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CORDIS Results Pack on

heat pumps

A thematic collection of innovative EU-funded research results

October 2023

Promoting clean and energy-efficient solutions for households

Research and Innovation

Contents

Editorial

As our world and climate continue to change, Europe must deliver solutions for a sustainable and secure use of energy. Heat pumps using green electricity can play a major role in supporting this goal.

Heating and cooling systems are the largest part of energy use in most homes throughout the world. In Europe they are responsible for 50 % of total energy consumption, with 80 % of household energy consumed still based on fossil fuels. Heat pumps offer a mature technology that is more efficient than using boilers, by extracting energy from the outside air or ground to warm the inside of a home or workspace. They can also work in reverse, to cool a building by transferring heat from indoors to the outside air or into the ground.

Heat pumps have an important role to play in our net zero future. The European Commission report on the competitiveness of clean energy technologies indicates there is a growing need to accelerate the roll-out of all types of heat pumps, from those designed for single-family houses, large multi-apartment buildings, and tertiary buildings or heat networks, to high-temperature heat pumps dedicated to industrial use.

A path to the future

The EU’s Green Deal Industrial Plan points to heat pumps as one of the key technologies for meeting climate-neutrality goals in the and for supporting industrial manufacturing in the Net Zero Industry Act. However, action is still needed to underpin the financing of heat pump development or related innovation and integrate them into buildings, industry and district heating/cooling networks. Financial support is also required for boosting the skills of workers, such as designers and installers, within the heat pump industry.

The EU’s Heat Pump Action Plan to accelerate roll-out across the EU includes the Heat Pump Accelerator partnership that will bring together the Commission, EU Member States, industry experts, financial institutions and training providers from across the entire heat pump value chain.

In addition, EU businesses and citizens will receive targeted information on existing heat pump solutions and future legislation will aim at phasing out stand-alone fossil fuel boilers by 2029. The mapping of financial opportunities for both heat pump deployment at the individual level and heating networks supplied by large heat pumps will contribute to heating and cooling strategies at local and regional levels.

Mobilising the heat below our feet to energise historical buildings

Europe has a wealth of historical buildings that need an energy retrofit. Special innovations to extract geothermal heat mean this totally fossil fuel-free energy resource can do the job.

Shallow geothermal heating and cooling systems are beginning to look more like attractive contenders for upgrading Europe's ageing building stock. EU initiatives, including the Renovation Wave, and policy measures such as the revision of the Energy Performance of Buildings Directive are spearheading this change.

However, historical buildings have their own restrictions limiting them from using this completely renewable energy source. The EU-funded GEO4CIVHIC project has developed and modified existing technologies to accelerate the deployment of shallow geothermal heating and cooling in such buildings located in built-up areas.

"On average, a geothermal system can supply 4 kW of thermal energy to the building by using 1 kW of electrical energy and extracting 3 kW of free energy from underground," notes Adriana Bernardi, project coordinator, physicist, research director and head of the National Research Council's Institute of Atmospheric Sciences and Climate, Padua, Italy.

Drilling and operating in a restricted space

A borehole heat exchanger coupled to a heat pump extracts the Earth's inexhaustible heat and supplies this energy to the emission units or radiators. Heat exchangers extract energy from the soil up to 8 °C, and the heat pump 'lifts' this energy to temperatures of up to 60-70 °C to supply the heating system. In summer, the heat pump reverses and draws heat from the building, recharging the soil.

Radically new approaches to drilling the borehole increase heat pump efficiency for high temperatures and new types of refrigerants used are required.

"Radically new approaches to drilling the borehole increase heat pump efficiency for high temperatures and new types of refrigerants used are required," Bernardi explains.

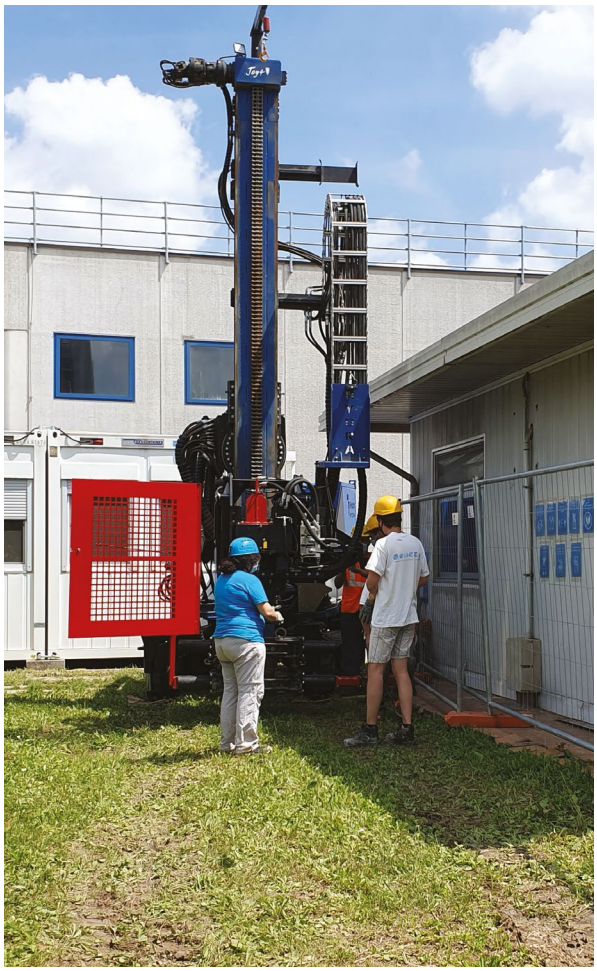
The historic city of Mechelen in Belgium boasts some 300 listed buildings. GEO4CIVHIC developed a compact and reduced-weight drill rig with a very small footprint that could be hoisted into gardens with a crane around the quaint narrow streets.

