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CAES 2.0 - Compressed Air Energy Storage, the next generation

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Abstract

For decades, the world has known only two compressed air energy storage (CAES) plants storing air in solution minded caverns. These were mostly built as back-up and black-start solution for power plants and for frequency regulation. In the past decades, several CAES developments were started and CAES pilots have taken place, but hardly any of these projects and pilots made it further than the initiation phase or evolved into full-scale developments. Only recently, the third CAES-plant in the world was commissioned in China.

In the meantime, integration of renewables is presenting a range of challenges to the existing electricity infrastructure. Long duration energy storage techniques, like CAES, can offer solutions to many of these challenges, while reducing the demand for fossil fuels in times of low renewable generation and substantially reducing GHG emissions. As pumped hydro storage, the CAES technology can store massive amounts of energy. Due to the increasing disbalance between electricity demand and the growing (but fluctuating) production of renewable electricity CAES is gaining in popularity as it minimizes curtailment and can deliver green energy, even when the sun does not shine, and the wind does not blow.

From this perspective, Corre Energy is co-developing a number of next-generation CAES-projects across Europe, of which the CAES-project in Zuidwending in the Netherlands, and the Green Hydrogen Hub in Lille Torup, Denmark, are the most advanced.

Besides offering different solutions to the electricity system than in the past, these CAES-projects differ in several technical aspects from the first generation CAES facilities, like the size of the installed compression and expansion capacity, the operating pressures during compression, during storage in the salt cavern and during expansion, and the shape, depth and size of the caverns. Also, the duration of both compression and power generation has increased significantly.

Another technical development in the CAES technology is the fuel the CAES installation needs to heat up the expanding air. While this used to be natural gas, consuming finite fossil energy sources and causing the emission of greenhouse gases, the next generation of CAES-plants will be fueled by (preferably green) hydrogen, as soon as this is readily available at the different CAES plant locations.

Of course, the changes in the plant's technical specifications and in the expected operational patterns, do require well-founded investigation of the thermodynamical and rock-mechanical effects to ensure cavern stability and safe cavern operation during the entire cavern lifetime. First results of these highly sophisticated investigations show that alternations of shorter time periods of compression and expansion do not lead to the onset of tensile effective stress, possibly leading to the creation of small fractures, and no dilation.

Based on this all, the conclusion can be drawn that the on several aspects enhanced CAES will become an important Long Duration Energy Storage application in the upcoming decade.

Key words: Compressed Air Energy Storage (CAES), Renewable energy, Rock Mechanics, Storage Cavern