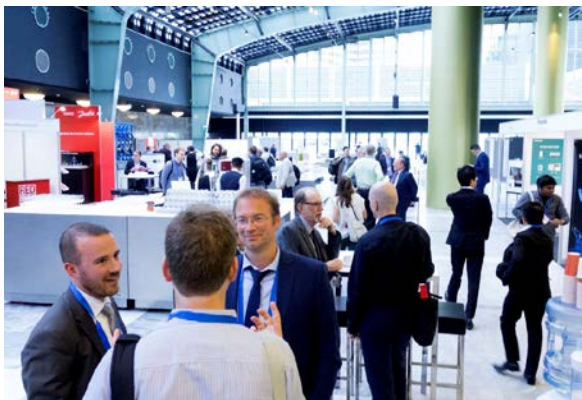




IEA Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)



Research, Development, Demonstration, and Deployment of Heat Pumping Technologies





ITALY COUNTRY REPORT

Maurizio Pieve & Raniero Trinchieri (ExCo Delegates)

The HPT TCP is part of a network of autonomous collaborative partnerships focused on a wide range of energy technologies known as Technology Collaboration Programmes or TCPs. The TCPs are organised under the auspices of the International Energy Agency (IEA), but the TCPs are functionally and legally autonomous. Views, findings and publications of the HPT TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

2023-06-20

www.heatpumpingtechnologies.org





Outline

- Context
- Market Summary
- Policy & Tariffs
- Innovation – R&D





General info - ITALY

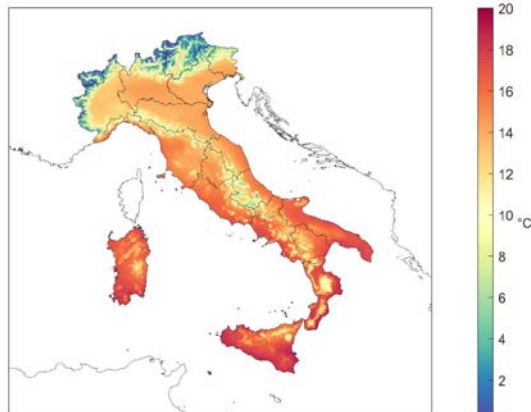
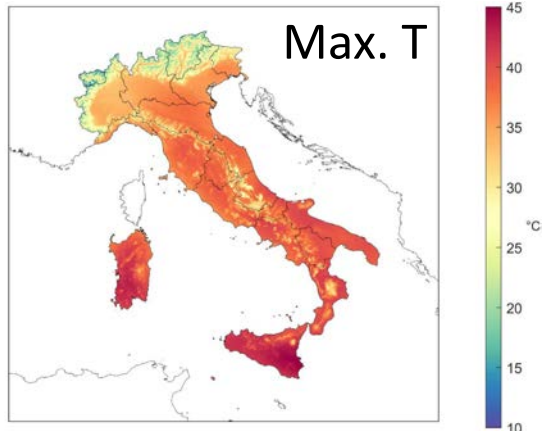
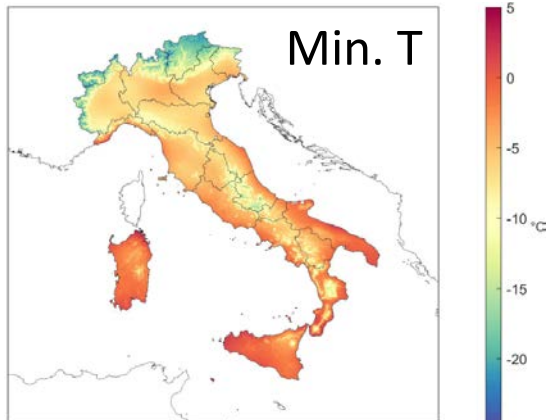


- Population ~ 59 Millions (2022)
- Land Extension ~ 302,000 km²
- Pop. Density ~ 195 ab./km²
- Residential Buildings ~ 12.2 Millions
- Households ~ 31 Millions
 - Main residence ~ 25.6 Mil.
 - Multifam. ~ 57%
 - Single fam. ~ 42%