GEO4CIVHIC optimised and installed several co-axial steel heat exchangers with up to 20-30 % higher energy extraction rates, reducing the total length of heat exchangers needed. These heat exchangers were patented in the Cheap-GSHPs Horizon 2020 project.

Variations across the demo sites Europe-wide

Three pilot and four demonstration sites show the extent of GEO4CIVHIC's success across a range of rocks in the Earth's crust and different building designs.

Three heat pumps using CO_2 as a more environmentally friendly refrigerant were developed for high-temperature emission systems. In Ferrara (Italy), Greystones (Ireland) and Mechelen (Belgium), these demonstrated coefficients of performance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up to 3.3 at temperatures of 60-70 °C. One dual-source (air/ground) heat pump is installed in a historical site in Malta for warm climate applications. Additionally, four compact plug-and-play heat pumps were integrated into the test facilities at the University of Padua, Italy, and at Tecnalia, Bilbao, Spain, to develop energy management apps and study new low global warming potential refrigerants.

Bernardi points out: "These developments include the use of new refrigerants with low global warming potential to respond to the upcoming legislation."

For drilling in hard rock, GEO4CIVHIC developed a compact, powerful roto-vibrating drill head. In Ireland, the demo case at Greystones is on compacted rock, so the team used compressed air as the drilling fluid. Compressed air consumption and drill bit wear were substantially lower compared to the conventional drilling method. In softer rock on Malta, at the Msida Bastion Historic Garden, water was used as drilling fluid and drilling was very fast, although at rates below 1 m/min.

The future for geothermal energy

GEO4CIVHIC's comprehensive drillability maps will characterise sites according to geological properties, complete with drilling rates and costs. "For integration of geothermal plants with other renewable sources, we are developing a decision-support system. This will help users improve overall energy efficiency and accelerate the return on investme nt," Bernardi emphasises.

Bernardi's vision for Europe's historical building stock involves "demonstrating to all stakeholders the long-term economic returns of shallow geothermal heating and cooling. Activities we plan for training, guidelines and workshops will contribute to increasing the awareness and confidence in this technology amongst the stakeholders," she concludes

PROJECT
GEO4CIVHIC - Most Easy, Efficient and Low Cost Geothermal Systems for Retrofitting Civil and Historical Buildings

COORDINATED BY
National Research Council in Italy

FUNDED UNDER
H2020-EU.3.3, H2020-EU.3.3.2

CORDIS FACTSHEET
cordis.europa.eu/project/id/792355

PROJECT WEBSITE
geo4civhic.eu/

Multi-stage heat pumps ignite a 'chain reaction' of greener homes

EU-funded researchers unveiled multi-stage heat pump-based systems, triggering a ripple effect of modest yet impactful shifts in sustainability. The innovative systems boost comfort and eco-conscious living, one home at a time, where every action counts.

The EU is taking significant steps to combat climate change and reduce greenhouse gas emissions. With existing buildings accounting for a significant portion of energy demand and CO_2 emissions, the EU-funded HAPPENING project aims to boost the current renovation rates that currently stand at a mere 1 %.

Central to HAPPENING is the implementation of decentralised heat pump cascade systems. This cutting-edge concept combines the best aspects of both central and individual systems to overcome the technical and non-technical challenges associated with the retrofitting of energy systems in buildings.

"The decentralised heat pump system works by having individual heat pumps installed in each dwelling rather than relying solely on a single central heating system. This allows for better control over energy management and generation, as well as increased efficiency," notes project coordinator Irantzu Urkola Lekuona. By decoupling energy generation from consumption, the system can optimise the production cost of the central heat pump and use locally generated electricity (photovoltaic panels) more effectively.

In other words, "inhabitants with HAPPENING technology installed in their buildings can enjoy the advantages of both central and individual systems," adds Urkola. "These benefits include generating tempered water during peak hours, minimising heat losses through low-temperature distribution, and offering versatility as each dwelling can choose a configuration that better suits their needs and interests.

