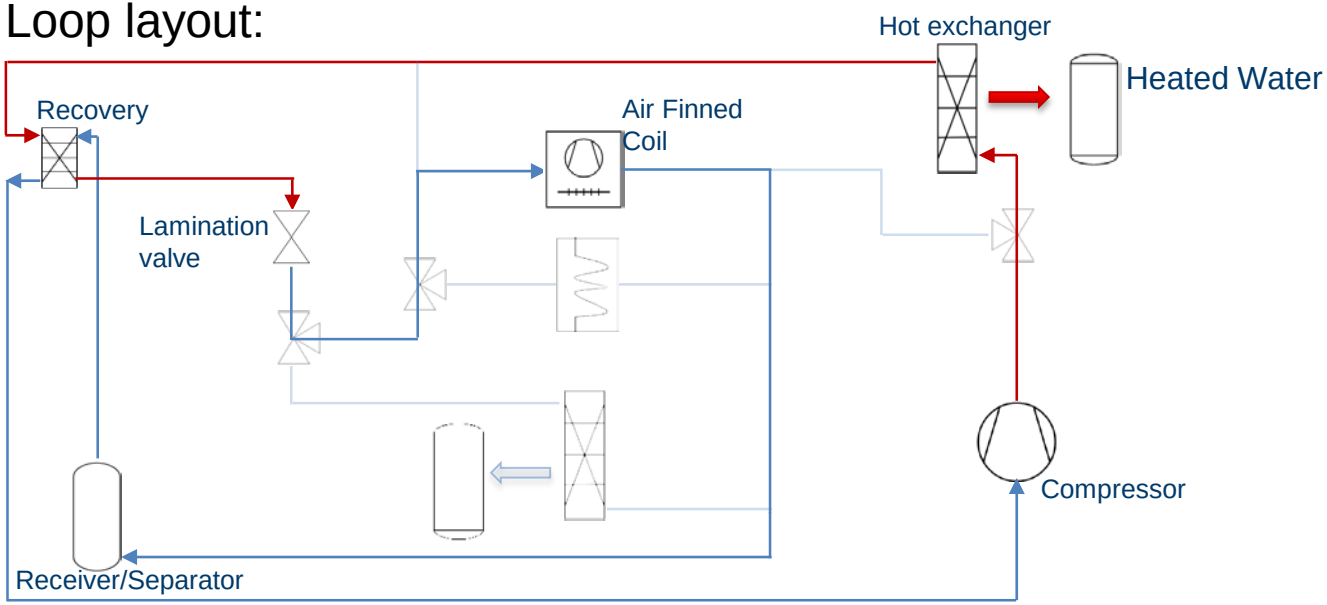
Modes #1-2: «Winter»

#1-2: «Winter» Heating with DHW → H_2O at T_{max} 60 °C

Cycle:



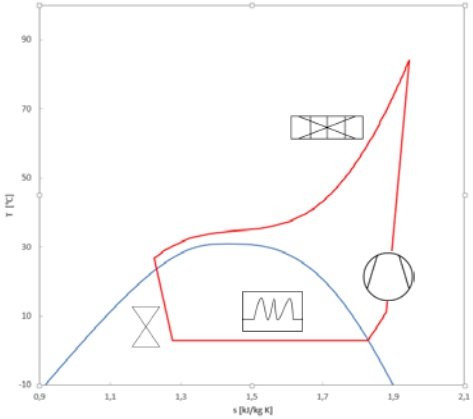
Loop layout:



