COMPARATIVE OF AN EXPERIMENTAL TRANSCRITICAL CARBON DIOXIDE REFRIGERATION CYCLE WORKING WITH A THERMOELECTRIC SUBCOOLER AND AN INTERNAL HEAT EXCHANGER.

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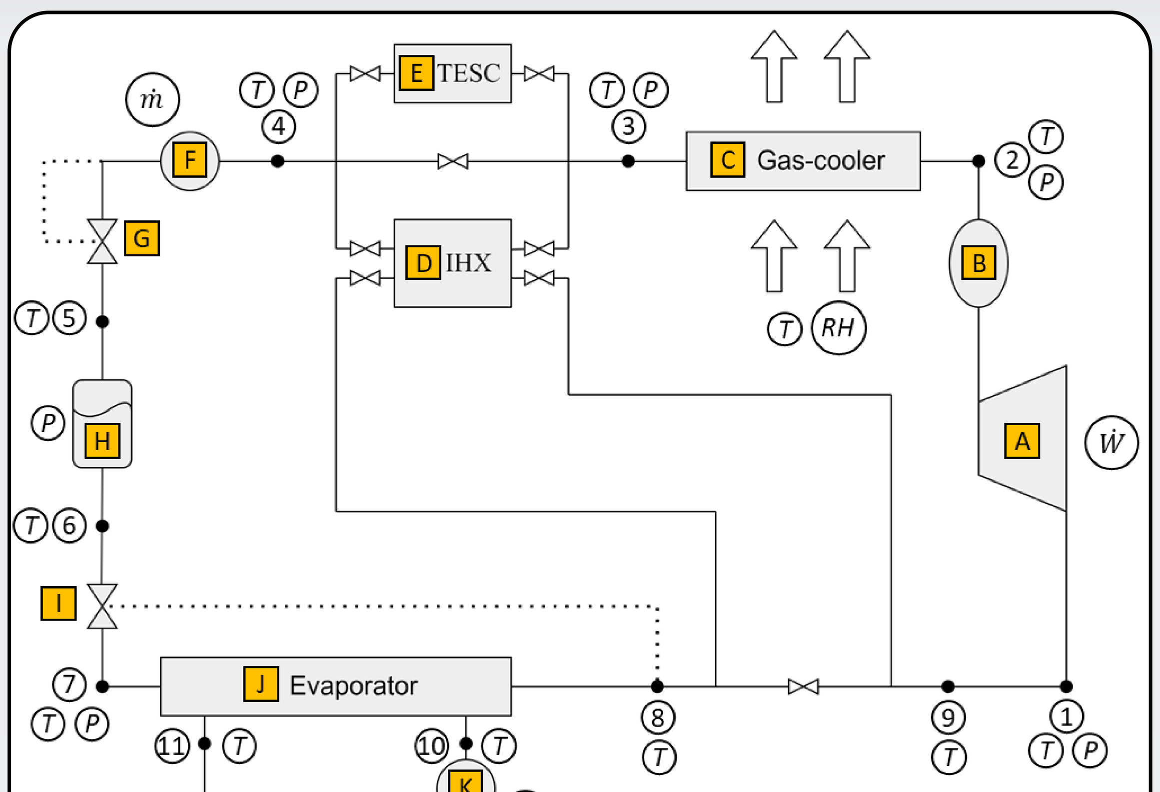
INTRODUCTION

The **Physical Science Basis Report** from the **Intergovernmental Panel on Climate Change** on 2021 was described as a **"Code Red for Humanity" by the United Nations Secretary**. The report describes thoroughly how climate change and extreme events can be attributed to the build-up of anthropogenic **greenhouse gas emissions** in the atmosphere. **The refrigeration sector** plays an important role in confronting climate change, being responsible for **7.8 % of the global emissions** and consuming **20 % of the electricity worldwide**. In addition, energy consumption of the sector is expected to **double or triple by 2050**, which remarks the paramount importance of **developing efficient and environmentally friendly refrigeration systems**.

This work focuses on **reducing the environmental impact of the refrigeration sector** by the development of a **Thermoelectric Subcooling System (TESC)** that is able to **boost the performance** of environmentally friendly vapour compression cycles that use **natural refrigerants** such as CO_2 or NH_3. The main objective of the thermoelectric system is to **efficiently subcool the refrigerant** at the outlet of the gas-cooler/condenser in order to **increase the cooling capacity** of the refrigeration system and **compensate the extra consumption** of the system, so that the **performance of the refrigeration system is enhanced**.