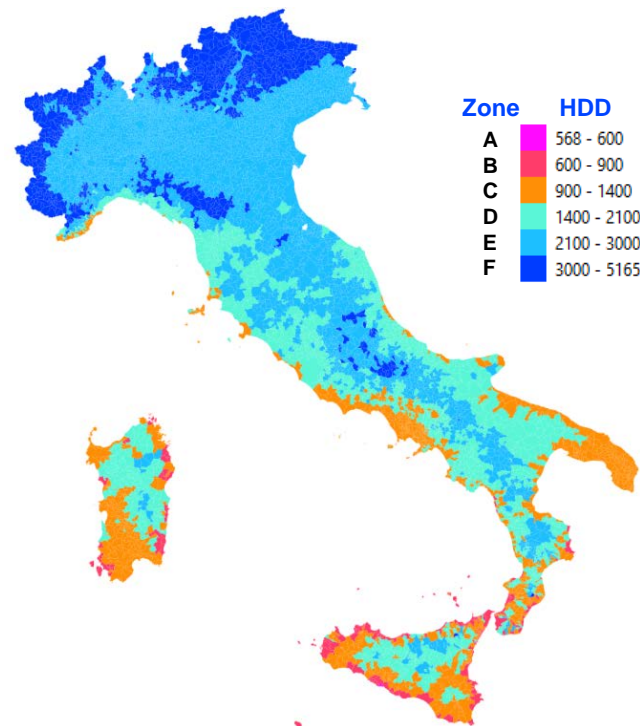
Climatics - 2021



Annual average T

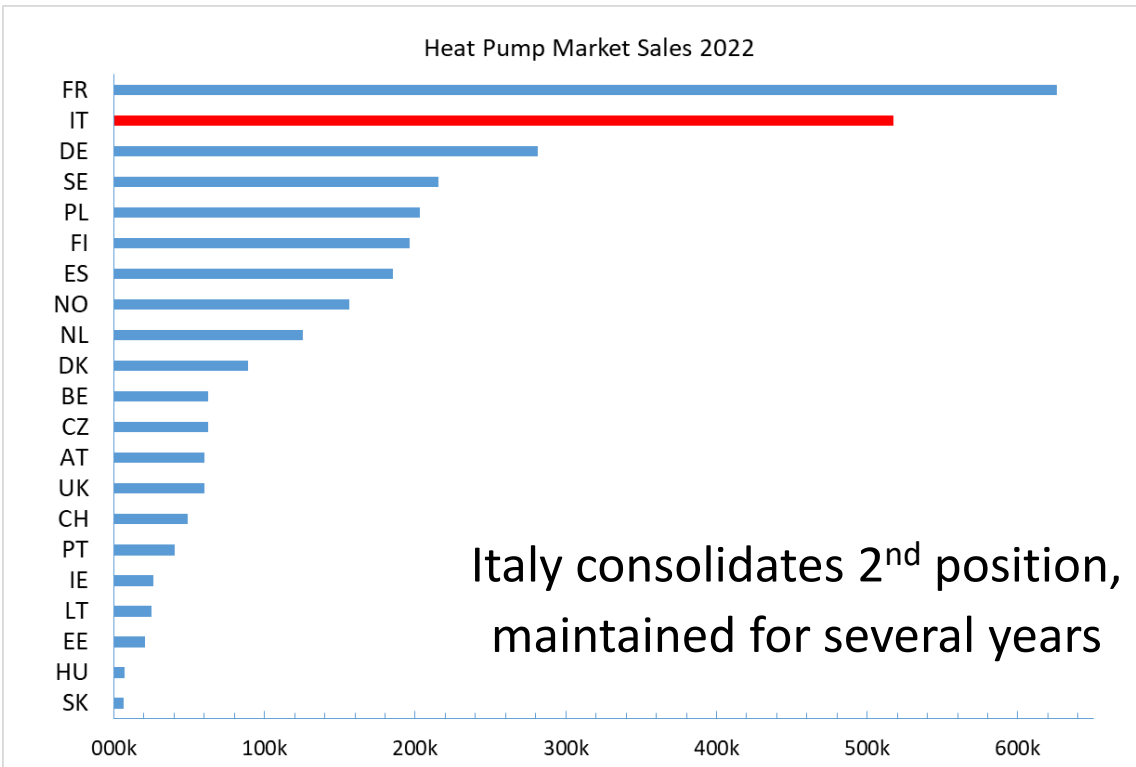
Source: Ispra

Heating degree days map

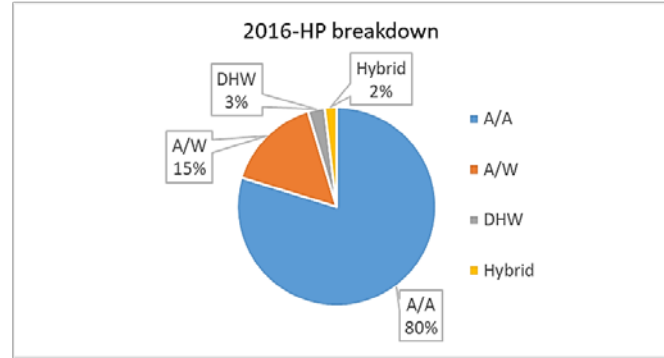
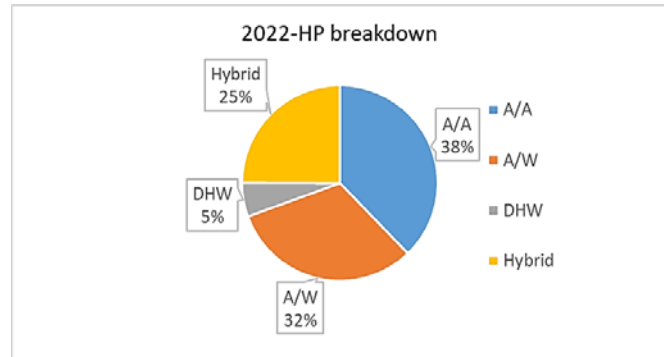




Market Summary



Source: EHPA





Market Summary – Insight, where such numbers come from



Steeper trend compared to previous years

Incentives effect (*next slides...*)

* Only HPs used as main space heating equipment (~ 10% of sold A/A)

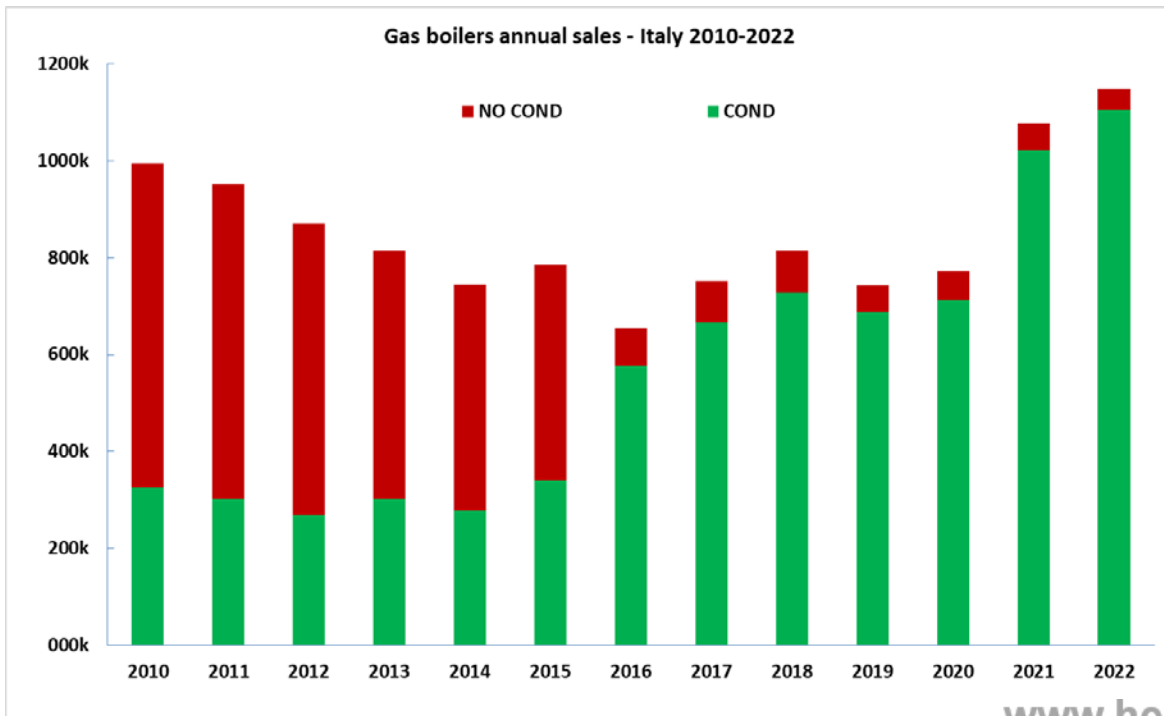
Source: **EHPA + Assoclisma**





Is it just a matter of a "SuperBonus effect"?

Gas boiler trend...



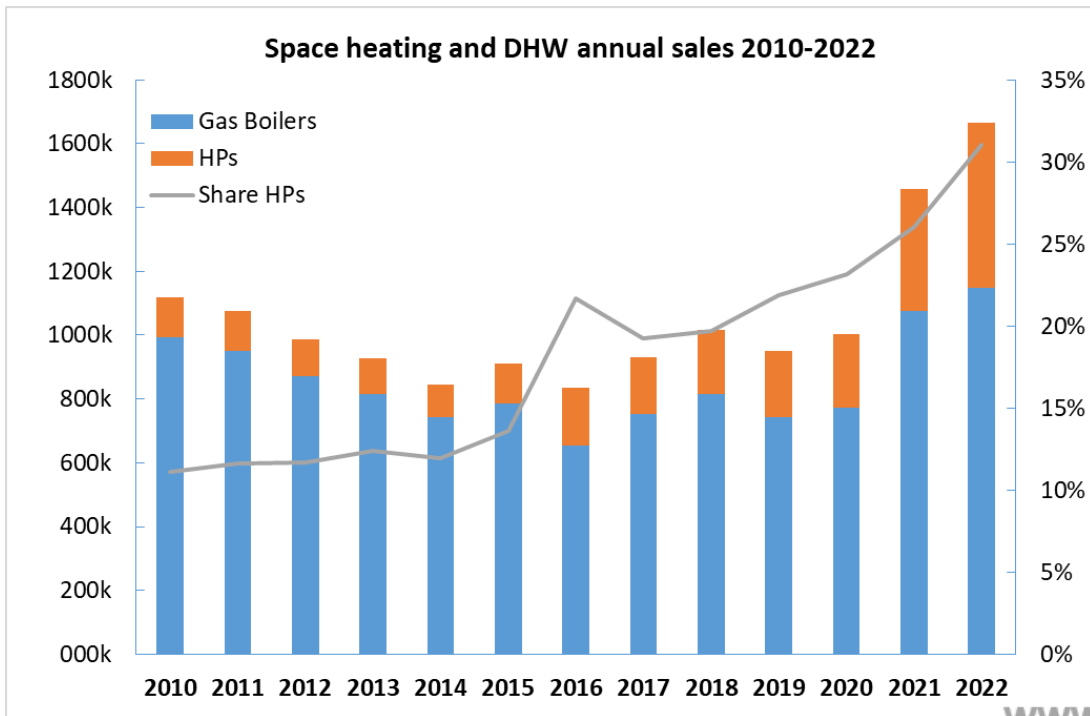
Superbonus mechanism (up to 110% tax deductions) as main driver for the heating systems market in 2021-2022





Is it just a matter of a "SuperBonus effect"?

... and HP comparison



Superbonus mechanism (up to 110% tax deductions) as main driver for the heating systems market in 2021-2022

But HP share increased more and more!



Policy & Tariffs

Superbonus mechanism: 2020-2022

110% tax deductions for residential buildings renovation in SF and MF

Credit transfers and direct invoice discount allowed

Requirements: The renovation should 1) increase the building energy performance class **by two classes at least** and 2) include at least one so called **leading work** among



- Thermal insulation of building envelope, $\geq 25\%$ of it;
- Replacement of existing space heating system (with condensing gas boiler or **HP**).



Policy & Tariffs

Note: Heat pumps (electric and gas driven), hybrid, condensing boiler are all eligible for incentives.

2023 **Superbonus** UPDATES:

- New requests (after 01/01/2023) allowed for 90% tax deductions only
- No more credit transfer nor invoice discount after 16 February 2023
- For SF: access allowed only for low-income owners

Other mechanism **Conto Termico**: existing since 2013, updated in 2016.

900 M€ annual funding. Eligible for private (700 M€) and public (200 M€). The grant covers 40-65% of the investment cost, depending on interventions.