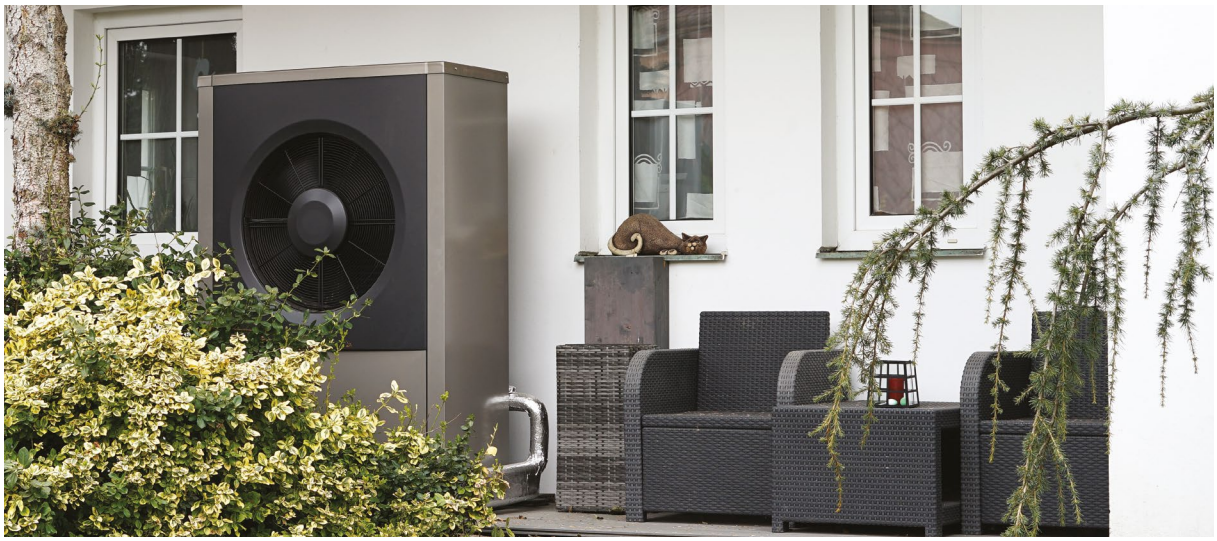
The decentralised heat pump system works by having individual heat pumps installed in each dwelling rather than relying solely on a single central heating system. This allows for better control over energy management and generation, as well as increased efficiency.

A two-stage thermal transformation

The decentralised heat pump cascade system works in two stages to optimise energy efficiency and provide tailored solutions for each dwelling.

In the first stage, central aerothermal heat pumps generate 'neutral temperature' water (20-30 °C), creating the first thermal gap. A thermal energy storage system at the central level stores this tempered water, promoting better control of the system. The tempered water is then distributed to individual dwellings.

In the second stage, decentralised heat pumps within each dwelling increase the temperature from the ring temperature (20-30 °C) to the consumption temperature, creating the second thermal gap. At this individual level, inhabitants can choose from a variety of configurations to suit their specific needs.



"Options include using a water-to-water micro heat pump for domestic hot water combined with several water-to-air micro heat pumps for heating and cooling in rooms," explains Urkola. "Another option is using a water-to-water booster heat pump for both domestic hot water and heating combined with low-temperature heat emitters."

Their innovative two-steps system is being showcased at the three demo sites in Spain, Italy and Austria.

This innovative system based on heat pumps can be powered by locally generated renewable energy, and its operation can be optimised thanks to a smart management and control system.

Over the course of the project, micro heat pumps with R290 (propane) refrigerant were developed for various configurations at the dwelling level, catering to specific needs. This innovative heat pumps technology are demonstrated at the Italian demo case.

A triple win: tailored heat pumps, improved financing, streamlined retrofitting

The team developed new financial and business models, bringing financial experts and innovative financing models into the residential retrofitting sector.

Furthermore, HAPPENING tackled barriers related to knowledge and training by providing resources and tools to streamline the entire retrofitting process, from planning to implementation and operation. The goal was to manage the risk of energy performance gaps between designed and installed thermal systems while reducing complexity, effort and investment risk.

HAPPENING is nearing completion, offering a versatile, scalable and replicable solution. This contributes to the EU's climate protection targets and helps create a more sustainable built environment.

PROJECT
HAPPENING - HeAt PumPs in existing multi-family buildings for achieving union's ENergy and envIromeNtal Goals

COORDINATED BY
Tecnalia Research and Innovation in Spain

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/957007

PROJECT WEBSITE
happening-project.eu/

Promoting the skills needed to deliver heat pumps' potential

The HP4All project has developed resources that promote the skills needed to meet the fast-growing demand for heat pumps – helping the EU reach its climate and REPowerEU objectives.

More efficient than fossil fuel boilers, heat pumps reduce life-cycle energy costs. If driven by green electricity, they also reduce carbon footprints. In buildings, they can provide space heating and domestic hot water as well as space cooling in the case of reversible systems.

According to the European Heat Pump Association, the EU has 16.98 million heat pumps installed, 14 % of the heating market, with 2021 heat pump sales growing by 34 %.

"We already see increased demand for skills along the value chain, from factories to installation, for both new and retrained professionals," notes Padraic O'Reilly, coordinator of the EU-funded HP4All (Heat Pumps Skills for NZEB Construction) project.

HP4All created a package of piloted measures to improve European awareness and skills regarding heat pumps. "We increased end-user awareness of high-quality heat pumps, while providing tailored training and promotion of existing options to boost the skills needed to meet growing demand," says O'Reilly.

We already see increased demand for skills along the value chain, from factories to installation, for both new and retrained professionals."

Three regional pilots

HP4All conducted three regional pilots, each representing different degrees of market maturity. To better understand each market, the team interviewed stakeholders, including installers, system designers, manufacturers, end users and training providers.

"This helped us identify each pilot region's specific requirements, so we could roll out tailored activities and training," explains O'Reilly.