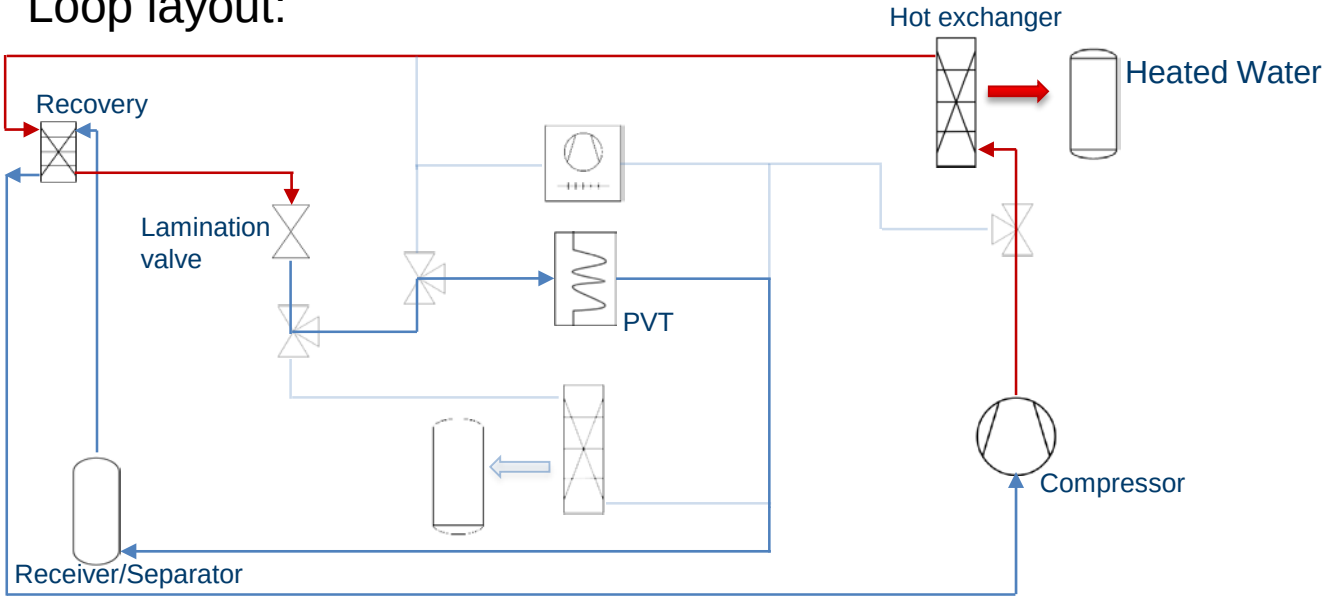
Modes #3-4 «Winter with PVT»

«Winter with PVT» Heating with DHW → H_2O at T_{max} 60 °C using the PVT

Cycle:



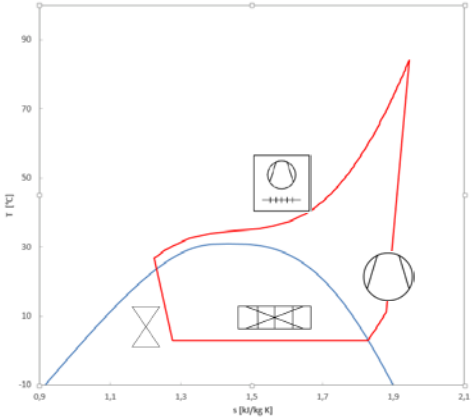
Loop layout:



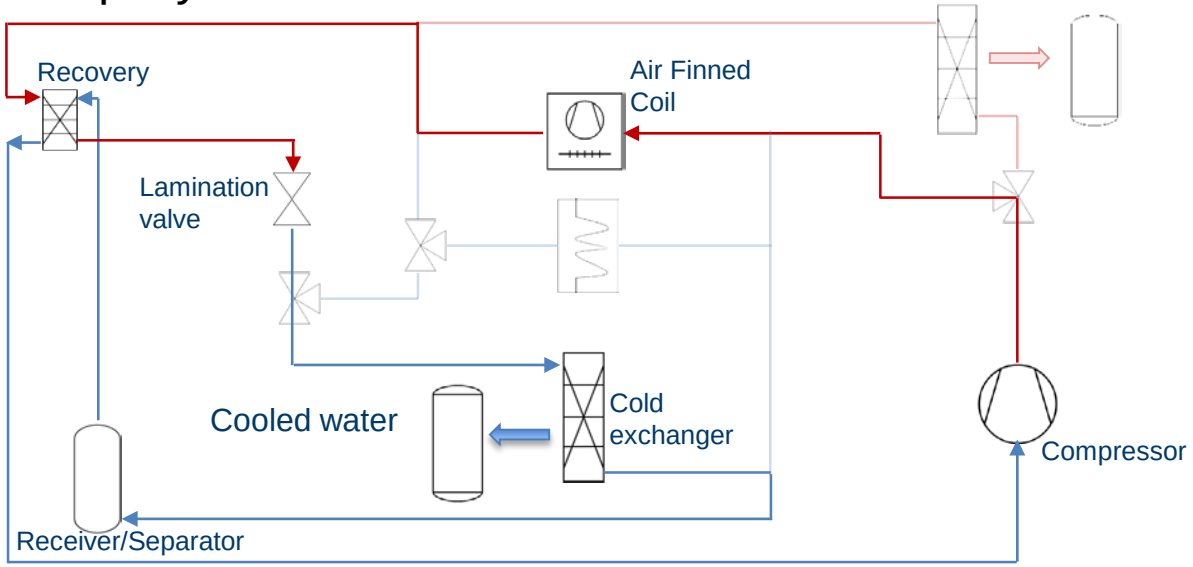
Mode #5 «Summer»

#5 «Summer» Cooling with water at 12-7 °C

Cycle:



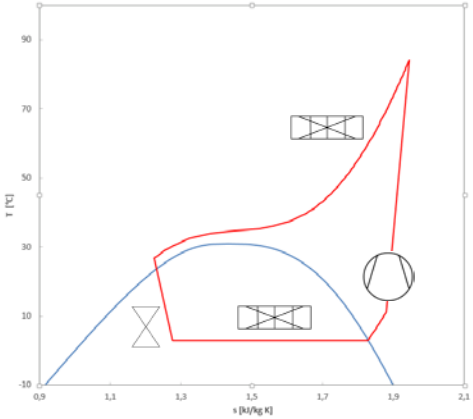
Loop layout:



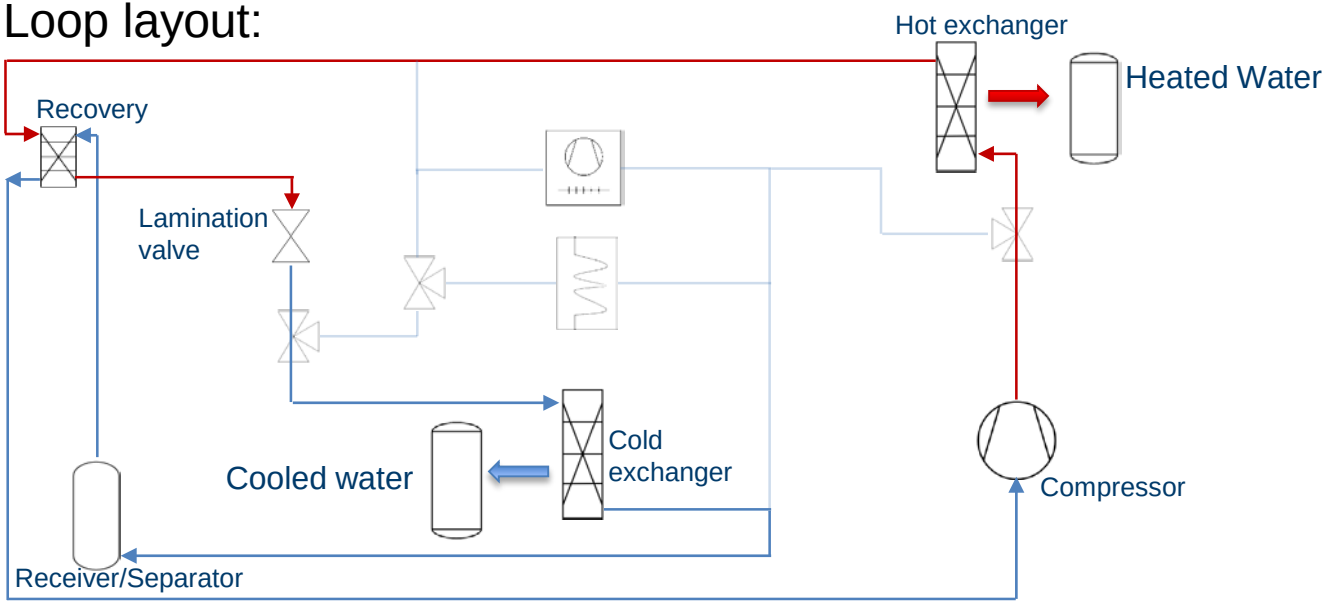
Mode #6 «Heating and Cooling»