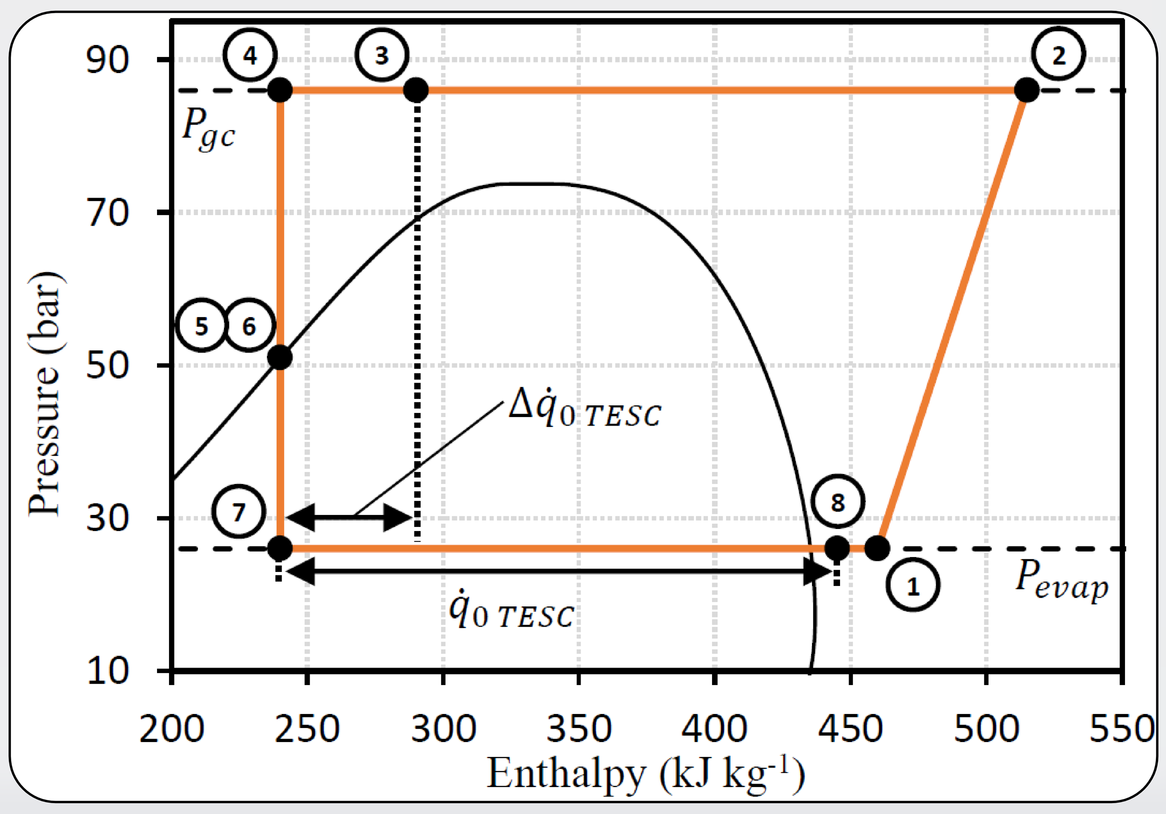
EXPERIMENTAL SYSTEM

Transcritical CO_2 vapour compression cycle

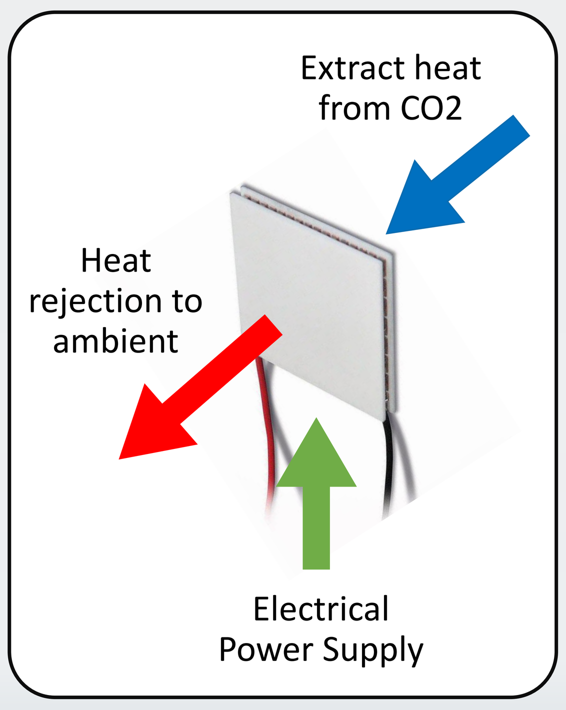