If < 5,000 €, disbursement in a single installment

Furthers: Building renovations expenses: 50-65% tax deduction in 10 years

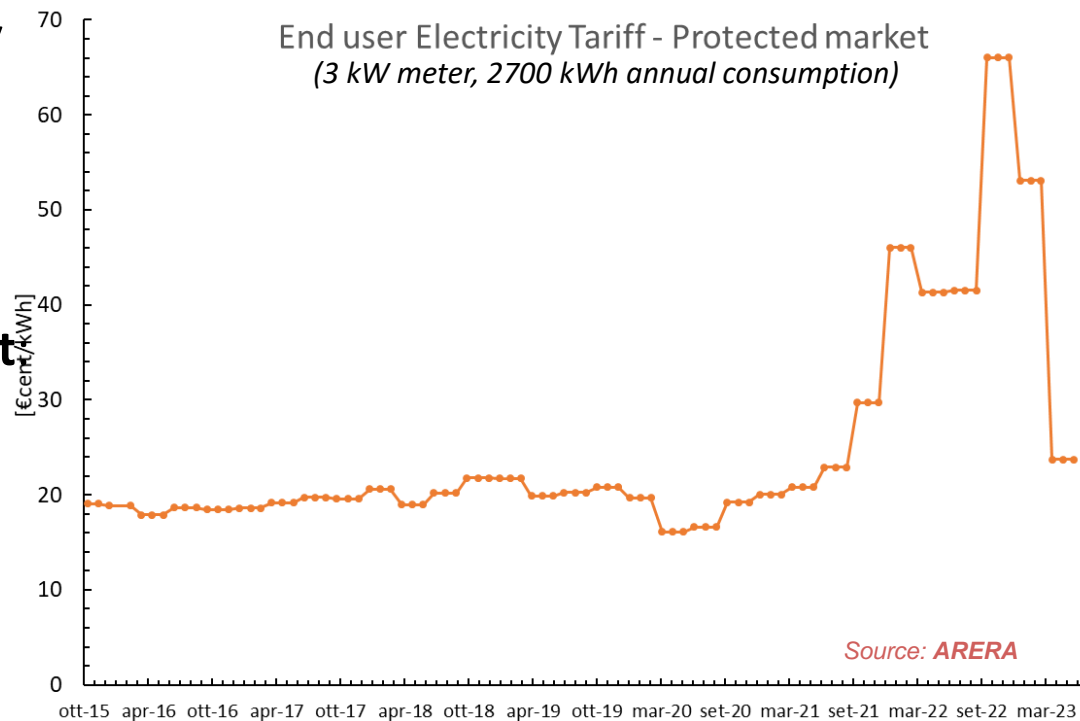




Tariffs: recent and past years

Electricity retail (30 Millions domestic final users) market main features:

- Free choice of electricity supplier since 2000's
- Current breakdown for electricity residential customers:
 - Free market 69%
 - Protected market 31%
- **Planned end of protected market January 2024**
- 3-months basis tariff update
- Protection mechanism for low-income users

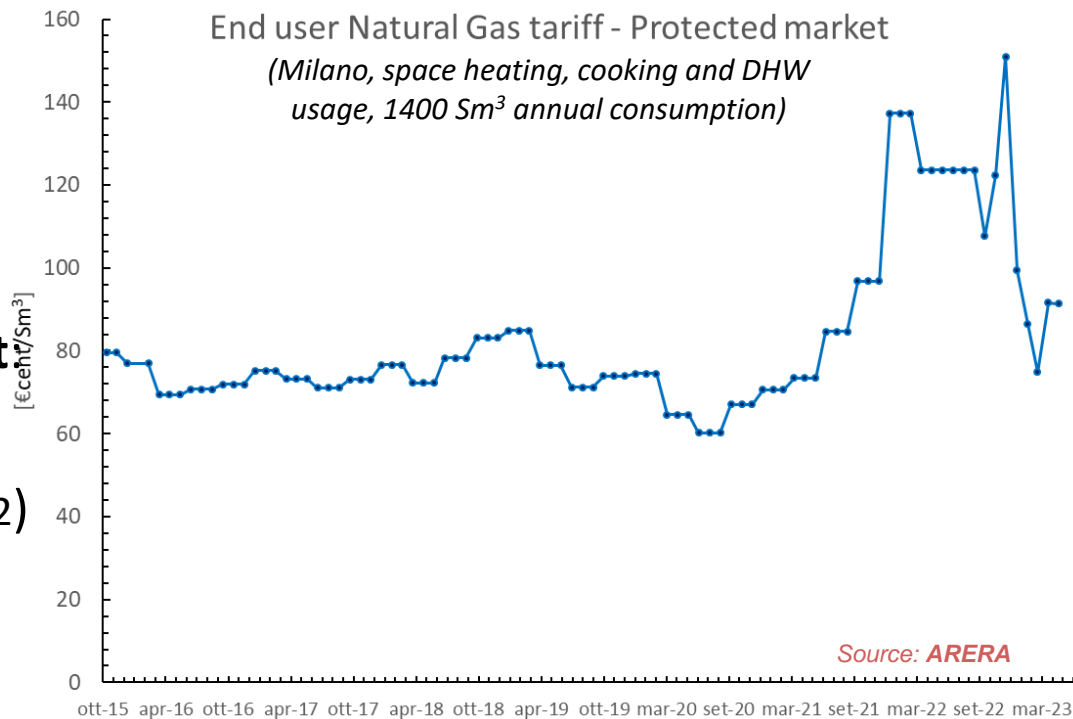




Tariffs: natural gas

NG retail (20 Millions domestic final users) market main features:

- Free choice of NG supplier since 2000's
- Current breakdown for NG residential customers:
Free market 68%
Protected market 32%
- **Planned end of protected market January 2024**
- monthly tariff update (since 10/2022)
- Protection mechanism for low-income users





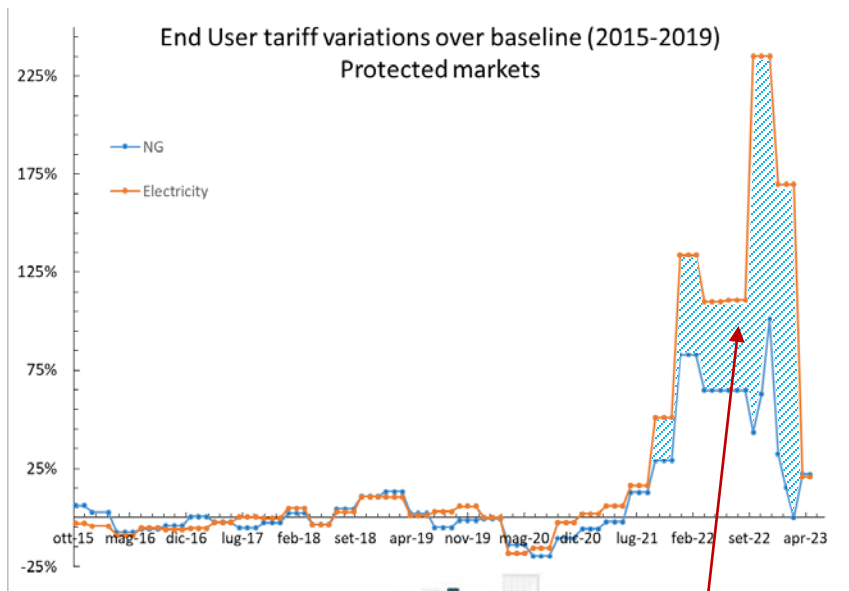
Tariffs: from market to end-user – different treatments



