**Canned Heat: HPC Optimizes Molten-Sulfur Storage for Standby Thermal Energy**

More than 20 percent of US energy consumption is for "industrial-process heating": the use of thermal energy from burners or electric heaters that transform materials such as scrap metal or sand or milk into products like steel, glass, or pasteurized cream.

Because industry runs nonstop, industrial-process heat (IPH) must be reliable night and day, in all weather. This leads to most IPH being powered by natural gas and coal. Researchers are exploring ways to reduce reliance on fossil fuels and decarbonize the industrial sector. A variable renewable-energy source like solar or wind, combined with a way to store this energy, will allow plants to generate 24-hour process heat and rely on renewable energy to replace heat from fossil fuels.

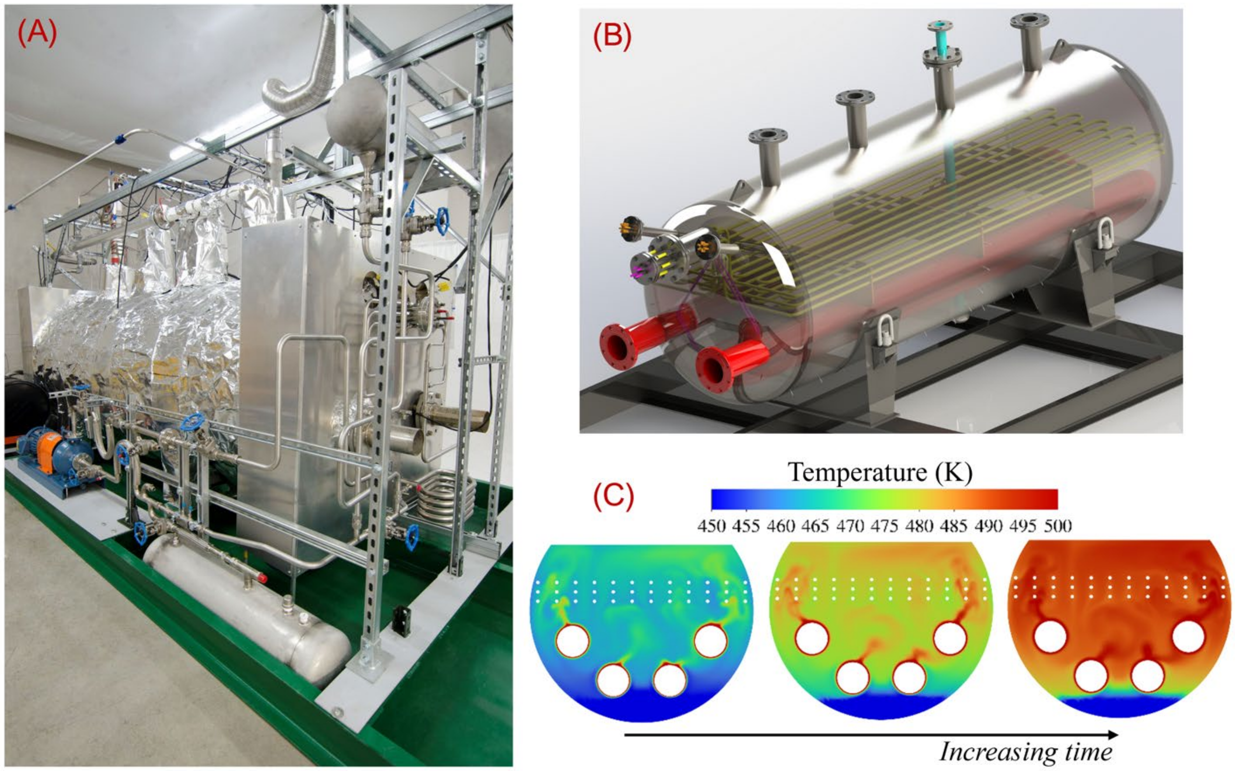
Industrial researchers have investigated various media for holding the heat in thermal energy storage (TES) systems, including metals, concrete, and molten salt, but these solutions are expensive. Element 16 Technologies, Inc., is exploiting molten sulfur, a cheap waste product of the oil and gas production, to develop and commercialize an exceptionally thrifty, flexible TES technology for reliable, plannable renewable energy that competes directly with fossil fuels on cost. Modeling and optimizing a sulfur-TES design, however, requires access to supercomputer to model a formidable conjugate thermal-flow problem involving three-dimensional geometries and complex physics with nonlinear thermophysical properties.

Element 16 turned to the HPC4EI to grind the math and accelerate development and was matched with the National Renewable Energy Laboratory (NREL) for its Eagle supercomputer and experts in computational fluid dynamics and machine learning. The team built a model of conjugate transient heat transfer and fluid-flow phenomena, including customized code mirroring sulfur's thermophysical properties, and simulated product-scale transient sulfur-TES charging and discharging, revealing fascinating insights into the physics.

Extensive simulation studies established a robust correlation between design parameters and performance metrics, and these outcomes informed a user-friendly design tool for sulfur-TES development, deployment, and operational scale-up. Element 16 designers can now customize sulfur-TES installations rapidly, minimizing design iterations and product time to market.

Element 16's first installation of sulfur TES at a US industrial facility will be a 1.5 MWh system that produces process steam for a mineral-processing facility. The project is expected to save tens of thousands of dollars in natural-gas costs annually. When widely adopted in US manufacturing for 100–300 $^{o}$C process heat, sulfur TES integrated with renewable energy could yield annual savings of 4000 trillion BTU at a levelized cost of heat lower than that of natural-gas boilers—while avoiding 210 million metric tons of carbon emissions per year.

LLNL-MI-859391




Snapshots of sulfur-TES technology:  (A) 350-kWh sulfur thermal-energy storage (TES) prototype at Element 16 facility; (B) Engineering drawing of sulfur TES illustrating charge (red pipe) and discharge (yellow pipes) heat-exchanger circuit within molten sulfur; and  (C) 3D computational simulations of the time variation of temperature contours at a cross-section of sulfur TES during charge process.