Final Press release – Development and validation of innovative thermal energy storage technology succeeded

RESTORE – *Renewable Energy based seasonal Storage Technology in Order to Raise Environmental sustainability of DHC* – was launched in October 2021 with support from the European Union's Horizon 2020 programme (Grant Agreement No. 101036766). The project brought together 12 partners from 7 countries, led by **Fundación CENER**, to develop a concept that facilitates the integration of renewable energy sources and waste heat into District Heating and Cooling (DHC) networks.

The innovative Carnot battery concept is based on two key technologies:

- **Thermochemical Energy Storage (TCES)**: enables long-term storage of heat using reversible chemical reactions
- **Reversible Organic Rankine Cycle (rORC)**: A flexible system that operates as both a heat pump and a power generator, depending on energy demand

The combination of both technologies has been successfully developed and validated in a laboratory environment.

Key Innovation and Achievements

1. **Thermochemical Energy Storage (TCES):** Different TCES reactors have been successfully developed by TU Wien in a scale-up procedure. The largest prototype is a 30 kW_{th} / 150 kWh system that can be operated up to 10 bars and 200 °C to handle different TCES materials like copper-sulfate or potassium-carbonate. After an extensive material examination, stable continuous operation with up to 30 heat charging and discharging cycles has been successfully proven. The reactor design and associated equipment were optimized through numerical simulations and experimental studies to reach high mass and heat transfer. An optimized process flow was engineered that allows for easy scale-up and further systems modularity.
2. **Reversible Organic Rankine Cycle:** In a collaborative work led by Enerbasque and the Politecnico di Milano (POLIMI), a rORC prototype has been successfully manufactured following a comprehensive design process. The key component of this prototype is the reversible volumetric machine based on a twin-screw compressor/expander, allowing to operate as a heat pump or as an ORC based on rotational direction. Moreover, a specific development as heat pump has been done to reach temperatures up to 130 °C. After being tested individually at POLIMI, the prototype was transferred to Vienna to be connected with the TCES prototype. Scale-up to small-to-medium (up to 500 kW) and large-scale applications (above 1 MW) is ongoing, where Enerbasque and Turboden are working on the detailed mechanical design for the respective systems.
3. **Simulation Platform and Virtual Tool:** A virtual tool has been developed by SimTech as an interactive web platform in IPSE GO, accessible via any web browser. The tool includes a customised model library (RESTORE_Lib) that was created to support process modelling of the RESTORE concept, consisting of over 80 component models. It was applied for a virtual representation of the six Use Cases investigated in RESTORE and to allow users to simulate the integration of the RESTORE technology for their own test cases.
4. **Virtual Use Cases:** Based on six virtual Use Cases, potential applications of RESTORE technology at several locations in Europe were analysed. The Use Cases investigate the integration of different kinds of renewable energy sources and waste excess heat from different industry sectors into District Heating and Cooling networks, differentiating between small-scale and large-scale networks. These simulations provide insights into system behaviour and show the benefits of integrating the RESTORE technology into the existing plants, as well as the challenges that have to be overcome. For each of the Use Cases, a techno-economic analysis has been performed, described in the respective deliverables.
5. **Sustainability Assessment:** A comprehensive sustainability assessment confirmed RESTORE's potential to significantly reduce greenhouse gas emissions, improve energy efficiency, and lower operating costs. The TCES material – the energy carrier – can be used again and again in numerous cycles. The use of non-toxic materials, modular design, and compatibility with existing infrastructure further enhance its environmental

sustainability. The socio-economic assessment identified the potential for job creation and skills development, energy resilience through reduced fossil fuel dependency and the potential to lower heating costs as key benefits.

6. **Stakeholder engagement:** All public deliverables are available via the RESTORE website and Zenodo repository. The project actively engaged stakeholders through webinars, workshops, and collaborative testing, fostering a community around the virtual implementation of RESTORE.

Looking Ahead

RESTORE's final phase includes the integration of the rORC and TCES systems and testing of the RESTORE demonstrator at TU Wien, paving the way for industrial application. The consortium invites stakeholders, municipalities, and industry leaders to explore collaboration opportunities and help scale this transformative solution.