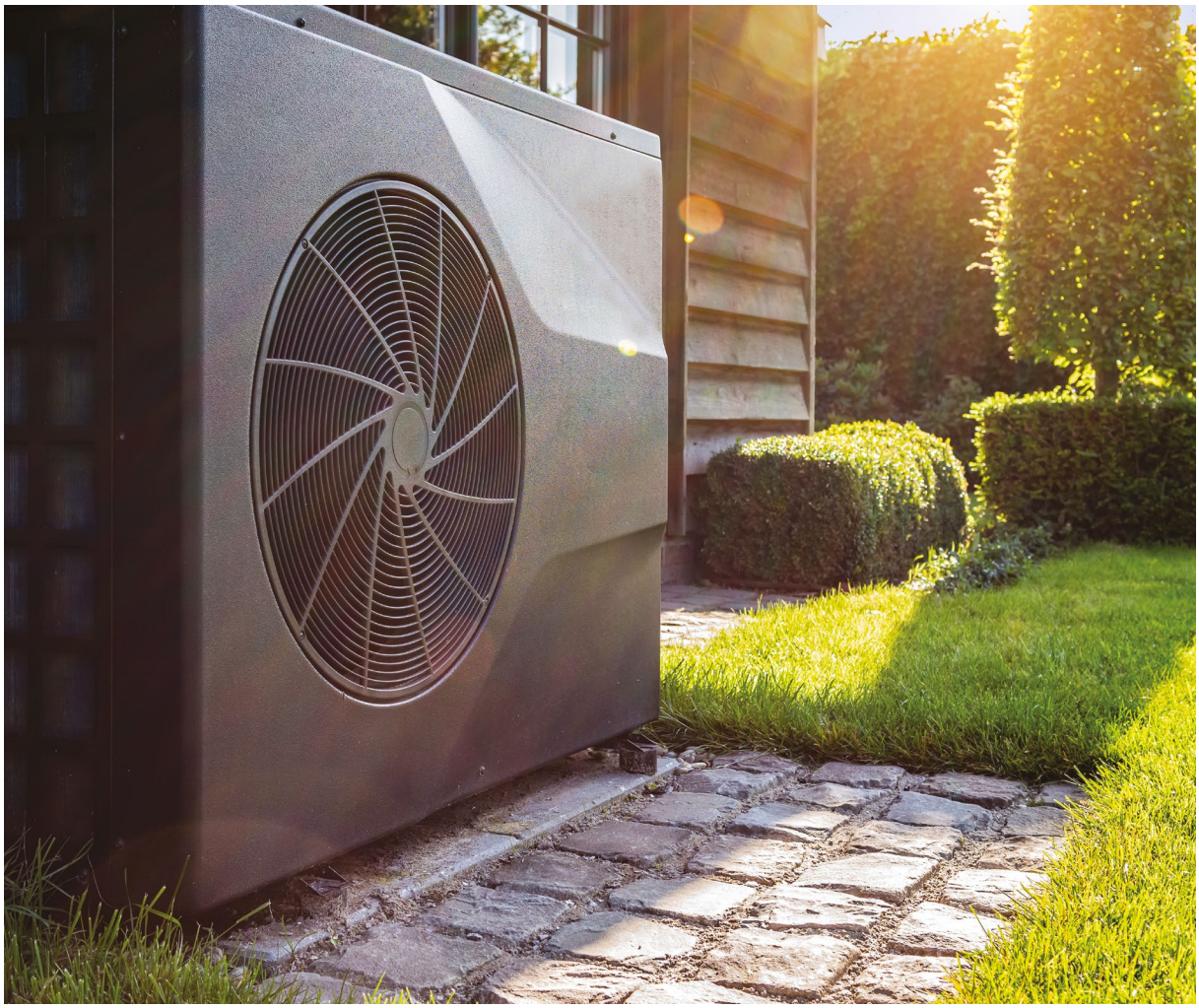
The Irish pilot has primarily focused on local authorities and their respective heat pump installations, with a secondary focus on large-scale heat pump installations and private domestic heat pump installations. HP4All has provided training to local authorities in a first attempt to provide the staff who will be responsible for installations with the information they need and a source of further resources if required.

The Upper Austrian pilot aimed to boost the market for mid- and large-scale heat pump applications (commercial and industrial). The project's activities were geared towards overcoming current challenges, such as low levels of awareness among planners and users, alongside the lack of required skills.

Pilot activities in Andalusia, Spain, tapped the public sector's potential to drive demand through public promotions and leveraging this sector as a key market influencer able to provide legislative, administrative and financial initiatives. The pilot focused primarily on heat pumps for public buildings (residential and non-residential).

Enabling resources

The HP4All project developed a Competency Framework outlining skills – grouped into technical, customer and business clusters – considered vital for heat pump sector growth.



The Framework was developed after consultation with stakeholders through workshops and surveys, interviews with heat pump expert groups and event panel discussions, such as those carried out by the European Heat Pump Association, a partner in the consortium. This was complemented by desk research, including into comparable models from other fields.

To retain and share the resources created and collated by the pilots, a Knowledge Hub was set up for each which included a heat pump benchmarking tool, a set of dedicated resources relevant for each stage of the supply chain.

"The tools help decision-making, after users learn more about operational performance, with information about seasonal factors, expected energy consumption and costs, based on building type and specific heat pumps," explains O'Reilly.

Based on the lessons learned in the project, the consortium also produced policy recommendations to help public authorities at various level of governance ensure the availability of skilled professionals. "We highlight where regulations need to be changed, and skills shortages as a significant obstacle to achieving not only heat pump initiatives, but also related ones, such as the European Green Deal and the renovation wave," says O'Reilly

Meeting the challenge

Industry estimates that by 2030, the number of heat pump manufacturing, installation and maintenance workers must increase by 50 %. In addition, at least 50 % of existing energy industry workers must be reskilled for heat pump technologies.

