RESTORE

Renewable Energy based seasonal Storage Technology in Order to Raise Economic and environmental sustainability of DHC

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About the RESTORE project

RESTORE - **R**enewable **E**nergy based seasonal **S**torage **T**echnology in **O**rder to **R**aise **E**conomic and environmental sustainability of District Heating and Cooling (DHC) - is a **HORIZON 2020** project financed under the SOCIETAL CHALLENGES - Secure, clean and efficient energy programme.

The main objective of the RESTORE project is to develop a solution that allows integrating a wide variety of Renewable Energy Sources (RES) and waste heat in DHC networks with high supply shares. This is done with an approach based on two key innovative technologies:

• Innovative Thermochemical Energy Storage (TCES) combined with
• reversible Organic Rankine Cycle (rORC): Heat Pump (HP) and Organic Rankine Cycle (ORC)

The innovative combination of rORC and TCES technologies makes it possible to overcome the differences between the availability of heat from RES or waste excess heat and the fluctuating demand for heat or cold in present DHC networks, thus increasing the availability and reliability of energy distribution in supply networks. In summary, the RESTORE project provides a clear break-through thermal energy storage technology for the decarbonisation of the district heating sector, enabling the use of RES and waste excess heat collected in summer for heating purposes in winter in a very competitive way.

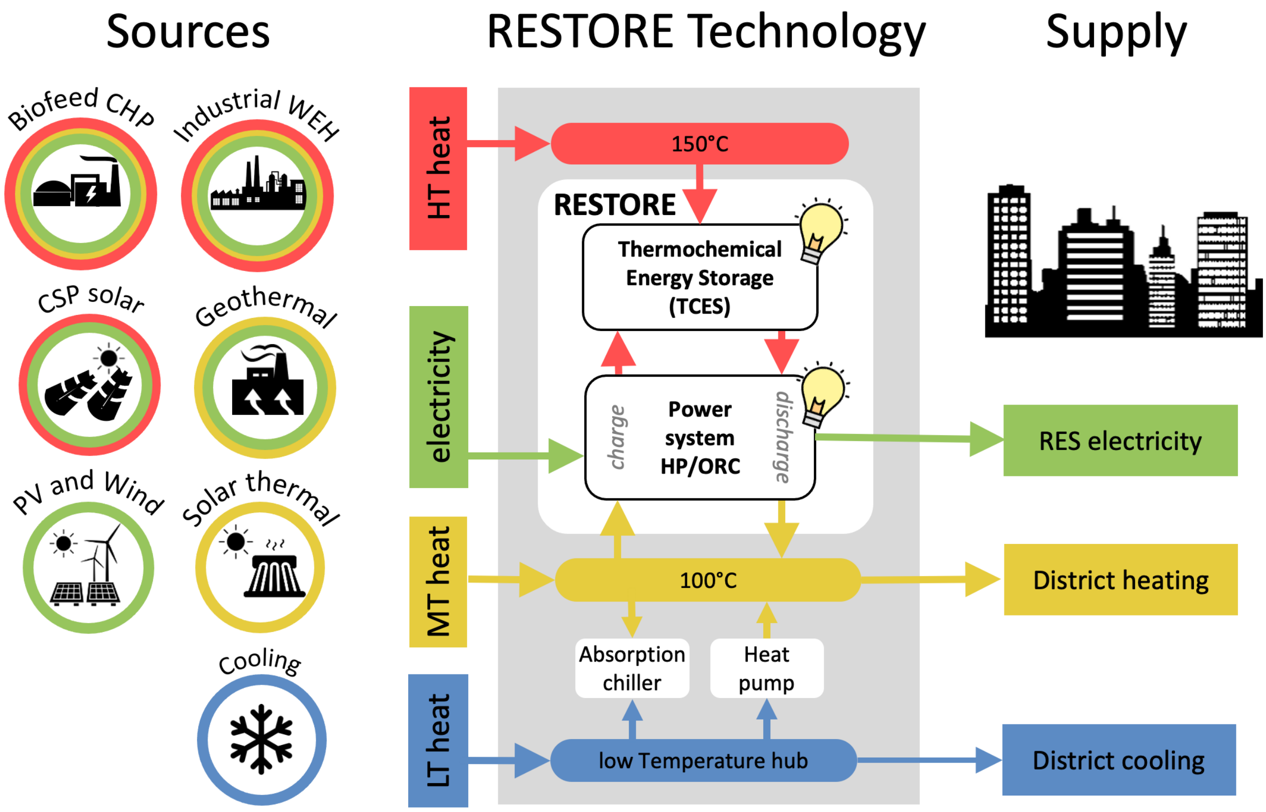
The RESTORE project addresses the heating and cooling sector, which is the sector representing the highest potential for the use of RES and waste heat integration due to fast and cost-effective transformation processes.

