



*University of Pisa - School of Engineering
DESTEC – Department of Energy, Systems, Territory
and Construction Engineering*

First year presentation

Network 4 Energy Sustainable Transition (NEST) – Spoke 5 – Energy conversion

Pisa, March 14th 2024

PhD Student: Matteo Benvenuti

Supervisors: Prof. Umberto Desideri, Prof. Lorenzo Ferrari

Objective

- **Provisional title**

- "Analysis and optimization of innovative Power-to-Heat systems"

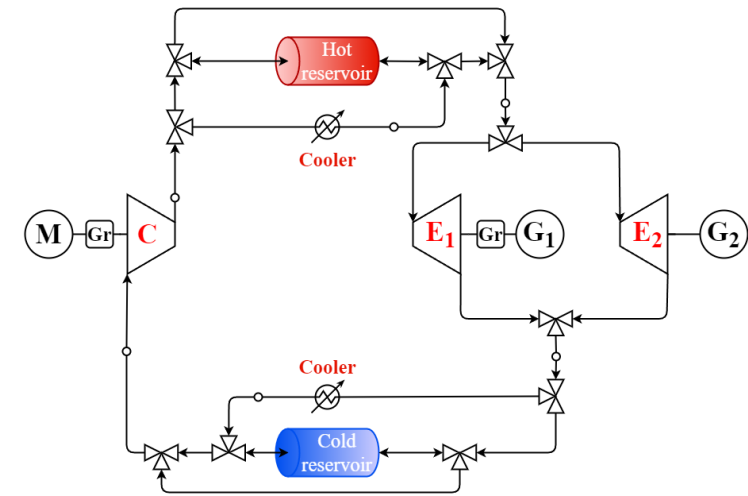
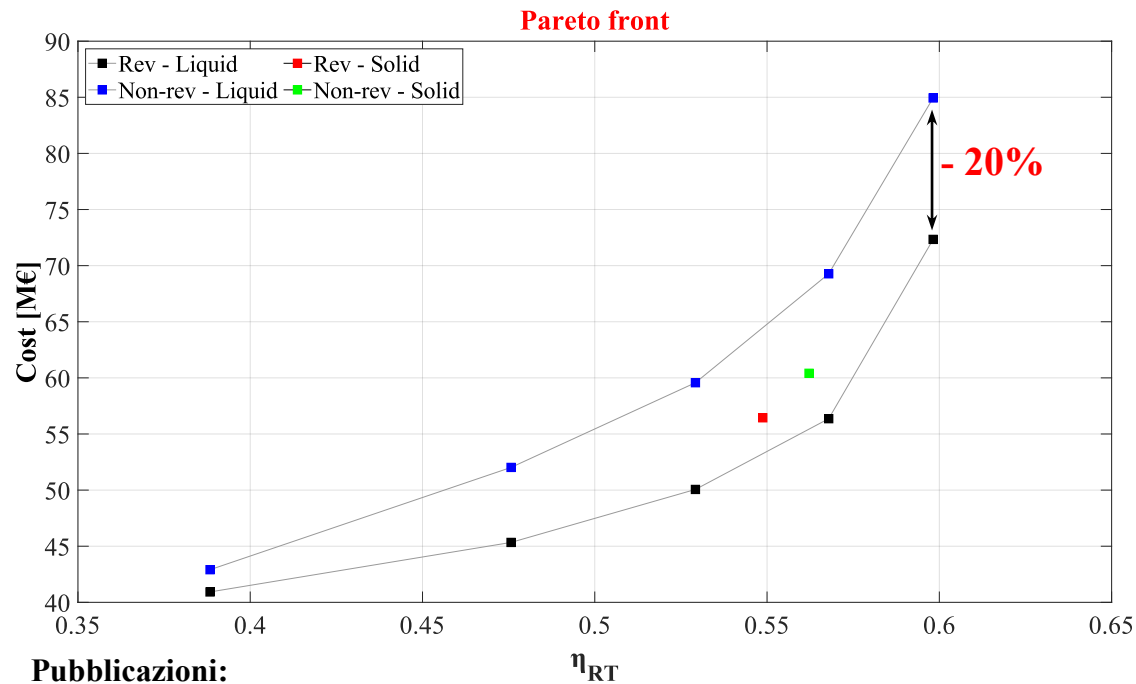
- **Research project**

- Analyse new technologies of Power-to-Heat-to-Power storage systems, as PTES, evaluating performance and costs.
- Analyse the high-temperature heat production (Power-to-Heat) through the modelling of a prototype of a High-Temperature Heat Pump evaluating performance and industrial applications.