Resources

Explore RESTORE's achievements through:

- Project Website: www.restore-dhc.eu
- Brochure: RESTORE Brochure
- Model Library in IPSE GO: RESTORE_Lib
- Use Cases Website: usecases.restore-dhc.eu
- Zenodo Repository with public deliverables: RESTORE on Zenodo
- Project Videos: RESTORE YouTube Channel

Contact

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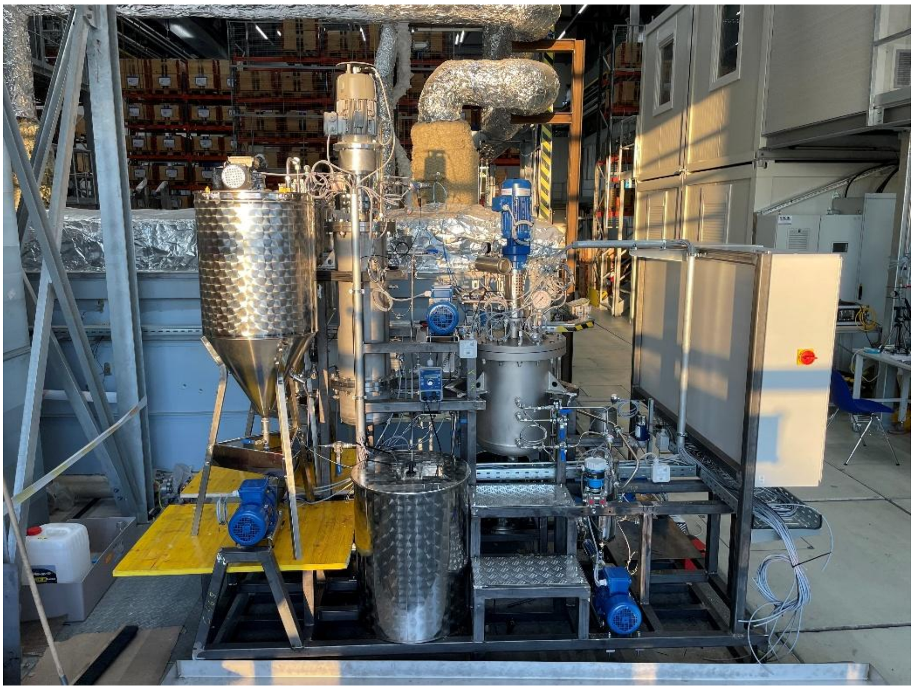
CSP plant in Brønderslev, Denmark that was investigated in Use Case I. Photo: Aalborg CSP

Construction of rORC prototype. Photo: Enerbasque



5 kW_{th} TCES reactor system that has been manufactured as intermediate scale-up step. Photo: TU Wien

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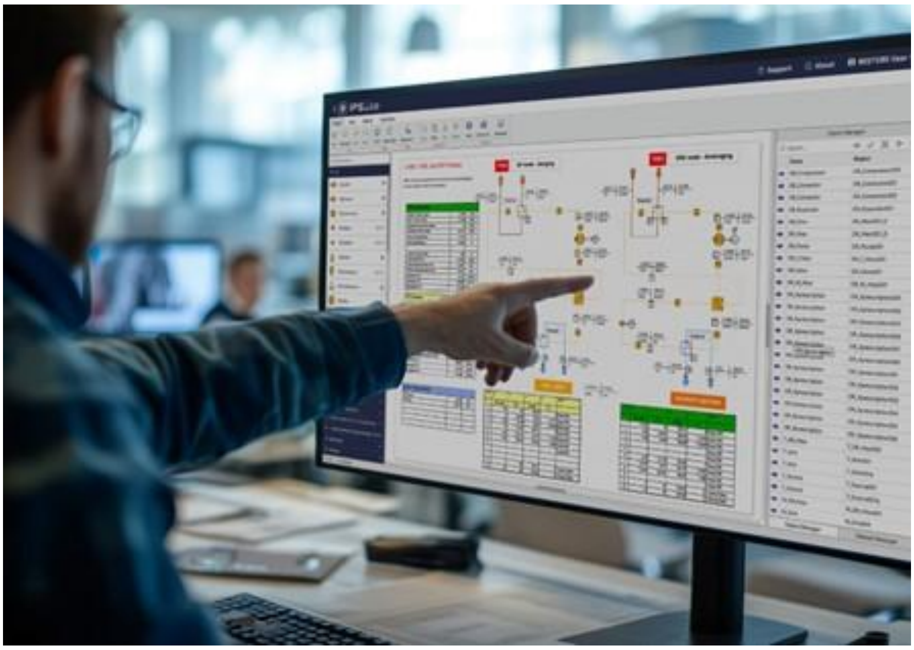

RESTORE Virtual Tool. Photo: SimTech

RESTORE General Meeting at Politecnico di Milano. Photo: Dennis Rein