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Compressed air energy storage (CAES) is considered a mature form of deep storage due to its components being firmly "de-risked" but few projects are operating in the Western world. A project in the remote New South Wales town of Broken Hill promises to lead the way.

In a disused mine-site cavern in the Australian outback, a 200 MW/1,600 MWh compressed air energy storage project is being developed by Canadian company Hydrostor. The facility came about after a deal struck with local electricity network operator Transgrid, which had gone to market looking for storage solutions to improve reliability in the famed frontier town of Broken Hill.

Dubbed the Silver City Energy Storage Centre, it will be Hydrostor"s first large-scale compressed air plant and will be one of the first "adiabatic" systems in the Western world, if successfully brought online by its expected 2027 date. Adiabatic CAES systems involve a thermal energy, or heat, storage component, in effect meaning they do not require the fossil fuels which have historically been used in such systems.

Silver City"s compressed air will be stored 600 metres below ground, with a project area of less than 40 hectares and a life expectancy of 50 years, as Hydrostor Australia vice president of origination and development, Martin Becker, told pv magazine.

Since compressed air batteries use turbines, the plant will also provide system strength and inertia to the electricity grid. Its grid services will be far more consistent than the synthetic inertia offered by big batteries, Becker added, since lithium batteries degrade with cycling and therefore can only act as virtual synchronous machines for a few hours per day. Hydrostor expects to reach a final investment decision on Silver City this year.

CAES today sits at a curious nexus. On the one hand, the technological components and individual systems that go into these large infrastructure projects are proven and have been used in industry for decades, sometimes centuries.

Only a handful of compressed air plants have ever made it into commercial operation, however. A 321 MW plant has been running in Huntorf, Germany, since 1978 and, since 1991, a 110 MW plant has operated in McIntosh, Alabama, in the United States. Both of those projects are diabatic - meaning they do not store heat and so use fossil fuels in their processes. Adiabatic compressed air systems are a far more recent phenomenon. Hydrostor opened the first commercial adiabatic plant in 2019, in Goderich, Ontario, in Canada, but the project has a peak power output of just 1.75 MW.

For Australian agency the Commonwealth Scientific and Industrial Research Organisation (CSIRO), compressed air is one of the most promising deep storage technologies, largely because of its comparatively low cost, long asset life, and relative flexibility. While costs are highly project dependent, a 2021 paper by David Evans et al., published in Applied Sciences noted CAES costs could be as low as $3/kWh to $6/kWh.

"The per-unit cost goes down the bigger it gets, which isn"t true for batteries," said Ben Clennell, a senior principal research scientist at CSIRO. CAES, said Clennell, "is cost competitive and if it"s also competitive in terms of being able to get projects up and running, and the geological locations are suitable ... it could play a large role [in energy storage]. We"re one gigaproject away from having a project that is actually demonstrating this technology in the Western world."

Compressed air batteries pressurize atmospheric air, storing energy in the form of potential energy, like a spring. To discharge, the air is released via an expander, to spin a turbine. Systems have two core components: the above-ground plant, with its turbomachinery, and the below ground storage void - which can take numerous forms.

Efficiencies between the types differ, with diabatic systems generally offering 50% to 55%, and potentially 60%. CSIRO"s Clennell says round-trip efficiency for adiabatic CAES systems with top-tier technology is somewhere around 70%. "It"s pretty well established what those numbers are," he said. "There are no bits we don"t understand, it"s just an engineering problem to get the best efficiency possible, really, without having an enormous amount of overbuild on the expense of the components. It"s unrealistic to go above around 75%, I think."

The company has opted to simply store heat in the form of pressurized water within insulated spherical tanks. That and every other aspect of Hydrostor"s system is designed around existing industrial kit.