Carried out activities – PTES

Techno-economic analysis of Pumped Thermal Energy Storage (PTES):

- ✗ High cost per kW
- ✓ Reversible system
- ✓ Turbomachine similitude between charging and discharging phase



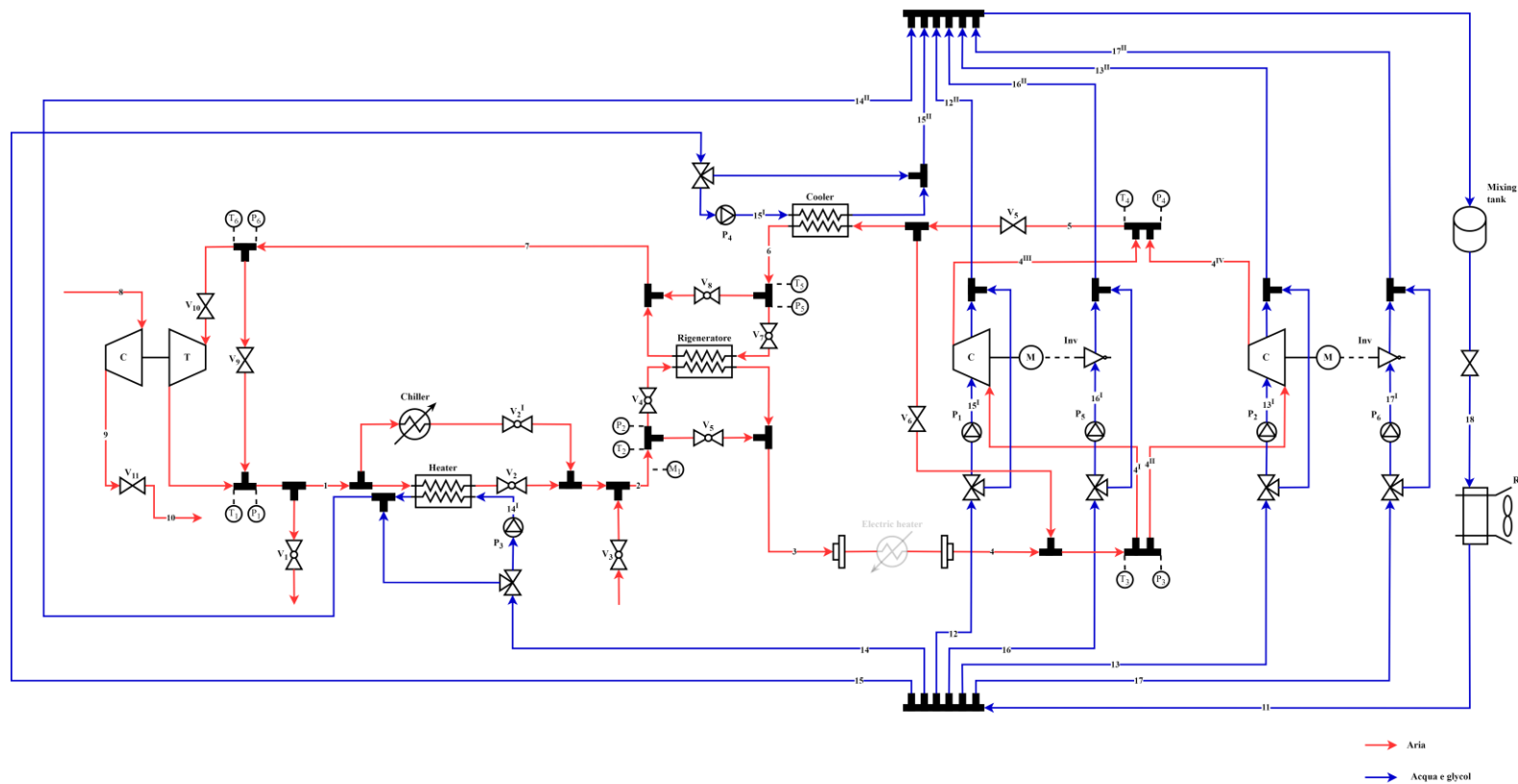
Publicazioni:

- ❖ "Techno-Economic Comparison of Reversible Brayton PTES" – Matteo Benvenuti, Guido Francesco Frate, Lorenzo Ferrari. To be submitted
- ❖ "Similitude-based reversible Brayton pumped thermal energy storage" – Matteo Benvenuti, Guido Francesco Frate, Lorenzo Ferrari. Proceeding of "37th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems"

Carried out activities – HTHP

Design of a prototype of a Brayton High-Temperature Heat Pump:

- Validate HTHP models
- ✓ Using "off the shelf" components
- ✓ Four different configurations



Open cycle:

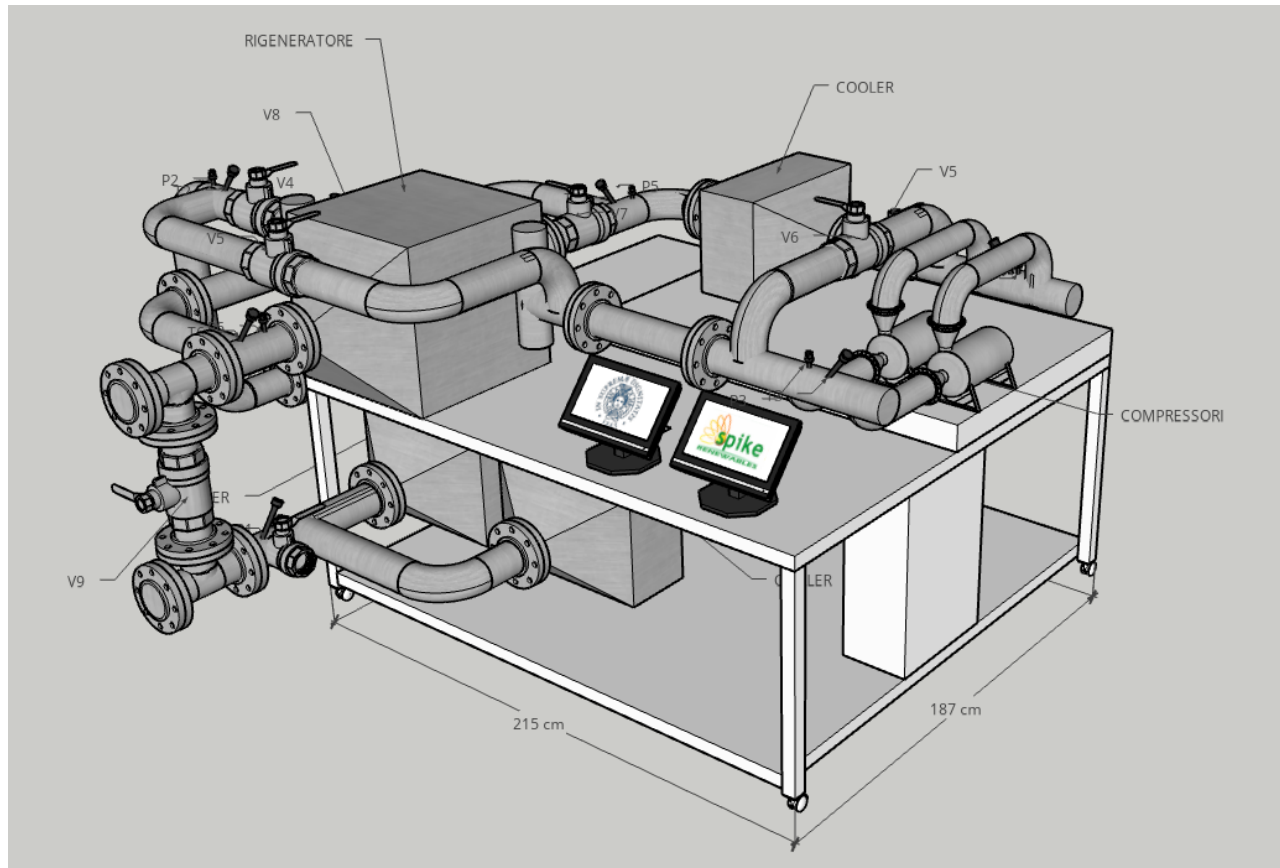
- Regenerated
- Non-regenerated

Closed cycle:

- Regenerated
- Non-regenerated

Carried out activities – HTHP

Render 3D of the High-Temperature Heat Pump prototype



Publicazioni:

- ❖ "Design of a high-temperature regenerated Brayton heat pump prototype" – Matteo Benvenuti, Guido Francesco Frate, Paolo Taddei Pardelli, Lorenzo Ferrari. To be submitted to "XXVII Biennial Symposium on Measuring Techniques in Turbomachinery"

Educational activities

- "Multiphysics FEM analysis of thermal and other engineering systems with COMSOL package". Held by Dt. Paolo Conti. Durations of 12 hours.
- "Energy Storage for Grid-scale Applications: Technology overview, current technological options, and future challenges". Held by Dt. Guido Francesco Frate. Durations of 4 hours.
- "4th Winter School for PhD Students Fluid Machinery and Energy System Engineering Renewable Energies, Energy Storage and Energy Transition". Pisa, Italy, from March 27th al 31th 2023.

Tutoring activities

- "Sperimentazione nelle macchine" – Prof. Lorenzo Ferrari. Corso di Laurea Magistrale in Ingegneria dei Veicoli. I° semester A.A. 2023/2024 10 hours.
- "Energetica applicata e progetto di macchine" (modulo "Progetto di macchine termiche") – Prof. Marco Antonelli. Corso di Laurea Magistrale in Ingegneria Energetica. II° semester A.A. 2022/2023 15 hours.

Future activities

- **Research activities**

- Development of off-design models to be validated on the high-temperature heat pump prototype.
- Acquisition of experimental data and validation of models on the heat pump prototype.

- **Abroad activities**

- The procedure for carrying out a four-month period abroad at “Deutsches zentrum für Luft und Raumfahrt (DLR)“ in Cottbus is currently being defined.



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