The EU's strategy for sector integration foresees that in 2030 40 % of all residential and 65 % of all commercial buildings will be heated by electricity – many using heat pumps.

"More reskilling and upskilling investment is needed, alongside incentive schemes to attract new professionals. A new

approach, promoting micro-credentials and digital/hybrid learning, alongside the mutual recognition of competencies, should also be pursued," adds O'Reilly.

HP4All's observer countries – Croatia, Portugal and Romania – now intend to become early adopters of the HP4All package, with the team planning to replicate their model in 10 more regions and Member States by 2030.

PROJECT
HP4All - HEAT PUMPS SKILLS FOR NZEB CONSTRUCTION

COORDINATED BY
Technological University of the Shannon: Midlands Midwest in Ireland

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.1., H2020-EU.3.3.7.

CORDIS FACTSHEET
cordis.europa.eu/project/id/891775

PROJECT WEBSITE
hp4all.eu/

Super-cool temperature for industrial processes with solar heat

EU-funded project HyCool is advancing the use of solar heat in industrial processes. Flexible and efficient, the technology developed can be adapted to supply both industry's cooling and heating needs.

Concentrated solar power CSP systems literally concentrate sunlight onto a receiver where the power collected from the sun is converted into heat. Among all the CSP technologies, HyCool is developing its concept based on the cheap and easy-to-install linear Fresnel system. Consisting of a large number of simple mirrors in parallel rows, these mimic a large Fresnel lens to maximise energy collection.

A hybrid – the pump with synergy

The prime mission of the EU-funded HyCool project is to increase the use of solar heat in industrial processes. "We have developed a new Fresnel CSP solar thermal collectors (FCSP) system with specially tailored hybrid heat pumps (HHPs)," says Silvia Jané, HyCool's project coordinator.

"The 'two-in-one' combination of adsorption- and compressor-based heat pumps results in a wider output temperature range, enabling both industrial heating and cooling powered by the sun," Jané explains. By increasing the flexibility of the system configuration, the objective is to extend the range of application of solar heat in industrial processes with temperatures ranging from 5 °C to 240 °C.

"Incorporating a wide range of design and operational configurations, we have increased the number of use scenarios for solar heat in industrial environments," Jané emphasises.

Incorporating a wide range of design and operational configurations, we have increased the number of use scenarios for solar heat in industrial environments."

The proposed system improves the adsorption technologies for cold generation – coupled with increased compactness and plug and play features. This also provides seamless integration with other conventional sources such as electrical energy, resulting in a higher deployability of solar heat in industrial processes (SHIP).

Moreover, when the HHPs developed in HyCool are driven by solar or waste heat and embedded in real industrial thermal processes, they can achieve twice the coefficient of performance of conventional heat pumps and further improve the overall process efficiency.

Component optimisation and final design of the full-scale modular solar HHP and its manufacture and commissioning have been completed. A characterisation protocol for the properties of different adsorber materials such as thermal diffusivity, heat capacity, adsorption behaviour, vapour transport properties and heat of adsorption at different temperatures and pressures has also been developed and will lead to an extensive material testing campaign to select the best candidate for real case applications.

Energy winners in industry and food sectors

"The biggest challenge facing the HyCool project was to obtain a valid configuration for the two pilots based on the first design of the modular heat

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pump and the hydraulic schematic as well as the specifications for each demonstration site," Jané comments. This key step has now been achieved, and field work has enabled a full display of energy profiles.

At the Spanish production site of consortium partner Givaudan, a flavours and fragrances company, the HyCool concept has been applied to several processes with either heating or cooling needs. Givaudan's current cold installation makes use of a glycolic water chiller to keep the water entering the liquid ring of the vacuum pumps at 7 °C, with a thermal demand of 125.5kW. "For the use cases considered, the electrical consumption of the compression chiller will be reduced by 29 % (spring) and 44 % (summer), respectively, by using HyCool technology," says Jané This efficiency gain is even higher if compared to common refrigeration systems.

Another prototype applies the HyCool concept to specialised small food industries with cooling needs in their processes and will be tested at Bo de Debò SL in Spain. Here, the industrial cold installation is necessary for the preparation of precooked fresh dishes and is used in different configurations: the food production area at 6-8 °C, whereas the delivery area is to be maintained at 10-12 °C. HyCool is poised to make a big difference in solar heat use in European industry, and so will the EU-funded SHIP2FAIR project, essentially

HyCool's 'twin' project that is due to finish in March 2022. Their developments focus in particular on the heating needs of the food and agro industry and are being demonstrated and validated in a variety of processes including spirits distillation (Martini & Rossi), meat transformation (Larnaudie), sugar boiling (RAR group) and wine fermentation and stabilisation (RODA). The objective is to supply 40 % of the heat demand through solar power.

PROJECT
HyCool - Industrial Cooling through Hybrid system based on Solar Heat

COORDINATED BY
VEOLIA SERVEIS CATALUNYA SOCIEDAD ANONIMA UNIPERSONAL in Spain

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.2.