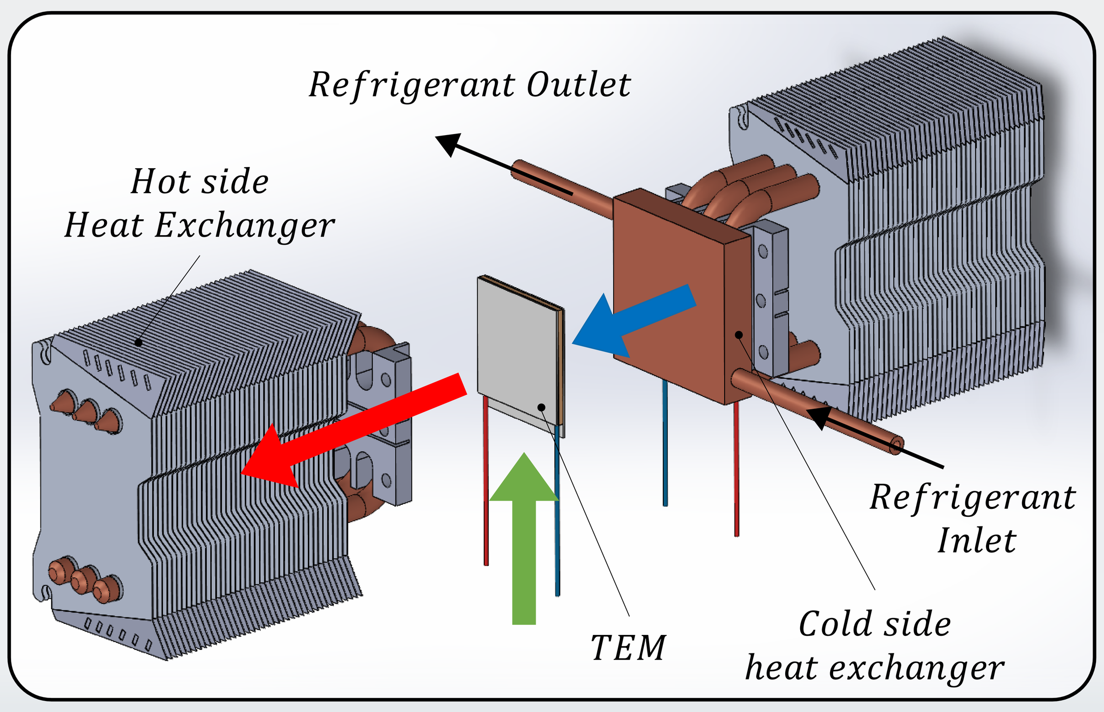
Schematic of the system

Pressure – Enthalpy diagram of the cycle

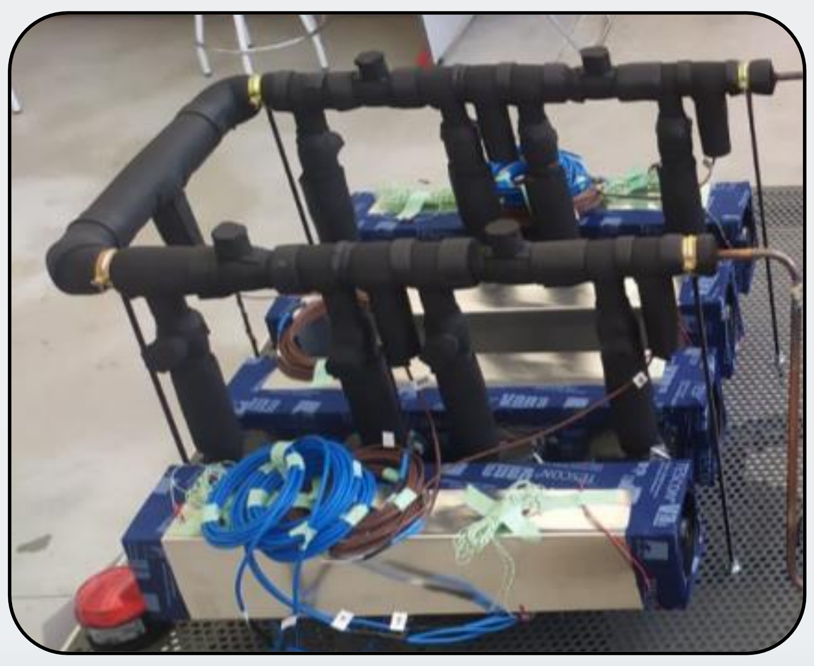


THERMOELECTRIC SUBCOOLER (TESC)