Source: GME



Substantially similar trends



END USER

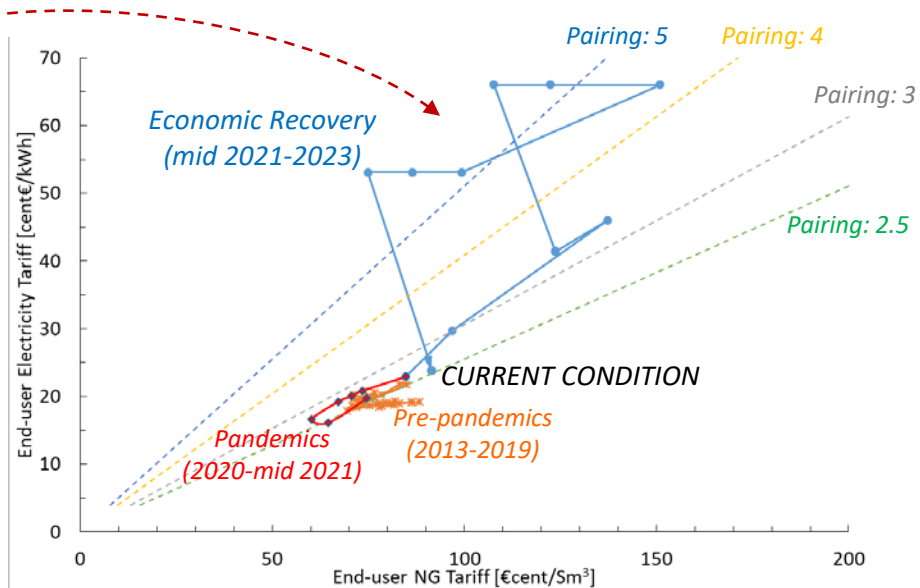
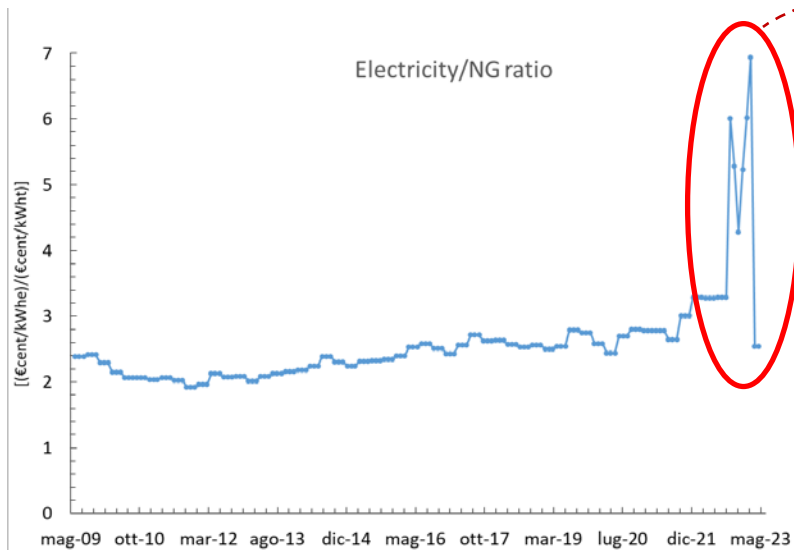


Substantially different effects!





Space heating & DHW: consequences of using HPs or CGBs





Innovation and R&D – Many Actors

Academia



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DELLE MARCHE



POLITECNICO
MILANO 1863



UNIVERSITÀ
DEGLI STUDI
DI UDINE

Public Research Institutions



Private Research Instit.s



- Funding channels: EU & National projects

www.heatpumpingtechnologies.org

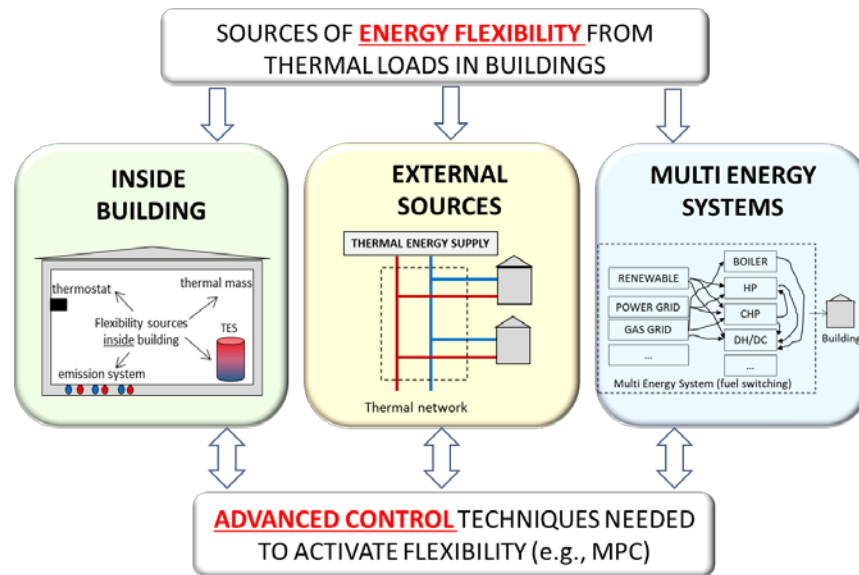
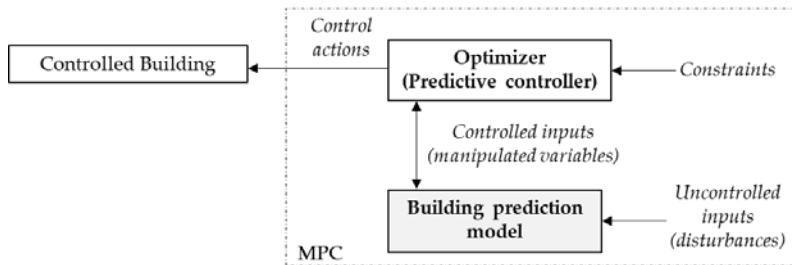


Università Politecnica delle Marche – *ref. Contact Person Alessia Arteconi*



UNIVERSITÀ
POLITECNICA
DELLE MARCHE

Research Topic: Flexible Heat Pumps



Development of:

- **Advanced simulation tools** for energy flexibility quantification
- **Control algorithms** for energy flexibility exploitation in multi energy systems
- Focus both on single buildings and clusters of buildings

Related projects (H2020)

EU MUSE GRID: Multi Utilities Smart Energy GRIDS

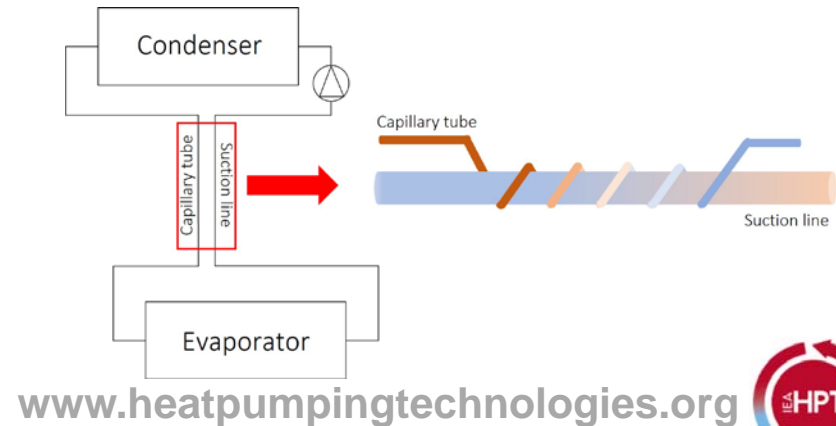
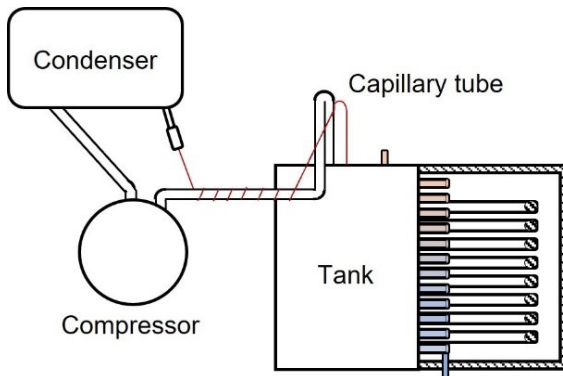
TRUST: blockchain technology for smart cities

Università Politecnica delle Marche – *ref. Contact Person Alessia Arteconi*



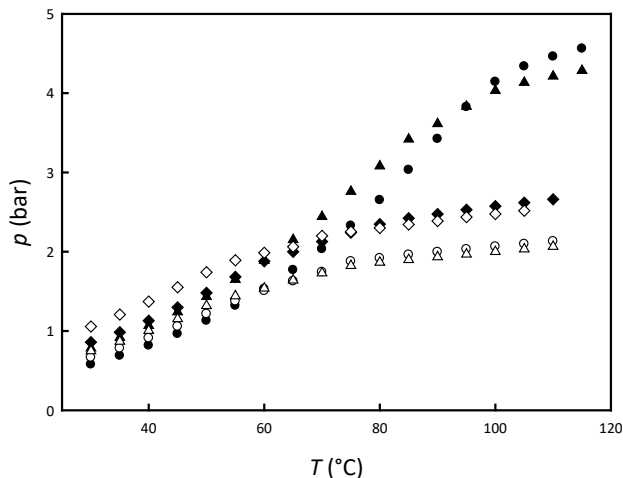
Research Topic: Natural Refrigerants: system optimization

- Development of an **optimization** framework for cycle optimization and **charge reduction** with **natural and flammable refrigerants** (i.e. Propane)
- Heat exchangers and non adiabatic capillary tube optimization
- **Integration** of PCM storage
- Focus on water cooling systems (*Project funded by Blupura company*)