#6 «Heating and Cooling» Cold and Hot water Tmax 60 °C and Tmin 7 °C

Cycle:



Loop layout:

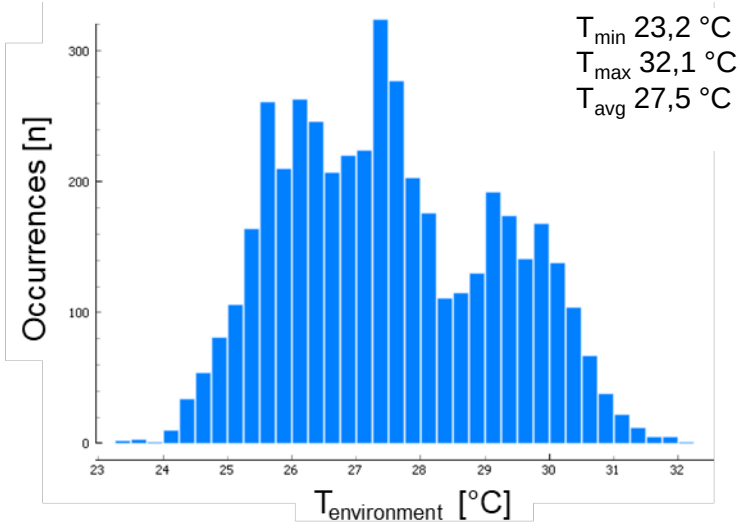


Results: #5 mode

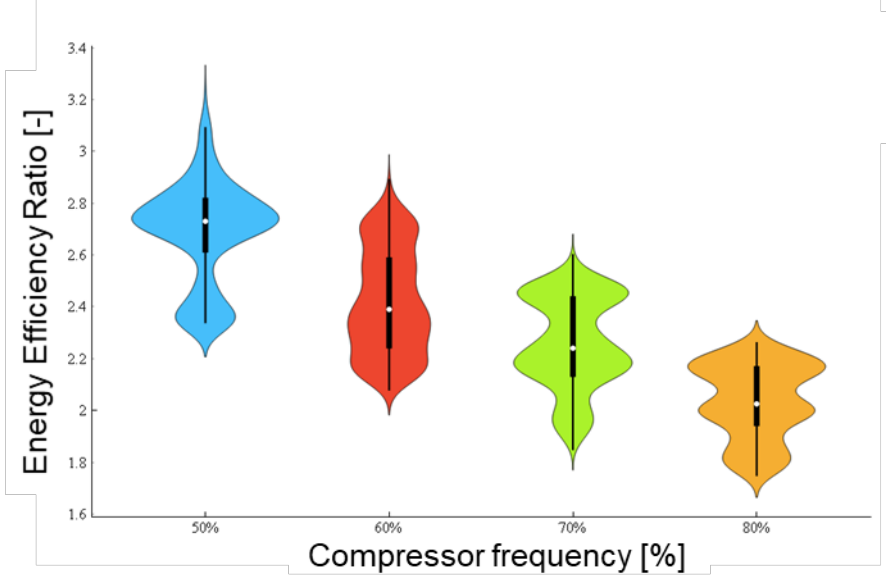
Period: 24/08/2021 – 01/10/2021

Mode: #5 «Summer»