The project started in October 2021 and will have a duration of 4 years.

RESTORE technology

The combination of the two key innovative technologies allows the integration of RES and waste excess heat (WEH) in DHC networks, as well as a competitive seasonal storage, allowing for up to 100% renewable shares and significant improvements of environmental sustainability. For an illustration of the concept see the following figure. A wide variety of renewable and waste excess heat sources, also on different temperature levels, as well as renewable excess electricity is possible as energy sources for the RESTORE concept (left column of the figure).

Input low- or mid-temperature heat is managed by the RESTORE concept and either supplied to the DHC network to cover actual existing demand or elevated to high temperature heat by the rORC unit to be stored by the TCES unit for later use (central column of the figure). In periods where the energy demand in the DHC network is higher than the actual availability of energy sources the stored energy can be discharged from the TCES and heat and electricity can be supplied to the DHC network (right column of the figure).



Restore technology (LT: Low Temperature; MT: Mid Temperature; HT: High Temperature)

Advantages of the RESTORE concept:

Local RES and waste heat integration: RESTORE exploits low and high-grade heat and electricity from any kind of RES and waste heat from industries, limiting waste of energy.

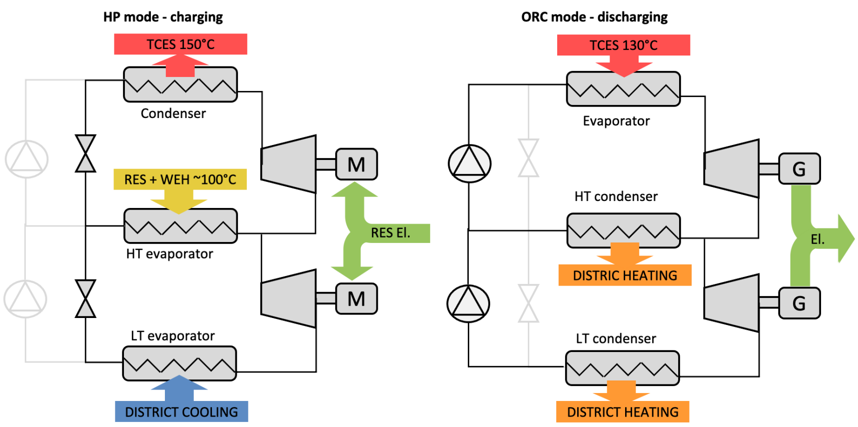
COST-EFFECTIVE & RELIABLE: RESTORE maximizes plant utilization and enables a consistent reduction of the payback period of investment costs by the use of cost-effective and durable components.

HIGH PERFORMANCE: RESTORE ensures high energy density and low heat losses thermal storage unlocking the possibility of short term and seasonal storage of both heat and electricity.

ZERO EMISSION: RESTORE provides electricity, heating and cooling to communities, reducing fuel consumption and greenhouse gas emissions from the DHC sector.

Reversible Organic Rankine Cycle

The RESTORE reversible HP and ORC technology gives the unique possibility to unlock the integration of any kind of RES and WEH in DHC networks ensuring their exploitation all year long with positive effects on environmental and economic aspects. This power system is based on a thermodynamic cycle that can operate as both HP during charging mode and as a direct power cycle in discharging mode.



Multiple level reversible ORC system for charging and discharging TCES
(LT: Low Temperature; HT: High Temperature; El.: Electricity)

The figure shows an example of a complex cycle configuration which is investigated within the project that encompasses a power system with double evaporator HP / double condenser ORC configuration.

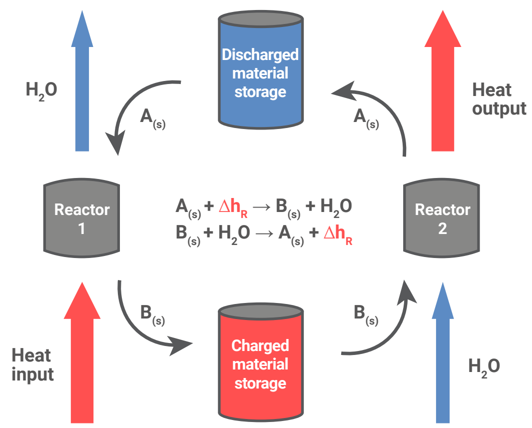
The HP charging cycle is provided by two evaporation levels in order to provide district cooling during summer by contextually boosting energy storage. The thermodynamic cycle when operated as ORC in discharging mode encompasses two condensation levels providing a better match with DH network temperature levels.

Thermochemical Energy Storage

A challenge for integrating high shares of RES and WEH into heat supply systems is the storage of summer surplus-heat until winter, when energy demand is higher. As a result, storage systems that can deposit energy without energy losses over long periods are particularly important.