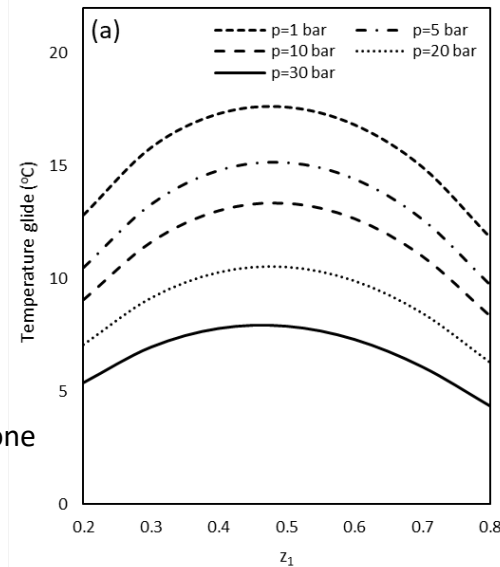


Research Topic: High Temperature Heat pumps

- Investigation of thermodynamic properties of **new refrigerant mixtures** to reach **up to 200° C** with a special focus on zeotropic mixtures (experimental measurements and thermodynamic simulations).
- Collaboration with KU Leuven (Belgium)



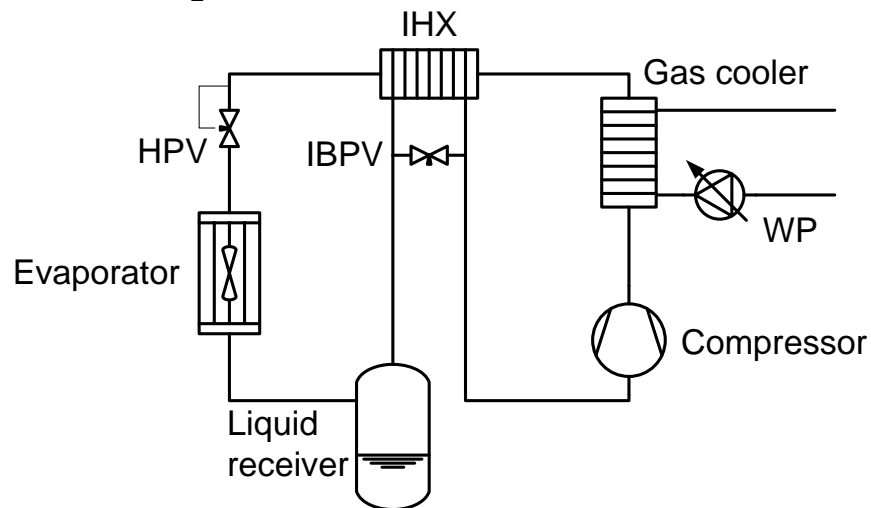
Example: R1234ze(Z)/acetone



Research Topic: Optimisation of circuitry and control rules for CO₂ HPs

- Heat pumps for DHW production, about 100 kW,
- Control rule for the Internal Heat Exchanger IHX in a **CO₂ system**
- Control rule for the best gas cooler pressure
- Off-design conditions

Self-funded





University of Udine – *ref. Contact Person Giovanni Cortella*



**UNIVERSITÀ
DEGLI STUDI
DI UDINE**

Other research Topics

Coupling HPs to smart local grids

- **Modelisation** of local energy communities
- Thermal and electrical grids, thermal storage
- **Dynamic simulation** of buildings, to predict heating and cooling loads
- **Best exploitation** of electrical energy from PV modules, thermal storage in water or in the building itself

HPs for high temperature applications, with CO₂ and hydrocarbons

- Heat pumps for high temperature applications
- Modelling, heat exchanger design, prototype
- **CO₂ and high glide mixtures** CO₂ - hydrocarbons
- Financed by **National Research Project Fund (PRIN) 2022** (not yet started)



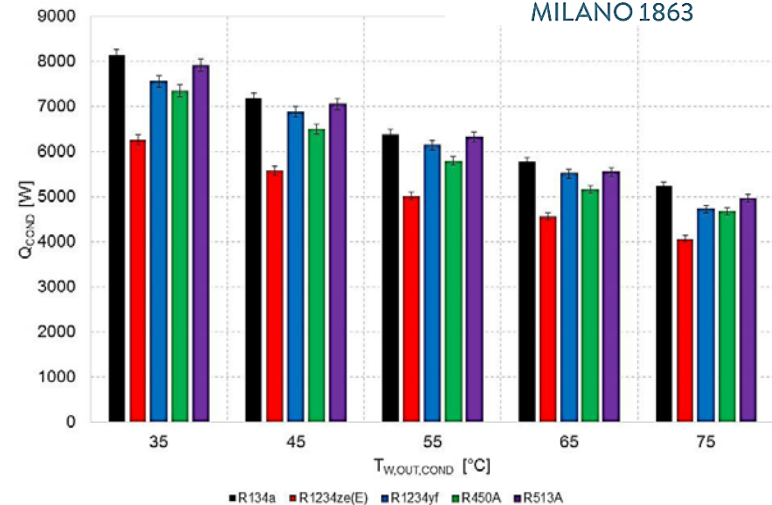
Politecnico di Milano – *ref. Contact Persons Luca Molinaroli & Tommaso Toppi*



POLITECNICO
MILANO 1863

Research Topic: Residential HPs

- Experimental analysis on **low-GWP** refrigerants in a drop-in application (*on the right: heating capacity for different refrigerants at different leaving water temperatures*).
- Development of a **R290-based**, small-capacity air-to-water HP integrated with PCM thermal storage.



- Development of a **compact gas-driven absorption HP**
- Studies on **innovative hybrid cycles** for HP application in the retrofitting market
- Environmental **LCA of HPs** and alternative heating technologies

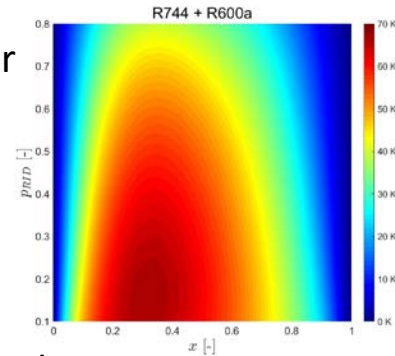
Politecnico di Milano – *ref. Contact Persons Luca Molinaroli & Tommaso Toppi*



POLITECNICO
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Research Topic: Industrial HPs

- Experimental analysis of the use of **CO₂-hydrocarbons blends** for moderately high temperature (max 120 °C) HP application (*on the right: glide of R744+R600a*).
- **Numerical assessment** of different heat pump layouts for low pressure steam production (2 bar, 120 °C).
- Demonstration of **different high temperature heat pump** and heat transformer in industrial applications (EU project **PUSH2HEAT**: <https://push2heat.eu/>)
- Experimental analysis of an **adsorption chiller** for low grade waste heat recovery.



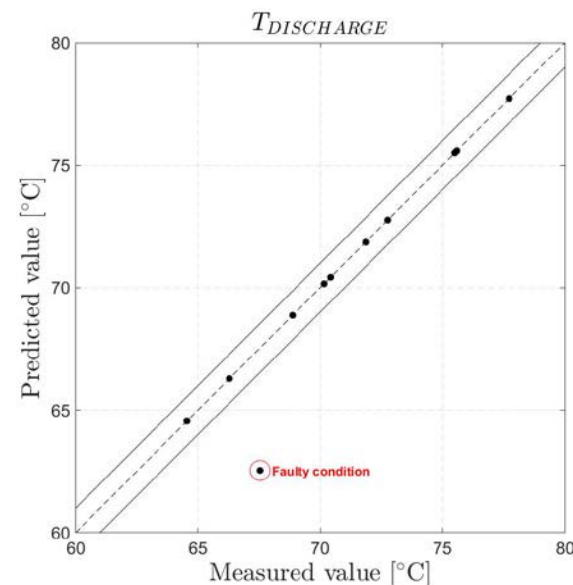
Politecnico di Milano – *ref. Contact Persons Luca Molinaroli & Tommaso Toppi*

Research Topic: Modelling



POLITECNICO
MILANO 1863

- Development and validation of a **dynamic model of air-to-water heat pump**.
- Assessment of the use of **Artificial Neural Networks** for fault detection and diagnosis (*on the right: example of result*)
- **Modelling of PCM storages** with different integration options for space heating and domestic hot water applications.
- Transient model of a **gas driven absorption heat pump**.
- Building-system integrated modelling for **yearly performance evaluations**.
- Transient model of **adsorption cycles and components** for design and optimization purposes.



