

A large fraction of energy produced in industry is lost as low-temperature waste heat, especially below 100 °C. Today, there are very few effective and affordable technologies that can store and reuse this energy. The SuperLow project addresses this challenge by exploring an entirely new way of using one of the most common, safe, and environmentally friendly substances on Earth: water.

Under extreme conditions of temperature and pressure, water becomes a *supercritical fluid*, a state where it behaves neither like a normal liquid nor like a gas. In this state, water can store large amounts of thermal energy and release it efficiently. However, in its normal form, supercritical water requires very high temperatures (above 370 °C) and pressures, making it impractical for recovering low-temperature waste heat.

Recent discoveries show that when water is confined inside extremely small pores—only about one nanometer wide—within specially designed hydrophobic materials, it can enter a supercritical-like state at dramatically lower temperatures, close to 100 °C. This unprecedented shift opens the door to using supercritical water for energy storage under mild and safe conditions.

The goal of SuperLow is to understand, at a fundamental level, how water behaves when it is trapped inside such nanoporous materials. The project will investigate whether key features of supercritical fluids—such as enhanced heat storage and reversible energy release—still exist under these extreme confinement conditions. By combining advanced calorimetric measurements, high-pressure experiments, state-of-the-art neutron and X-ray techniques, and atomistic computer simulations, the project will connect thermodynamic behavior with molecular-scale structure.

Beyond energy storage, the knowledge gained in SuperLow may have broader impacts in green chemistry, catalysis, and environmental technologies, including the treatment of persistent pollutants. Importantly, the project relies on abundant materials and water itself, supporting long-term sustainability.

By lowering the temperature and pressure required for supercritical behavior, SuperLow aims to lay the scientific foundations for a new class of thermal energy storage technologies capable of recovering vast amounts of currently wasted low-grade heat, contributing to higher energy efficiency and climate neutrality in Europe.