Environmental temperatures



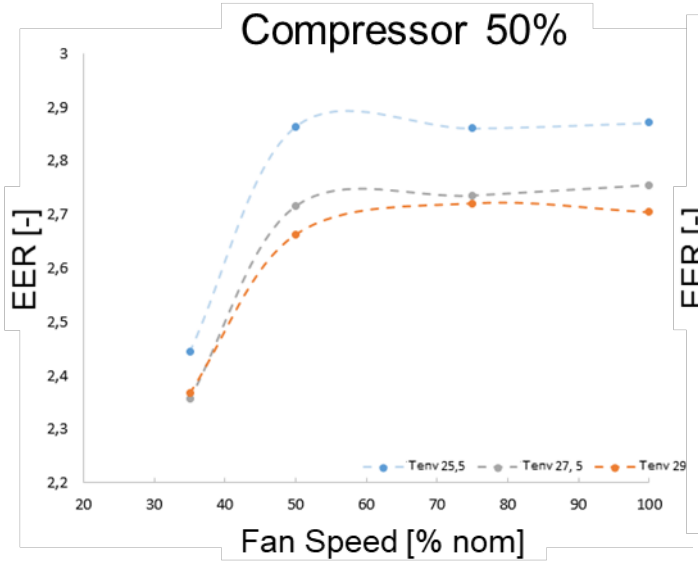
Compressor frequency effect

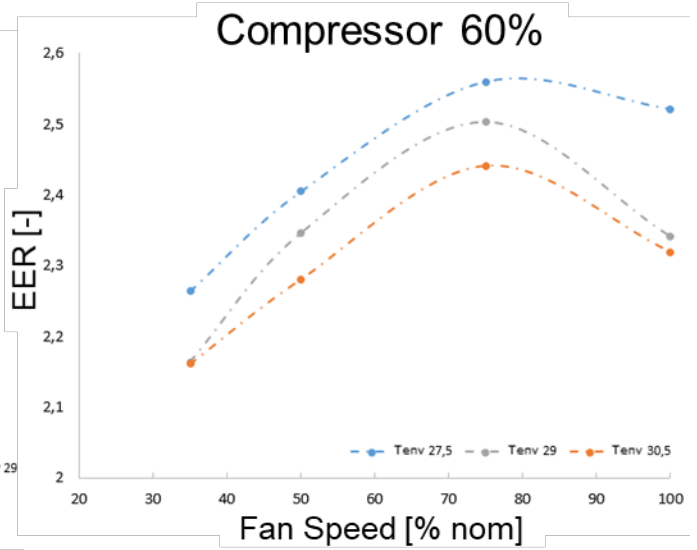


Results: #5 mode

Energy Efficiency Ratio Vs compressor frequency and fan speed

- The EER depends on fan speed and compressor frequency.
- There are no improvements to increase fan speed after a specific point (depending on the compressor frequency)
- Environmental temperature affects negatively the efficiency