Politecnico di Milano Projects & Funding numbers:
10 ongoing projects with around 1M€/y during last 5 years

www.heatpumpingtechnologies.org

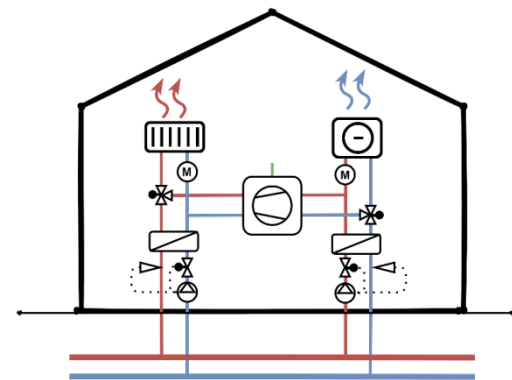


EURAC Research – *ref. Contact Person Roberto Fedrizzi*

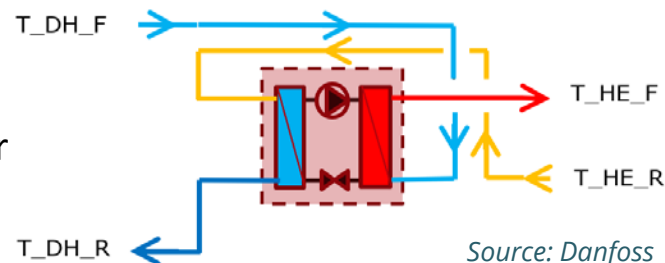
eurac
research

H2020-REWARDHEAT (COORDINATED)

- 15 M€ funding; 2019-2024
- Scope: Optimisation of **renewable and waste heat utilisation** in district heating and cooling networks
- HP related objectives: development of standardised heating and cooling thermal plants and industrialised substation with **optimal integration of HP and thermal storage**, and their smart control with MPC techniques
- HP related results:
 - **Database** of suitable solutions and pre-design tool
 - **Plans of H&C thermal plants** and substations and their demonstration
 - **MPC codes** elaborated and implemented
 - **Policy** paper delivered



Source: e.on ectogrid



Source: Danfoss

Reverse flow configuration

EURAC Research – *ref. Contact Person Roberto Fedrizzi*

eurac
research

H2020-HAPPENING (PARTNER – COORDINATOR TECNALIA)

- 2.5 M€ funding; 2020-2024
- Scope: Development of **easy to plan and to install HP systems** for retrofitted multifamily houses with at least 70% RE exploitation
- HP related objectives: development of a **cascaded heating system based on the water-loop concept**, coupled with PV and BESS
- HP related results:
 - Development of **water-to-air micro-HP** for room installation
 - Development, laboratory test and demonstration of water-loop system
 - **Development of MPC based strategies** for the optimal management of the system



Source: Innova



Source: Tecnozenith



EURAC Research – *ref. Contact Person Roberto Fedrizzi*

H2020-SPIRIT (PARTNER – COORDINATOR TNO)

- 11 M€ funding; 2022 - 2026
- Scope: Development of **large HPs for industrial applications**
- HP related objectives: SPIRIT will demonstrate three full-scale (> 700 kWth) industrial heat pump systems that **upgrade industrial waste heat** to valuable temperatures (135-160 °C). The demonstration covers sites in the **paper & pulp and food & beverage** industry
- HP related results:
 - Development of 3 large scale industrial heat pump systems
 - **Demonstration in real industrial environment**
 - Development of market studies and impact scenarios



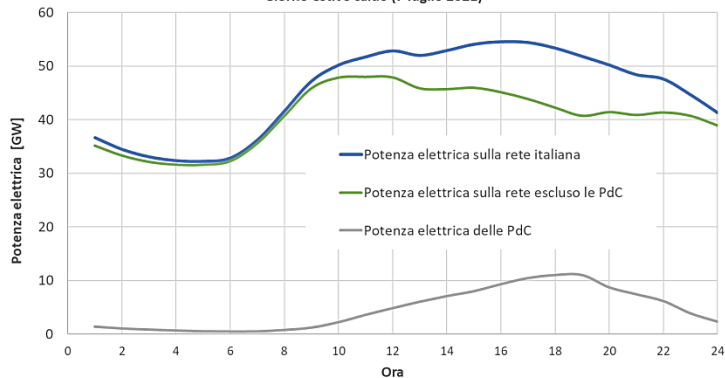
RSE (Energy System Research) – *ref. Contact Person Lorenzo Croci*

Research Topic: **The potential of demand response applied to HPs**

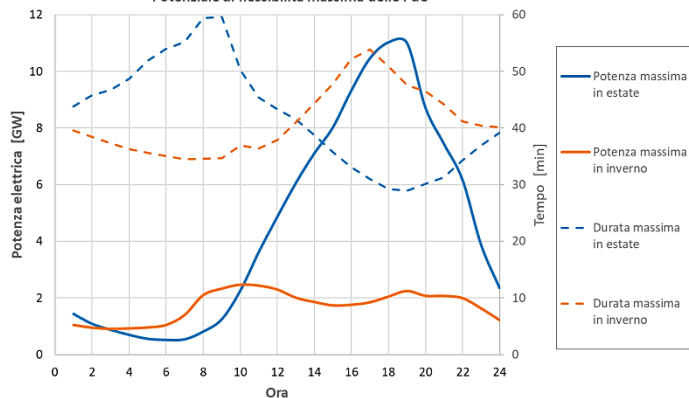
- **Goal:** identify and evaluate the **potential of electrical technologies to perform flexibility services**, without compromising the service quality provided to the end user.
- **Flexibility potential** of electric heat pumps was assessed at regional level by 2021 and 2030 in Italy.
- **Flexibility** defined as the **capability of deviating from a given operating profile** for a given period, using Demand Response solutions.

Funded by National Plan for System Research

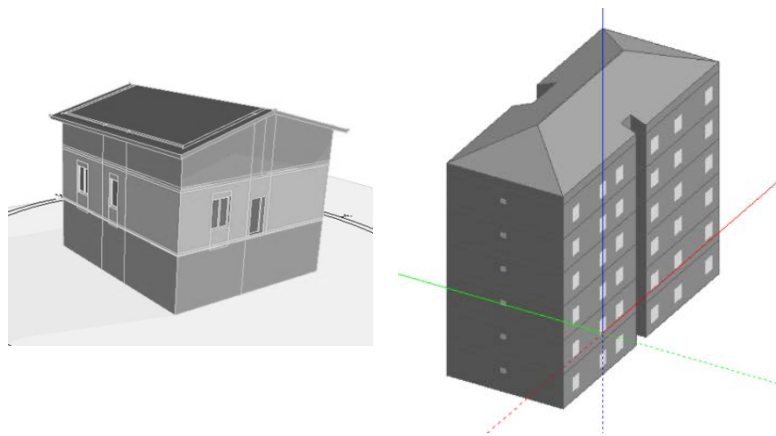
Giorno estivo caldo (7 luglio 2021)



Potenziale di flessibilità massima delle PdC

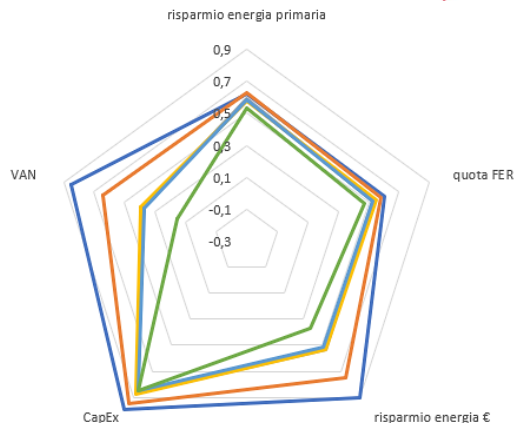


RSE (Energy System Research) – *ref. Contact Person Lorenzo Croci*



Support activities for the National Regulatory Authority for Energy, Networks and the Environment.

- Comparison study on existing homes to be renovated, in different climatic zones and analysis of **8 space heating system solutions** involving the use of natural gas, hybrid solutions (HP+boiler), electric heat pumps with and without PV.
- Calculation of **main economic indicators** to evaluate, according to many conditions and commodities price forecasts, the economic convenience of the investment, with or without the main incentives and the energy and environmental advantages.



