Novel CO_2-based electrothermal energy and geological storage system

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Rising energy demand is pushing electricity prices and emissions to unprecedented levels, with serious implications for the economy and the energy transition. The EU's long-term climate strategy and the European Green Deal emphasise the key role of renewables in the continent's decarbonisation goals and the implementation of large-scale energy storage to continuously power the entire electricity system.

The CEEGS (CO_2-based Electrothermal Energy and Geological Storage Systems) research project is a three-year project funded by Horizon Europe EU programme. The project aims to implement a new transcritical CO_2 cycle concept, based on underground energy storage and simultaneous CO_2 sequestration in the geological reservoirs. Due to the thermodynamic properties of CO_2, this gas will act as a working fluid in the energy storage system. Under favourable geological environments, an added value may result from geothermal heat recovery.

The main challenge of this project is to solve the difficulties related to the interface between the surface and underground parts. This includes aspects related to CO_2 flow composition, well design, turbomachinery properties and overall integration. To achieve this, a conceptual integration design is to be developed and adapted to operate in different scenarios and modes of operation based on: Energy storage from renewable energy sources or energy storage for CO_2 capture.

Preliminary results show that these cycles are promising energy storage technologies, highly competitive in terms of electricity-to-electricity storage efficiency (42-56%) and cost (70-120 USD/MWh) for energy storage capacities ranging from 500 kW and limitless. Furthermore, the results indicate that more than 1 Mt/year of additional CO_2 can be stored [2,3]. The energy storage system is composed both of surface thermal storage and of underground storage through CO2 injection and production wells, thus decreasing environmental and visual impacts at surface. The CEEGS concept has great potential to be replicated worldwide in a range of realistic geological environments.

The project is expected to increase the CEEGS current TRL 2 to TRL 4, through overcoming obstacles such as the interfacial gap between the surface transcritical cycle and the CO_2 reservoir, improving the technological economics of the technology and to prove its feasibility. An analysis of the social, economic and sustainability impact is to be conducted to clarify the contribution of the technology for the climate change mitigation, its economic viability and possible business models, while identifying the social acceptance challenges that it may face.

By coupling energy storage with direct CO_2 emissions reductions, CEEGS supports the ambition of the Paris Climate Agreement and Europe's green objectives to explore new smart energy systems. This will improve the efficiency and cost-effectiveness of CO_2 capture, utilisation and storage (CCUS), enabling cost-effective and environmentally friendly renewable energy storage technology.

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References

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