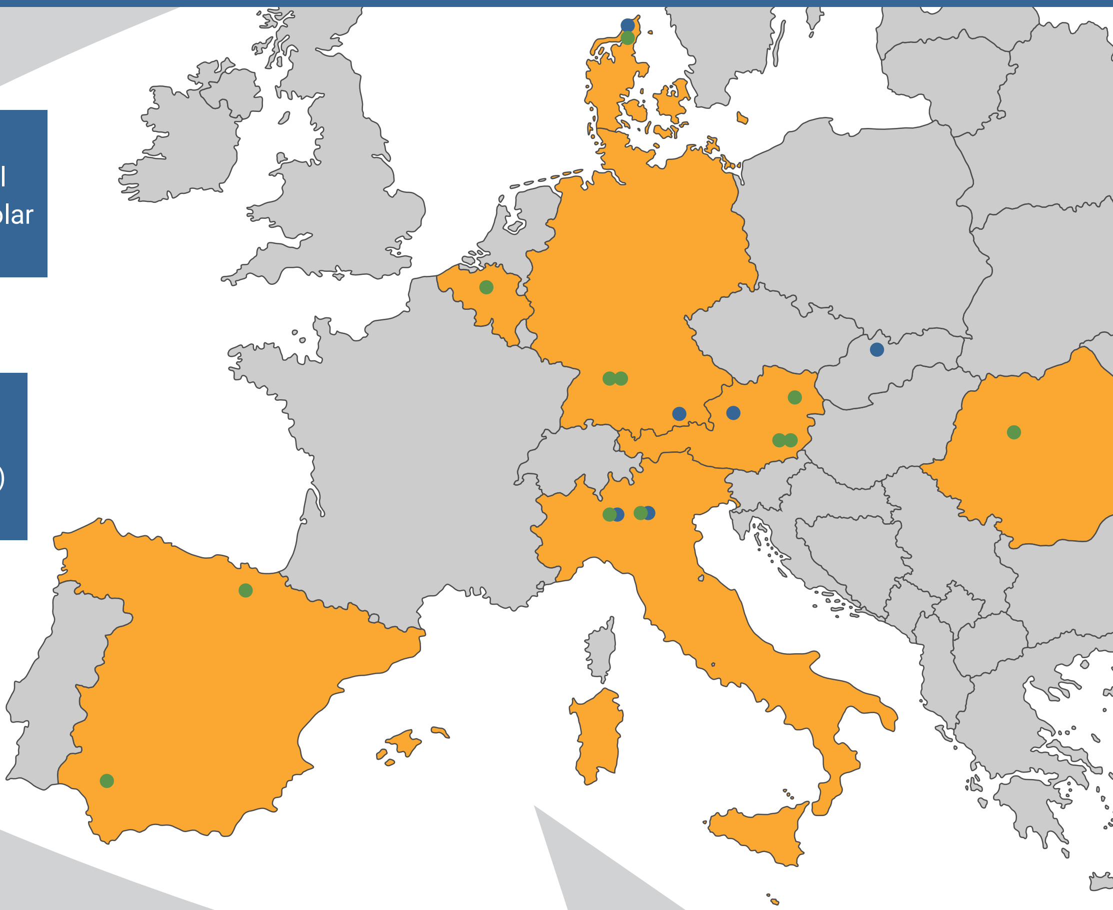
Storing energy in chemical reactions, also known as Thermochemical Energy Storage (TCES), meets this requirement and convinces with high energy densities in comparison to other storage technologies. During charging of TCES, heat is added to an endothermic chemical reaction, which results in products that can be stored separately without losses for any period of time. For discharging, the products are combined again in order to release the reaction enthalpy.

The process can be operated in a continuous mode when using an appropriate reactor concept with two separate reactors and storage tanks in between, see figure. In the first reactor, heat is added, and solid component A reacts to solid component B and a gaseous component, in this case water vapour, which is released. For discharging, component B enters the second reactor with addition of water. This releases the stored energy.



Continuous charging and discharging in two TCES Reactors

Six Virtual Use-Cases will analyse potential configurations of the RESTORE technology for integrating RES and waste heat recovery into different plants connected to DHC networks, spread over different locations in Europe:



Use Case I deals with a residential and industrial DH with biomass and solar collectors in Denmark.

Use Case II deals with the integration of different heat sources in district heating (DH) of a cement factory in Austria.

Use Case III integrates RESTORE with different heat sources in DH of a paper mill in Slovakia.

Use Case IV deals with the integration of different heat sources in DH of a steel industry in Italy.

Use Case V concerns the district heating with geo-thermal technology in a plant in Germany.

Use Case VI deals with the small-scale DHC network of the Politecnico di Milano university campus in Italy.

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with support of the RESTORE project partners.

Image sources: malp - stock.adobe.com, Soonthorn - stock.adobe.com, Solites

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101036766.