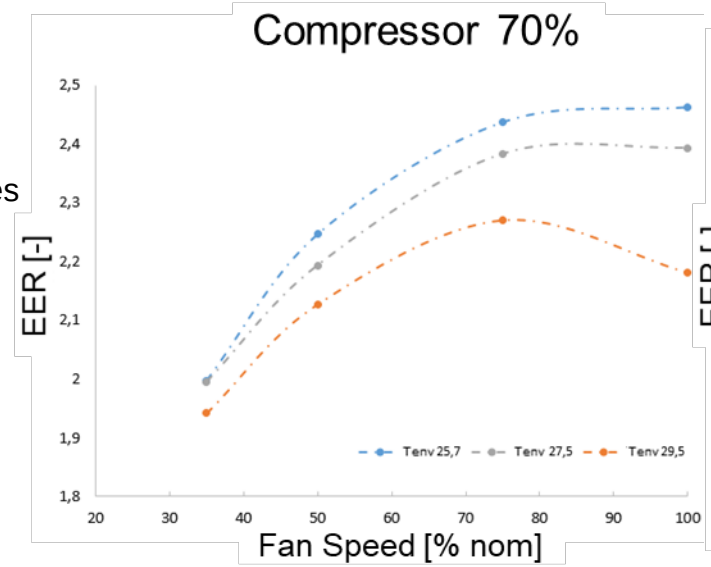


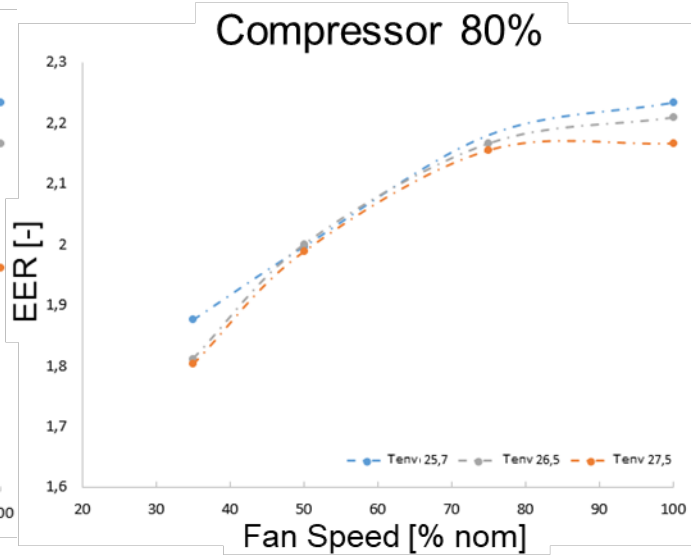
Going under 50% of compressor can damage the heat pump

Results: #5 mode

Energy Efficiency Ratio Vs compressor frequency and fan speed

- At higher compressor frequencies the EER lowers
- The optimal fan speed increases with the compressor frequency
- Environmental temperature affects negatively the efficiency
- The effect of environmental temperature lowers at high compressor frequency



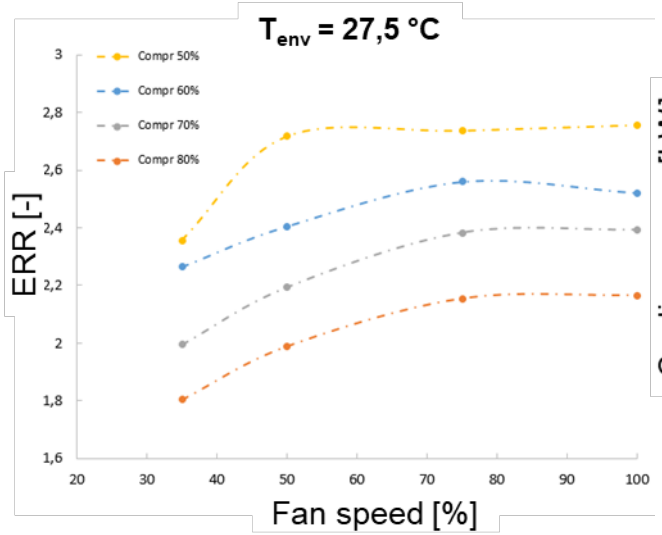


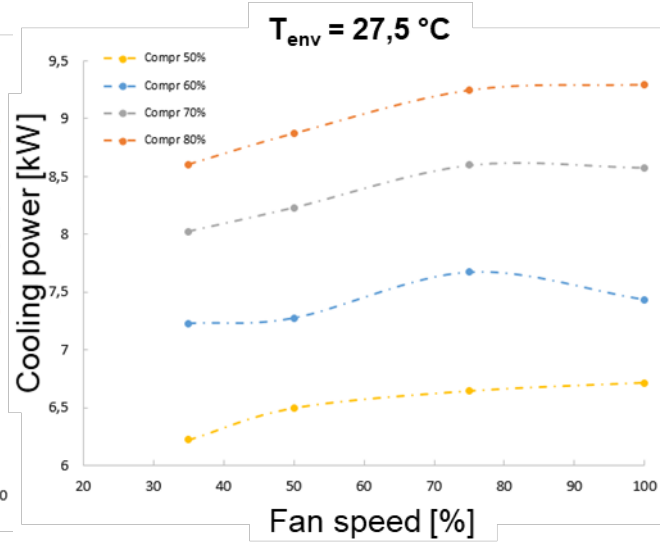
Going over 80% of compressor was not necessary due to the target cooling power of 10 kW

