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Scientists in Poland have developed a compressed air energy storage technology using a thermal energy storage (TES) system built into a disused mine shaft. The system works without external heat sources, and utilizes an air compressor, a compressed air reservoir with a built-in thermal energy storage system, and an air expander.

A group of scientists from the Silesian University of Technology in Poland has developed a compressed air energy storage (CAES) technology using a thermal energy storage (TES) system built into a disused mine shaft, which is effectively repurposed as a compressed air tank. “Our storage concept is aimed at reusing and protecting the post-mining underground infrastructure, which very often, after the closure of the mine, is irretrievably devastated,” the research"s corresponding author, ?ukasz Bartela, told pv magazine.

The group sees these mining sites as having potential for low-cost energy infrastructure. “Mine shafts are usually located in proximity to power plants and/or distribution stations,” the research group stated. “This allows the use of existing grid connection infrastructure. In addition, proximity to highly industrialized areas reduces energy transmission losses. The lack of requirement to build an aboveground TES storage tank economizes the limited space available.”

The system works without using external heat sources, and utilizes an air compressor, a compressed air reservoir with a built-in thermal energy storage system, and an air expander. The elements of the system can be either one- or two-sectional.

In the proposed system configuration, the TES tank is embedded and attached to the shaft casing. This helps reduce heat loss, even when the heat leaves the accumulation material and goes through the air in the shaft reservoir. The TES system itself is adapted to the geometry of the shaft, and the heat conduction field is reduced, which has a positive effect on the energy efficiency of the heat storage process.

“The greatest advantage of placing the TES system in the volume of the pressure reservoir is the possibility of using a thin-walled shell structure in which the thermal energy storage material is placed,” Bartela further explained. “This allows for a significant reduction in the cost of the TES system.”

Steel cylinders with a perforated underside are used to divide the tank into segments, which allows easy installation and periodic inspection of the heat-absorbing material bed. “Communication between the sections will be possible using ladders, which are also part of the TES vertical positioning system,” the scientists specified.

At the charging stage, electricity is used to drive the compressor. The hybrid underground system is charged with hot, compressed air injected into the reservoir through an inlet pipeline with a built-in shut-off valve. The air then flows through the TES system, heating the storage material.

They also explained that, in exceptional situations, it is possible to maintain the air at a pressure of up to 8 MPa, depending on the specific characteristics of the mine shaft. “In this case, the energy capacity of the system may exceed 200 MWh,” Bartela emphasized. “The use of common rocks such as granite or basalt in the TES system will be most advantageous from an economic point of view. Currently, however, research is conducted at the Silesian University of Technology on alternative synthetic materials.”

The group introduced the energy storage concept in the study Evaluation of the energy potential of an adiabatic compressed air energy storage system based on a novel thermal energy storage system in a post mining shaft, which was recently published in the Journal of Energy Storage. “We are currently working only on optimizing the design of the heat storage tank, which could reduce the cost of the TES module,” Bartela concluded.

According to the group, there are 139 shafts in active coal mines in Poland and also 34 shafts in active copper and rock salt mines. Currently, 39 are scheduled for decommissioning, about half of which is used for pumping water. The deepest shafts are over 1,300 m deep.

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