TESC Prototype



TEST CONDITIONS

Configurations:

- Base cycle
- IHX (Internal Heat Exchanger)
- TESC (Thermoelectric Subcooler)
- TESC + IHX

Ambient Temperature:

- 25, 30 and 35 °C

Gas-Cooler Pressures:

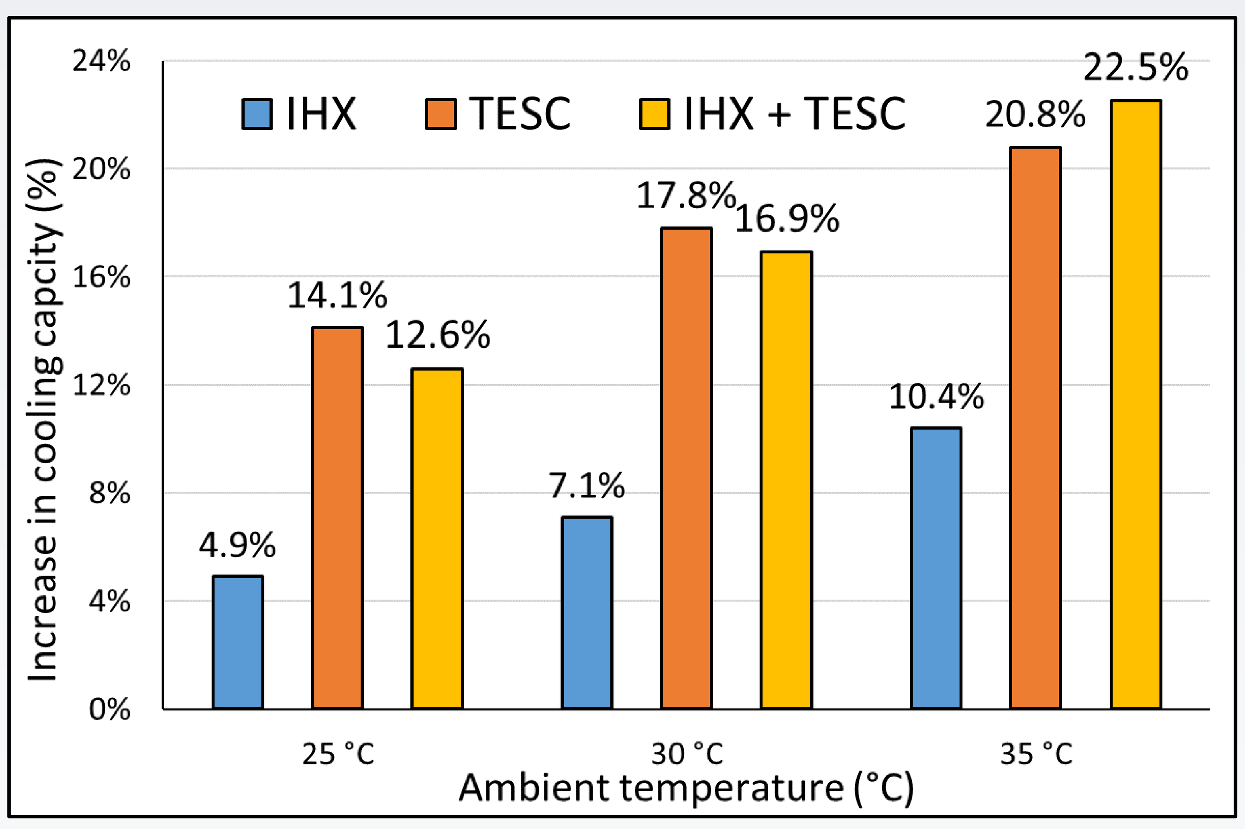
- 70 – 94 bar

Voltage TESC:

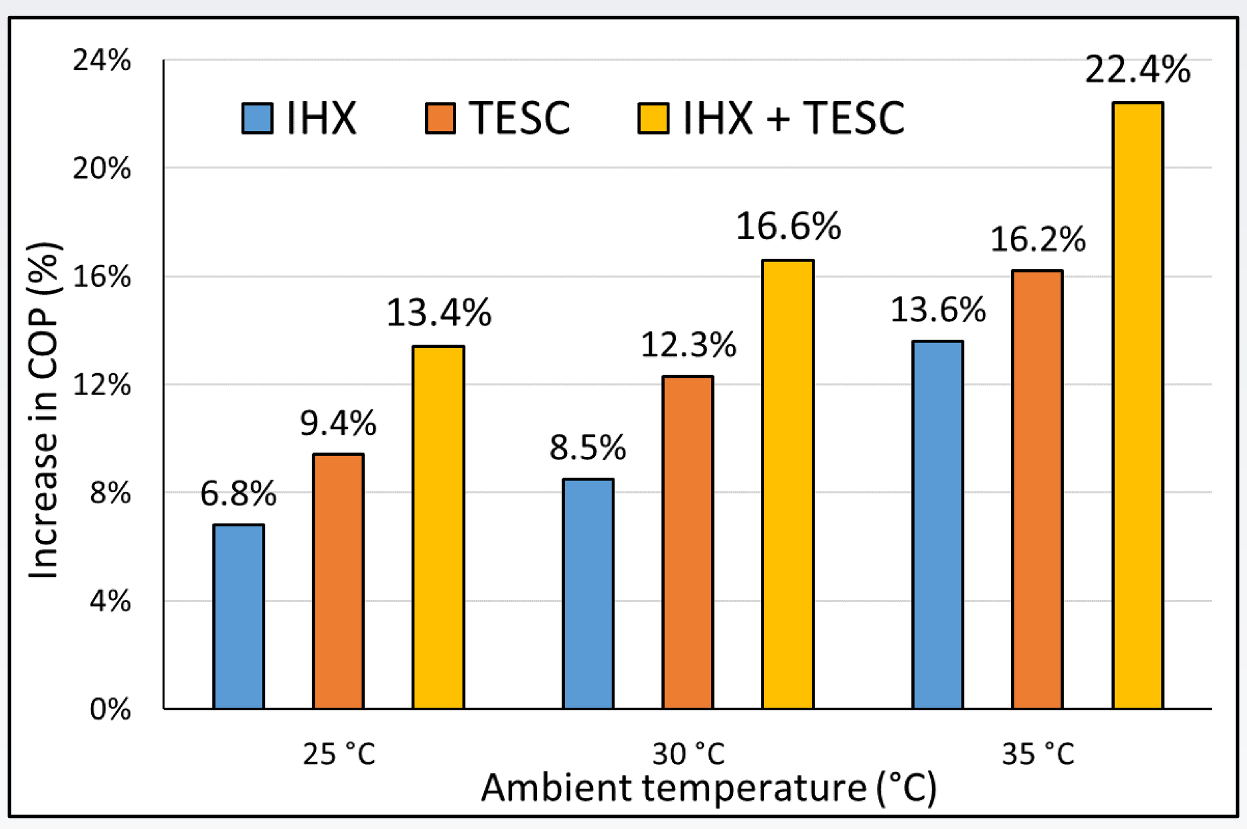
- 0.5 – 4 V

RESULTS

The **Cooling Capacity ($\dot{Q}_{evap}$)** and **Coefficient of Performance (COP)** are compared with the **Base Cycle** for each configuration **(IHX, TESC and TESC + IHX).**



Increase in the Cooling Capacity ($\dot{Q}_{evap}$)



Increase in the Coefficient of Performance (COP)

$$COP = \frac{\dot{Q}_{evap}}{\dot{W}_{tot}} = \frac{\dot{Q}_{evap}}{\dot{W}_{comp} + \dot{W}_{TEMs}}$$

More results and information available by scanning the following QR codes:

SCAN ME

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CONCLUSIONS

- ✓ The performance of a transcritical CO_2 vapour compression refrigeration cycle working with a **TESC**, **IHX** and **TESC + IHX** has been **experimentally analysed.**
- ✓ Results show that the cycle with the **TESC outperforms the cycle with the IHX** in both Cooling Capacity ($\dot{Q}_{evap}$) and Coefficient Of Performance (COP). Moreover, the combination of **TESC + IHX** results in even **greater performance**, enhancing the **Cooling Capacity** up to **22.5 %** and the **COP** up to **22.4 %.**
- ✓ The experimental work demonstrates that the **inclusion of a TESC** is a viable solution to **boost the performance of vapour compression refrigeration systems** that use **natural refrigerants**, **reducing emissions** and contributing to the **production of cold in a sustainable way**.

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