CORDIS FACTSHEET
cordis.europa.eu/project/id/792073

PROJECT WEBSITE
hycool-project.eu/

District heating and cooling addresses climate and energy goals

Innovative cost-effective technologies and smart controls support district heating and cooling from low-temperature waste heat and renewable energy sources.

District heating and cooling (DHC) networks rely on one or more centralised plants, conventionally producing hot or chilled water distributed through a network of insulated pipes to nearby buildings, including office buildings, schools, hospitals and airports. By combining loads for multiple buildings, they create economies of scale that can help reduce energy costs.

Since the first generation of DHC in the 1880s, operating temperatures have been decreasing and, more recently, energy sources are shifting to more sustainable ones. The EU-funded REWARDHeat project is accelerating this evolution, developing and demonstrating advanced DHC solutions that drastically reduce source temperatures and exploit thermal energy storage capacity integrated through smart controls. Their cost-effective, high-tech and sustainable solutions will support Europe's Fit for 55 goals.

Flexible and optimised control harnesses waste heat and renewable energy sources

A huge amount of low-grade waste heat is produced within urban areas, primarily by air conditioners and cooling systems in industrial processes, supermarkets and data centres. Lakes and

© Eurac Research

rivers are also an excellent untapped source of low-temperature thermal energy. Exploiting the potential of distributed waste heat and RES requires a new paradigm of construction and operation with greater flexibility.

REWARDHeat's substations integrate thermal energy storage and electric-driven heat pumps. They harness low-temperature (low-grade) waste heat and renewable energy, balance supply and demand, and deliver higher temperatures to the network and the users. Using models that predict loads 24 hours ahead, the team is developing smart controls for individual substations and the entire DHC network to optimise low-grade heat harvesting and minimise the electricity required by the heat pumps.

Grid interoperability: integrating thermal and electric networks

According to project coordinator Roberto Fedrizzi of Eurac Research, "our technologies and smart controls move towards grids interoperability and more flexible integration of RES across energy sectors, via the systematic combination of thermal and electric grids. The electric-driven heat pumps support smart management of thermal capacity and loads, enable potential electric grid services, and deliver efficient and flexible renewable electricity use compared to air-driven heat pump systems."

Beyond an extreme reduction in supply temperature, REWARDHeat's solutions optimise the combined use of thermal and electric renewable energy and waste heat for specific climate and seasonal operating conditions.

Changing policies and practices

REWARDHeat kickstarted investments of more than EUR 20 million, supporting eight DHC demonstration networks that are implementing its innovative technologies and smart control strategies. Supplied with more than 80 % RES or waste heat, they will reduce CO_2 emissions from our DHC networks by more than 35 000 tonnes per year. Explore the demonstrators or try out your own DHC scenarios using the TIMES (The Integrated MARKAL-EFOM System) energy scenario model generator on the project website.

Supplied with more than 80 % RES or waste heat, [the district heating and cooling solutions] will reduce CO_2 emissions from our DHC networks by more than 35 000 tonnes per year.

"The potential of our DHC solutions is huge and recognised by the European Commission in its revisions of the Energy Efficiency Directive and Renewable Energy Directive III. These acknowledge waste heat to be of equal importance to renewable energy for achieving efficient, decarbonised district heating networks," notes Fedrizzi. The team has published a policy paper with key project messages to support decision-makers. The next generation of DHC networks has arrived.

PROJECT
REWARDHeat – Renewable and Waste Heat Recovery for Competitive District Heating and Cooling Networks

COORDINATED BY
Eurac Research in Italy

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.2., H2020-EU.3.3.1.2.

CORDIS FACTSHEET
cordis.europa.eu/project/id/857811

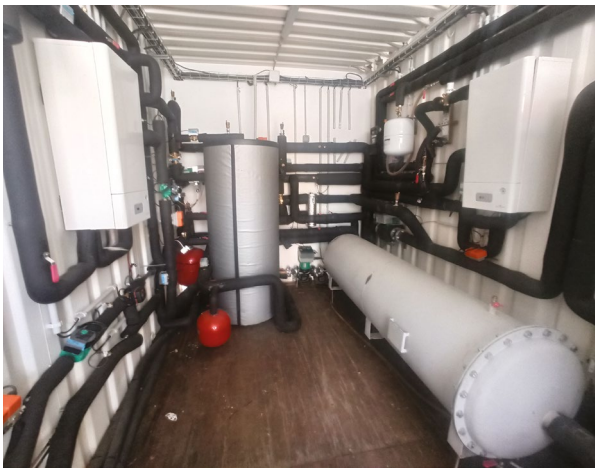
PROJECT WEBSITE
rewardheat.eu/en/

Salt and water: enablers of high-density thermal energy storage

Thanks to a novel selective water sorbent, a seasonal thermal energy storage solution can support residential active solar power throughout the year.

The Sun's energy is practically infinitely renewable and without geopolitical barriers to access. Currently, commercialised residential active solar systems for heating, cooling and domestic hot water include a short-term heat storage tank. The tank can store heat for a few hours, extending operation briefly if clouds roll in or when night falls. However, it cannot accommodate areas with less sun throughout the year, including central and northern Europe, or the increasingly rainy weather even in historically sunny regions.

Seasonal thermal energy storage (STES) is required to unlock the full potential of solar energy. The EU-funded SWS-HEATING project has developed an innovative, cost-effective STES system that can store heat for months. It will support widespread adoption of active solar systems for residential use anywhere in the world, regardless of the weather or climate.