Results: #5 mode

Total cooling capacity and the ERR at different compressor speeds and fan speed

- Data showed at the same environmental temperature
- At higher compressor frequency the EER lowers
- Cooling power rises with the compressor speed with a good regulation
- The ERR reaches its maximum at 80% of fan speed, the air finned coil is oversized
- The cooling power reaches its maximum at 80% of fan speed, the air finned coil is oversized

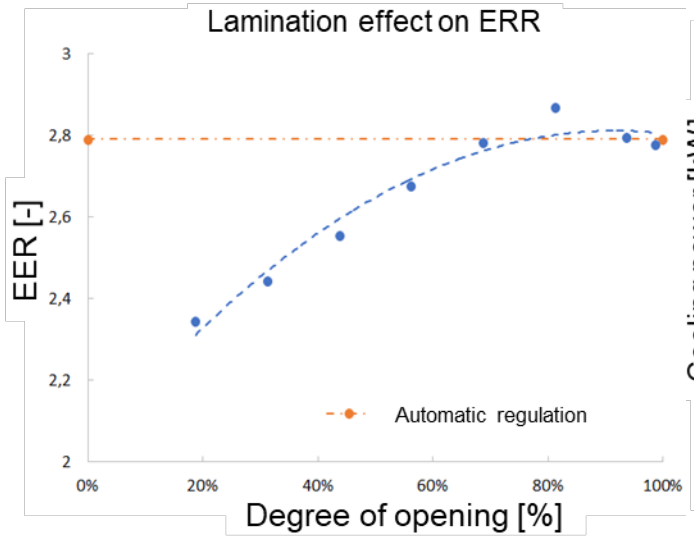


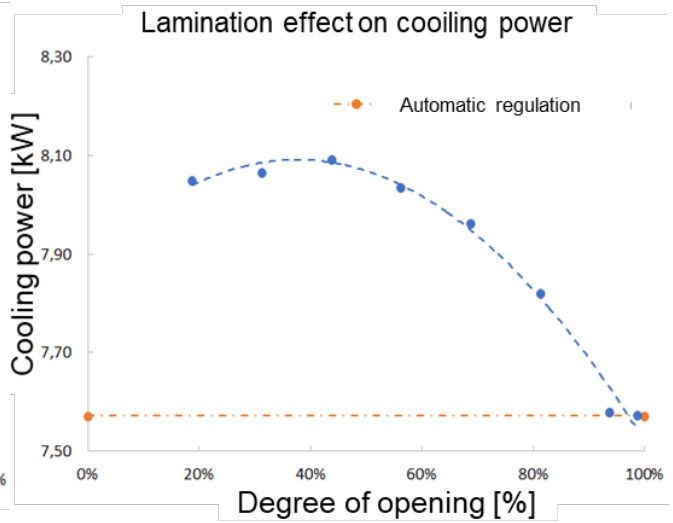


Results: #5 mode

Automatic and manual lamination valve control comparison

- The lamination valve can act manually or automatically in cooling mode
- The percentage represents how much the valve is open
- The automatic control works quite well
- With manual control a higher power is possible but with a lower EER
- Closing too much the valve can lead to overtemperatures





Data showed at 60% of compressor frequency and 70% of fan speed

Conclusions

Innovative sun-assisted CO2 transcritical heat pump

- **Eco-friendly refrigerant (GWP = 1)**
- **Max renewable share exploitation**
- **Integration with solar panels**

Test on summer mode (conditioning)

EER and its relation with compressor frequency, fan speeds and lamination degrees

DHW and cooling water tests ongoing (mode #6)

Winter test will be made during upcoming winter (innovative PVT usage)

Contacts:
raniero.trinchieri@enea.it
maurizio.pieve@enea.it
luca.saraceno@enea.it

IT Workshop for IEA-HPT ExCo Meeting