CNR ITAE (National Council of Research) – *ref. Contact Person Andrea Frazzica*

H2020 Project HYCOOL: industrial cooling through hybrid system based on solar heat

5.8 M€ FUNDING; 2018-2022 - Coordinator: Veolia Serveis Catalunya (Spain)



Partners: 16 partners from 6 countries

Main objectives: demonstration of solar cooling plants for industrial applications, based on concentrated Fresnel solar collectors and **hybrid adsorption chillers**

Main results:

- 2 demo cases installed in Spain in a food and a chemical company, cooling up to 40 and 80 kw
- Validated **SEER improvement up to 25%** in cascading mode down to -10 °C cooling supply
- Use of low-GWP refrigerants (propane and propylene) for the hybrid chillers



Facilities with hybrid chiller installed in solar driven plants



*Cascade industrial sorption/propylene compression
(30 kW cool)*



CNR ITAE (National Council of Research) – *ref. Contact Person Andrea Frazzica*

H2020 Project GEOFIT: Deployment of novel geothermal systems, technologies and tools for energy efficient building retrofitting

7.9 M€ FUNDING; 2018-2022 - Coordinator: R2M (Italy)



Partners: 25 partners from 9 countries

Main objectives: to validate vapour compression and gas-driven heat pump solutions for geothermal retrofitting in different building types and climatic conditions

Main results:

- 5 demos installed and monitored for space H&C and swimming pool conditioning
- Technologies validated in the lab, using low-GWP refrigerants
- Thermal **COP of gas-driven HP** up to 1.2 for lab-scale integration

*Geothermal Gas-driven HP
(10 kW heat)*



*Geothermal gas-driven
adsorption HP installation in
a demo in Italy*



CNR ITAE (National Council of Research) – *ref. Contact Person Andrea Frazzica*

H2020 Project SUNHORIZON: Sun coupled innovative heat pumps

9.0 M€ FUNDING; 2018-2023 - Coordinator: RINA CONSULTING (Italy)

Partners: 20 partners from 12 countries



Main objectives: to develop and demonstrate innovative solutions for integrating solar systems with heat pumps

Main results:

- 4 demos installed and running under different configurations.
- Pre-commissioning in lab showing high flexibility in operation for the hybrid chiller config.
- **Solar heating and cooling fractions up to 60%.** Full monitoring by the end of 2023.



*Solar cooling system
installation in Spain*

*Parallel hybrid
sorption/propane compression
chiller (40 kW cool)*



CNR ITC 2 (National Council of Research) – *ref. Contact Person Laura Fedele*



H2020 Project GEO4CIVHIC: Most easy, efficient and low cost geothermal systems for retrofitting civil and historical buildings

Start date 01/04/2018 - Duration 68 months - Coordinator CNR – ISAC



Main objective: to develop easier to install and more efficient geothermal HPs, with compact, innovative and tailor-made drilling machines and developing or adapting HPs or other hybrid solutions in combination with renewable energies, to the renovation of buildings

GEO4CIVHIC **aims at accelerating the implementation** of shallow geothermal systems for H&C in the retrofitting of existing and historic buildings, through innovative solutions.

R454B refrigerant: Monitoring of the **GSHP performance** by measuring the main thermodynamic parameters (temperatures, pressures, mass flowrate) on the refrigerant side



CNR ITC 2 (National Council of Research) – ref. Contact Person Laura Fedele

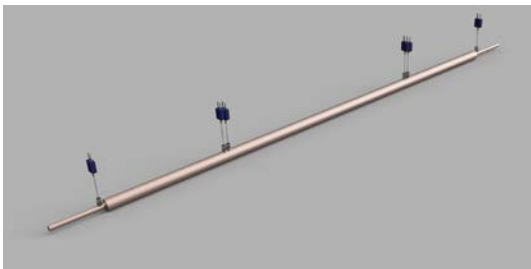


BILATERAL PROJECTS

- CNR + CNRST (Centre National pour la Recherche Scientifique et Technique – Morocco)

Phase change materials (PCMs) for thermal energy storage (TES) in industrial production processes

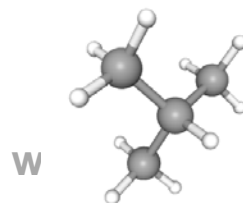
Goal: to investigate and develop a **novel latent heat thermal energy storage** (LHTESS) system incorporating PCMs capable of storing and utilizing industrial waste heat at high temperatures from different industrial applications.



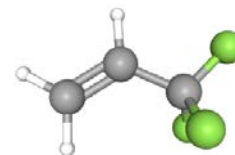
- CNR + NRF (National Research Foundation of Korea - South Korea)

Experimental evaluation of new low greenhouse effect refrigerants for heat pump applications

Goal: identifying **one or more blends of low GWP refrigerants** as potential substitutes for the current refrigerants. The energy efficiency of the fluid(s) will be evaluated with experimental tests on an instrumented HP.



mping



rg



CNR ITC 2 (National Council of Research) – *ref. Contact Person Laura Fedele*



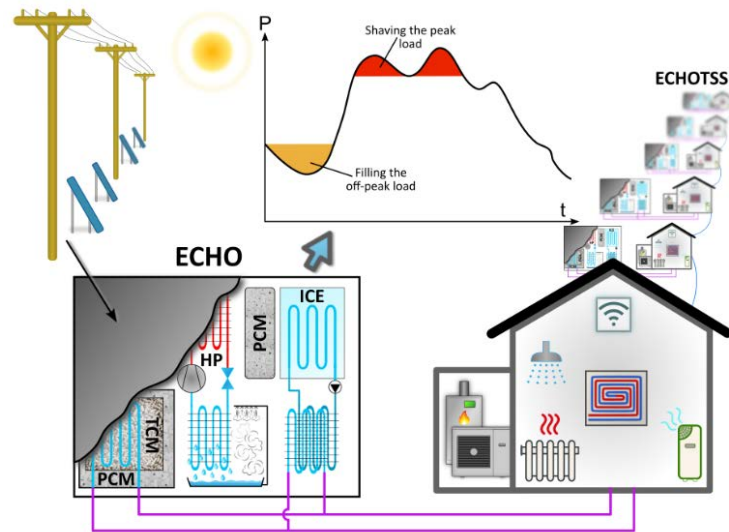
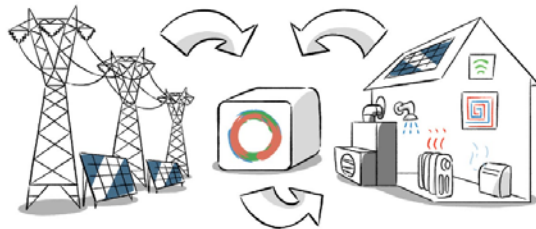
Horizon EU Project **ECHO**: Efficient Compact Modular Thermal Energy Storage System

Start date 01/01/2023 – 8.1 M€ Funding - Duration 48 months - Coordinator CNR – ITC

Objective: to develop and demonstrate **new modular, compact, high-performance and Plug&Play thermal energy storage (TES) solutions** for H&C and DWH.

The project will provide a key tool for thermal energy storage in the context of **sector coupling**

The ECHO system will be adapted to different energy scenarios. Furthermore, its **modularity** will allow it to be used at different scales, from small apartments to larger buildings.



CNR ITC 1 (National Council of Research) – *ref. Contact Person Silvia Minetto*



H2020 Project MULTIPACK: Demonstration of the next generation **standardised integrated cooling and heating packages for commercial** and public buildings based on environment-friendly CO₂ vapour compression cycles

Duration: 2016-2021 (closed)

Partners: 7 (coordinator NTNU)

Main focus areas:

- Supermarkets
- High energy demanding buildings (hotel, gyms,..)

website <https://www.ntnu.edu/multipack>



H2020 Project ENOUGH: European food chain supply to reduce GHG emissions by 2050

Duration: 2021-2025 (ongoing)

Partners: 30 (coordinator Sintef Ocean)

Main focus areas:

- All links of the food chain (post farm gate)

Website <https://enough-emissions.eu/>



CNR ITC 1 (National Council of Research) – *ref. Contact Person Silvia Minetto*



CNR-ITC DEMONSTRATOR: ELECTRIC TRANSPORT REFRIGERATION UNIT-FRESH AND GREEN DELIVERY

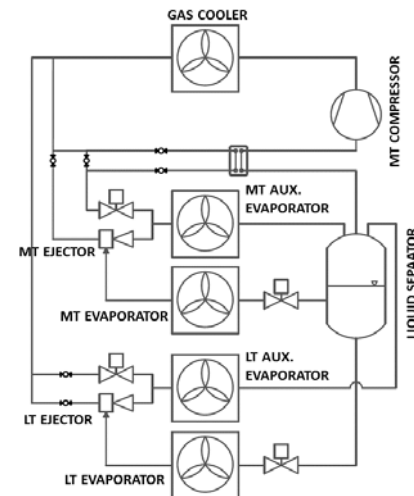
Technology: Natural Working Fluid refrigeration, Renewables (Photovoltaic PV)

Goal: Electrically powered refrigeration in place of diesel motor, no synthetics

Products: all (fresh & frozen)