© SWSHeating Project

Selective water sorbents for STES

According to project coordinator Sotirios Karellas of the Laboratory of Steam Boilers and Thermal Plants at the National Technical University of Athens, "one simple STES concept under development relies on large-capacity underground water tanks but high manufacturing costs and large space requirements limit applications, particularly for residential energy needs. Latent heat and electrochemical seasonal energy storage are in their infancy and face challenges related to stability and costs."

SWS-HEATING focused on selective water sorbents (SWSs), using an inorganic salt impregnated in a porous host matrix to trap (adsorb) water molecules. Many host matrices and salts are possible to tailor properties to applications. Further, SWSs have several advantages over other sorbents: minimum heat loss – perfect for long-term (seasonal) storage applications; high heat storage density; and low-cost production.

A new SWS and single-plate heat exchanger

"SWS-HEATING developed a novel SWS material with a storage density in lab testing over 20 % greater than existing SWS materials. It was not degraded nor did it lose adsorption capacity after 1 000 ageing test cycles under working conditions more severe than real ones," notes Karellas.

A single-plate heat exchanger (HEX) for the SWS designed by SWS-HEATING can be used as an adsorber/desorber as well as an evaporator/condenser. This technological feat will

significantly reduce costs since only one type of HEX will be produced, mounted differently for each application.

Critically, "the SWS adsorber/desorber HEX has nearly three times greater adsorbent volume relative to heat transfer fluid volume (2.73 relative to 1.1-1.4 for commercial HEXs). This means much more adsorbent to trap water molecules, enhancing storage density and performance," Karellas adds.

Residential solar power all year round, anywhere in the world

"Remarkably, fruitful cooperation among the consortium members and the European Commission's project officers enabled us to overcome the materials and suppliers' availability and costs challenges and quarantines of the COVID-19 pandemic," notes Karellas. Despite the odds, the project successfully designed and manufactured the holistic SWS-HEATING prototype including its SWS, HEX and a smart control system, enabling proof of concept.

Our [seasonal thermal energy storage (STES)] technology with minimal heat loss can cover up to 60% of a residential building's annual energy needs and will enable solar power exploitation in regions with limited solar availability in the winter.

"Our STES technology with minimal heat loss can cover up to 60 % of a residential building's annual energy needs and will enable solar power exploitation in regions with limited solar availability in the winter. It could be a breakthrough for the residential sector, enabling significant reductions in energy costs and emissions, and support EU energy policy and independence," Karellas concludes.

PROJECT
SWS-HEATING - Development and Validation of an Innovative Solar Compact Selective-Water-Sorbent-Based Heating System

COORDINATED BY
The National Technical University of Athens in Greece

FUNDED UNDER
H2020-EU.3.3., H2020-EU.3.3.2.

CORDIS FACTSHEET
cordis.europa.eu/project/id/764025

PROJECT WEBSITE
swsheating.eu/

Triple the output, triple the green: novel systems cater to the energy needs of multi-family homes

All-in-one carbon-neutral systems provide power, heating and cooling to residential buildings utilising renewable energy sources and natural refrigerants.

For the first time in Europe, a supercooling ice slurry heat pump system was successfully demonstrated in the laboratory, marking a substantial advancement in this technology. Our simulations reveal that solar-ice slurry systems can achieve higher efficiencies at comparable costs to state-of-the-art Ground Source Heat Pump (GSHP) systems, offering several additional benefits.

Twelve partners joined forces in the EU-funded (TRI-HP) project to develop innovative trigeneration systems. Their goal was to develop eco-friendly, affordable energy systems for apartment buildings by combining heat pumps, solar power and energy storage, using 80 % of the 100 % self-produced renewable energy onsite.

The shift from synthetic to natural refrigerants

Aware of the damaging effects of synthetic refrigerants – used since the 1930s and linked to ozone depletion, global warming and health issues – the team sought eco-friendly alternatives. As the core components of heat pumps, sustainable natural refrigerants are essential for minimising the system's environmental impact.

Project coordinator Daniel Carbonell stresses that natural refrigerants (hydrocarbons, water, ammonia and carbon dioxide) provide the most reliable, long-term solution for heat pumps. With this in mind, TRI-HP developed two heat pumps with propane and one with carbon dioxide.

Project members conceived two groundbreaking concepts to provide renewable heat to the heat pumps: the solar-ice slurry system with the supercooling method and the dual source/sink system.

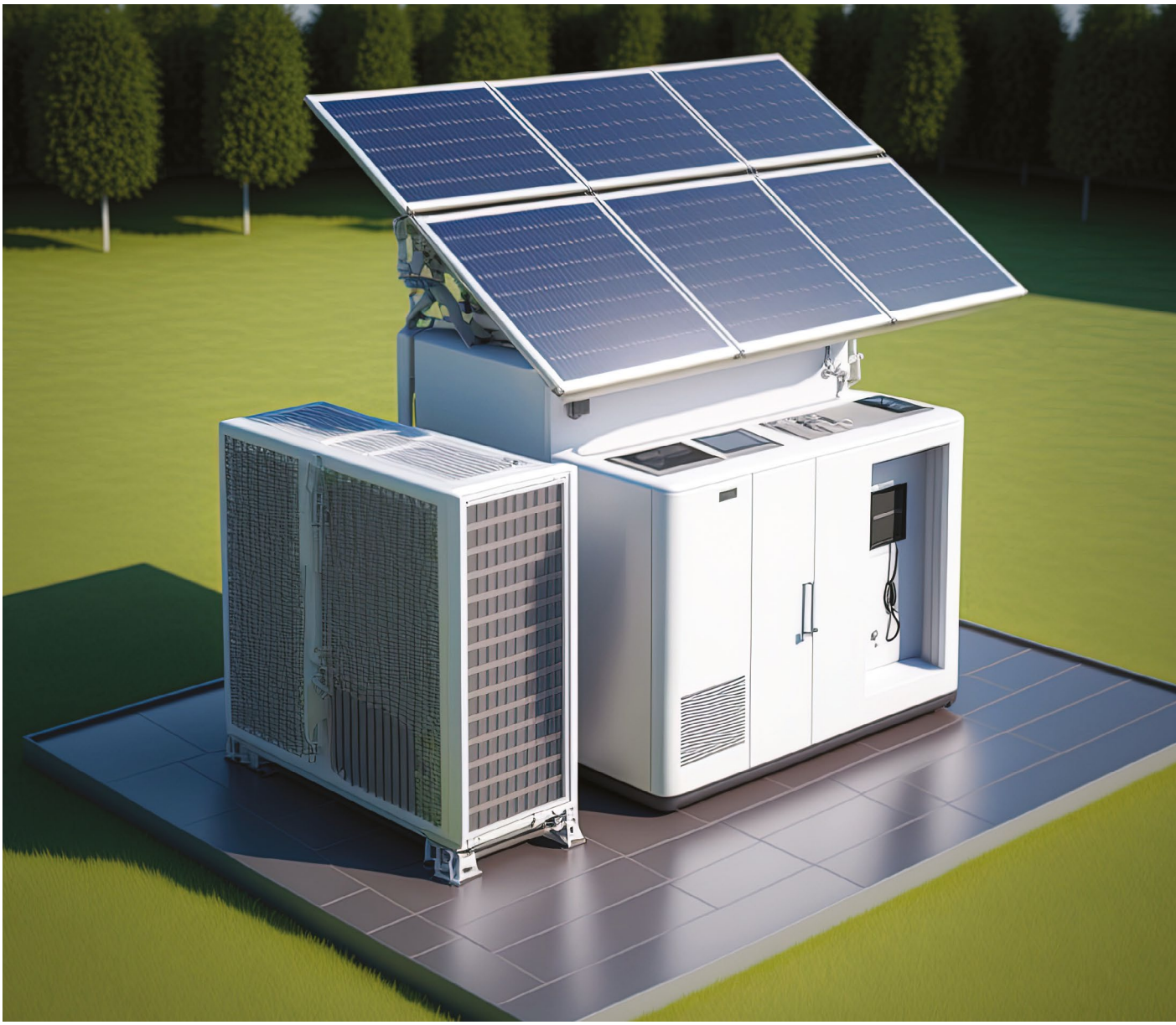
Heat pump system tapping into ground and ambient air

The dual source/sink reversible heat pump system utilises propane as a refrigerant. It is designed to harness two renewable heat sources (ground and ambient air) in the evaporator of the heat pump to provide heating. The same sources also serve as heat sinks for meeting cooling requirements.

In simpler terms, this heat pump system can efficiently switch between using heat from the ground and heat from the ambient air, depending on which source is more suitable at a given time. A key benefit of this dual system is that it has proved to reduce the need for extensive drilling in central Europe.

Harnessing the sun and storing heat in the frost

The solar-ice slurry system serves as a sustainable solution for heating buildings with the capability to provide some free cooling, addressing certain limitations of traditional ground source heat pump (GSHP) systems. By using solar thermal



collectors and ice storage, the system captures solar energy during the summer months and stores it melting the ice to provide heating in the winter. The system also partially charges and discharges daily in the winter to compensate for periods without sufficient solar irradiation such as night-time

"A notable breakthrough was the development of the ice slurry concept that utilises a supercooling method and ice repellent coatings. This innovation allows removing internal heat exchangers from the ice storage, leading to significant cost savings in system installation," remarks Carbonell.

"For the first time in Europe, a supercooling ice slurry heat pump system was successfully demonstrated in the laboratory, marking a substantial advancement in this technology," adds Carbonell. "Our simulations reveal that solar-ice slurry systems can achieve higher efficiencies at comparable costs to state-of-the-art GSHP systems, offering several additional benefits."

Setting the stage for a sustainable residential energy future

Researchers developed an open-source simulation framework called pytrnsys to evaluate the cost and energy potential of their TRI-HP systems across Europe. The propane-based solar-ice slurry system achieved high annual system performance

factors around 4, improving GSHP energetic efficiencies by 5-8 % in certain cities. The levelised cost of energy ranged from EUR 16 to 26.7 ct/kWh, depending on the location.

TRI-HP's innovative trigeneration systems, harnessing natural refrigerants and renewable sources, will pave the way for a greener future in residential energy management

PROJECT
TRI-HP - Triple the output, triple the green: novel systems cater to the energy needs of multi-family homes

COORDINATED BY
OST - Ostschweizer Fachhochschule in Switzerland

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CORDIS FACTSHEET
cordis.europa.eu/project/id/814888

PROJECT WEBSITE
tri-hp.eu/

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