Chain Link: transport

Status: prototype in lab/components optimisation



First results

- Design of CO₂ Medium Temp +Low Temp unit with single compression stage
- **Design and optimization of specific components** (MT and LT ejectors), experimental tests planned
- **Preliminary numerical assessment** of the cooling unit performance, dynamic model under development



www

CNR ITC 1 (National Council of Research) – *ref. Contact Person Silvia Minetto*



CNR-ITC AND ENEX SRL DEMONSTRATOR: CO₂ BLAST FREEZER

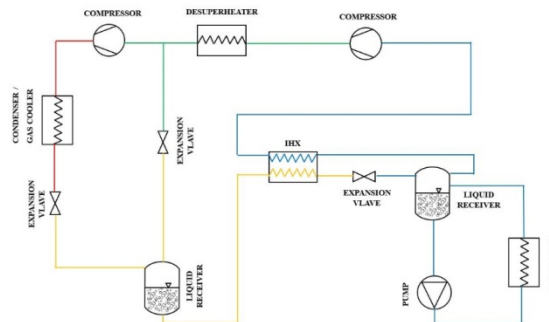
Technology: Natural Working Fluid refrigeration, Renewables, freezing improvement

Goal: Natural working fluid based direct expansion freezer for food processing, heat recovery

Products: meat (fish, vegetables)

Chain Link: processing

Status: prototype in lab/components optimisation



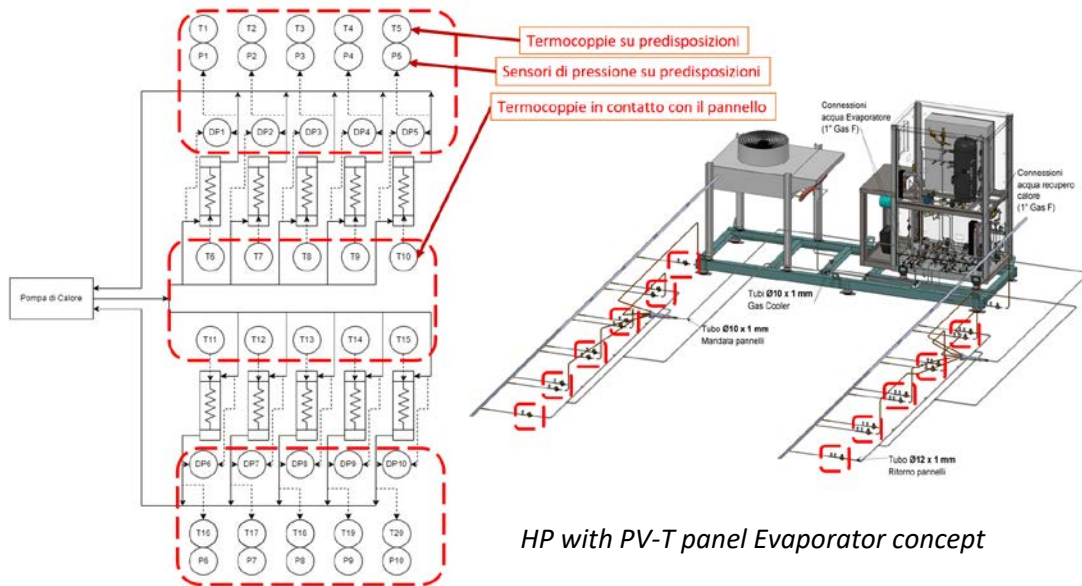
First results

- Design of CO₂ blast freezer with **focus on technological issues** related to very low evaporation
- Prototype built and ready to test
- Potential improvements under evaluation

ENEA – ref. Contact Person Raniero Trinchieri

Research Topic: HP Integrated systems

- Experimental study on **dual-source HP (air-solar)** with innovative PV-T panel Evaporator Concept
- Test in HiL mode to simulate different types of end-users (new, old buildings, etc.)



HP with PV-T panel Evaporator concept



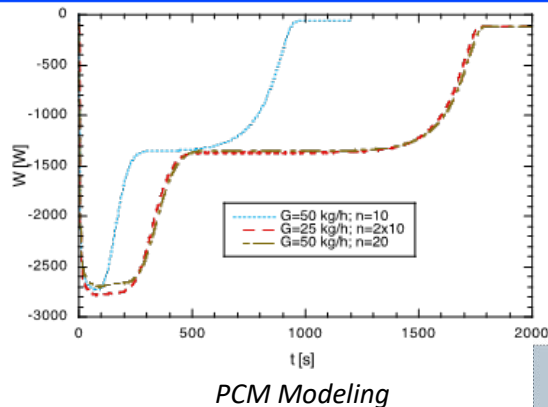
PV-T Panel Installation



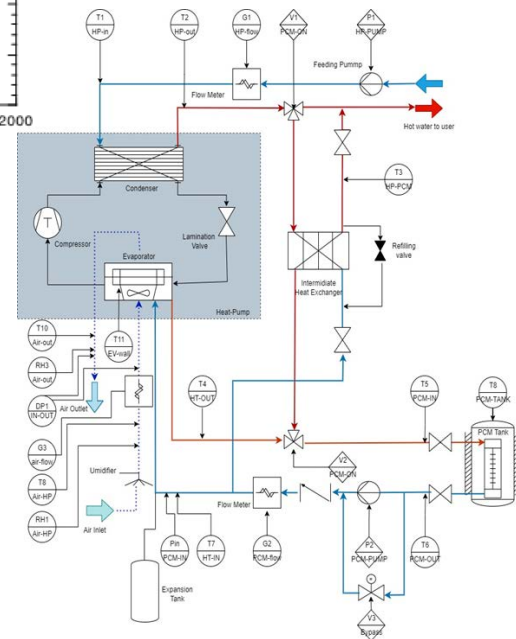
ENEA – ref. Contact Person Raniero Trinchieri

Research Topic: Defrost and refrigerants

- Experimental study of **innovative defrosting solutions**, using PCM tanks, waste heat or internal regeneration systems
- **Modeling and experimental study of ultra-low GWP refrigerants**, able to meet the requirements of the new F-GAS regulation



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



PCM tank and system concept

Project Three-year Implementation Plan (PTR 2022-2024)

www.heatpumpingtechnologies.org





AT A GLANCE: FURTHER ACTORS & STAKEHOLDERS

Institutions, Research, Manufacturers



HP supply chain permanent Table





IT PARTICIPATION IN THE TCP ANNEXES

ADVANCED COOLING/ REFRIGERATION TECHNOLOGIES DEVELOPMENT	53	CN, DE, IT, KR, US
HEAT PUMP SYSTEMS WITH LOW GWP REFRIGERANTS	54	AT, DE, FR, IT, JP, KR, SE, US
INTERNET OF THINGS FOR HEAT PUMPS	56	AT, CH, DE, DK, FR, NO, SE
FLEXIBILITY BY IMPLEMENTATION OF HEAT PUMPS IN MULTI-VECTOR ENERGY SYSTEMS AND THERMAL NETWORKS	57	AT, DK, DE, FR, NL, SE
HIGH-TEMPERATURE HEAT PUMPS	58	AT, BE, CA, CH, DE, DK, FR, NL, NO, JP
HEAT PUMPS FOR DRYING	59	AT, CN, DK, SE
RETROFIT HEAT PUMP SYSTEMS IN LARGE NON-DOMESTIC BUILDINGS	60	AT, UK, IT
HEAT PUMPS IN POSITIVE ENERGY DISTRICTS	61	AT, CH, DE, JP, US
HEAT PUMPS FOR MULTI- FAMILY RESIDENTIAL BUILDINGS IN CITIES	62	DE, FR
PLACEMENT IMPACT ON HEAT PUMP ACOUSTICS	63	DE, AT
SAFETY MEASURES FOR FLAMMABLE REFRIGERANTS	64	DE, KR, SE

ITALY PARTICIPATES IN 3 ANNEXES (+ INTEREST IN 2 NEWS)





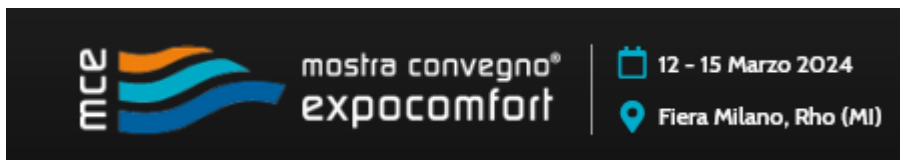
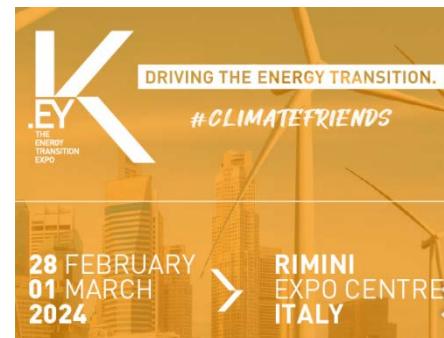
Forthcoming Initiatives & Events

HP_sim&app23 - Carnot User Meeting 2023

June 22 - 23, 2023, Bologna, Italy



**Keynote by Caroline H. Stignor
on behalf of TCP**





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