CEEGS

Novel CO_2-based Electrothermal Energy and Geological Storage system

Frequently Asked Questions (FAQ)

What does CEEGS stand for?

CEEGS is an acronym for a project entitled "CO_2-based electrothermal energy and geological storage system".

What is the CEEGS project?

CEEGS is a research initiative funded by the European Union. Its goal is to create cutting-edge technology for the energy transition by combining renewable energy storage using the transcritical CO_2 cycle, storing CO_2 in geological formations, and extracting geothermal heat.

Who is working on this project?

The project is led by the University of Seville and includes a consortium of 10 key partners from 5 EU countries, along with 20 affiliated entities. The team is made up of experts in energy systems, storage technologies, geology, geothermal systems, and CO_2 storage.

Why is the EU funding this project?

The EU prioritises decarbonisation and achieving net-zero greenhouse gas emissions. CEEGS addresses three key challenges:

- Phasing out fossil fuels and reducing environmental impact
- Creating economically viable and innovative energy storage systems
- Solving the mismatch between renewable energy generation (e.g., from wind and solar) and energy consumption

By developing an underground electricity storage system that uses CO_2 as a working fluid, CEEGS offers a groundbreaking approach to renewable energy storage while also capturing and storing CO_2 safely in geological formations.

What does 'transcritical CO2 cycle' mean?

The term **transcritical CO_2 cycle** refers to a thermodynamic process in which carbon dioxide (CO_2) is used as a working fluid to transfer energy. The cycle operates across the critical point of CO_2, which is the temperature and pressure at which the distinction between liquid and gas phases disappears.

In a transcritical CO_2 cycle:

- **CO_2 as a Working Fluid:** CO_2 is compressed to a supercritical state (above its critical point: 31.1°C and 7.38 MPa) and then expanded or cooled to extract energy.
- **Crosses Critical Point:** The process moves between supercritical and subcritical conditions, enabling efficient heat exchange and energy transfer.
- **Applications:** This cycle is widely used in advanced refrigeration systems, heat pumps, and energy storage technologies due to CO_2's favourable thermodynamic properties, such as high efficiency and eco-friendliness.

In the context of CEEGS, the transcritical CO_2 cycle enables energy storage and retrieval while integrating CO_2 storage and geothermal heat extraction, making it a key innovation for renewable energy systems.

Photo: Pressure test on the CEEGS installation prototype developed at the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) in Dresden, Germany. Credit: HZDR.

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What are the environmental benefits of the technology?

CEEGS provides a clean energy storage system for renewable electricity, while safely and permanently storing CO_2 in geological formations. The technology uses low-impact materials to minimise environmental harm. It supports decarbonisation and renewable energy reliability.

Does the technology involve any risks for the environment or health and safety?

The CEEGS technology aims to minimise risks to the environment and health and safety through careful design and planning. However, like any innovative technology, it involves some challenges that must be addressed:

- There is a potential risk of CO_2 leakage from geological storage sites. To mitigate this, the project uses advanced monitoring systems and ensures storage in secure, well-characterised geological formations.
- Large-scale projects may disturb local ecosystems during construction or operation. Measures like environmental impact assessments and sustainable site selection minimize this risk.
- CO_2 is a colourless, odourless gas that can displace oxygen in confined spaces, posing a suffocation hazard. Safety protocols, proper ventilation, and monitoring equipment need to be in place to address this.
- The technology involves high-pressure systems for the transcritical CO_2 cycle. Proper design, regular maintenance, and safety controls minimise risks related to pressure containment.

In summary, while there are potential risks, the project incorporates robust risk analysis to mitigate them, prioritising safety, sustainability, and environmental protection.

By when can we expect a commercialisation of the technology?

The development process is divided into three stages:

1. **Stage 1:** The current three-year project will demonstrate the concept and solve challenges at the interface between surface and subsurface parts. This stage will achieve Technology Readiness Level (TRL) 4 through a 20 kW lab-scale demonstration.
2. **Stage 2:** A second three-year phase would create a 100 kW demonstrator, integrating all components and reaching TRL 6.
3. **Stage 3:** A final three-year project would scale the technology to a commercial level.

If all stages succeed, commercialisation could begin within approximately 9-10 years.

Where is the technology most likely to be first implemented?

The technology is most likely to be first implemented in regions with:

- Significant renewable energy production, such as wind or solar farms, that require efficient storage solutions to balance energy supply and demand.
- With suitable geological conditions for CO_2 storage, such as depleted oil and gas reservoirs or saline aquifers, which are ideal for integrating this technology.
- Government incentives, research funding, and policies supporting decarbonisation and energy storage innovations.
- Industries that emit large amounts of CO_2, where the captured CO_2 could be used in the system, turning emissions into a resource.

Examples include countries in Europe, such as Germany, Spain, and the Nordic countries, which are leaders in renewable energy and CO_2 sequestration technologies.

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How does CEEGS differ from other energy storage technologies?

CEEGS is an innovative energy storage solution that offers multiple benefits: it integrates with renewable energy sources, scales up to large storage capacities, stores CO_2 underground, connects easily with major CO_2 producers, supports heating and cooling applications, and remains cost-effective with a low environmental impact.

What makes CEEGS unique is its ability to achieve a **negative CO_2 footprint**. It operates through a two-phase cycle:

- **Charge phase:** CO_2 from a capture plant enters the renewable energy storage cycle and is injected into an underground well.
- **Discharge phase:** The CO_2 extracted from that well goes through the power production cycle while being simultaneously injected into a secondary well.

This continuous process ensures that **more CO_2 is injected than produced**, making CEEGS a powerful tool for emissions reduction.

Additionally, CEEGS can manage a steady supply of CO_2 from capture facilities, allowing it to store and generate electricity while permanently sequestering captured CO_2 in underground geological formations.

How much does it cost to implement and maintain the CEEGS system compared to other renewable energy storage solutions?

Preliminary studies suggest that CEEGS is economically competitive, though the exact cost depends on the system size and location. For a **10 MWe plant**, the estimated cost of electricity production (LCOE) is around **105 USD/MWh**, which is slightly higher than standard solar PV without storage (**60-70 USD/MWh**) but falls within the range of similar energy storage systems (**70-140 USD/MWh**).

The actual cost will depend on factors such as storage capacity and geological conditions.

How much CO_2 will be safely stored underground, and for how long?

During the initial setup, CEEGS will store approximately **2 million metric tons** of CO_2 over **two years**. After that, the system will continue operating with an annual CO_2 storage of **250,000 metric tons**. The amount of CO_2 stored and its duration depend on the geological conditions of each site, but once injected, the CO_2 remains permanently trapped in underground formations.

Photo: CO_2 pump installed and connected to the CEEGS test facility at the Helmholtz-Zentrum Dresden Rossendorf (HZDR) in Germany. Pressure and leakage tests were performed to ensure the safe and stable operation of the pump. Credit: HZDR.

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Are there any risks to local communities near geological storage sites?

CEEGS is designed to be safe for local communities. It operates in a **closed-loop system**, meaning no gases or fluids are released, No waste is generated and there is no risk of contamination. The system also helps reduce emissions by storing CO_2 underground.

Regarding **seismic activity**, CEEGS follows strict safety protocols similar to those used in **existing CO_2 storage and geothermal projects**. These include:

- **Risk assessments** before operations
- **Real-time monitoring** of underground activity
- **Prevention and mitigation plans** to address potential seismic activity

These measures ensure safe and reliable operation.

What regulatory measures are required to implement this technology?

As CEEGS is an emerging technology, specific regulations may still need to be developed. However, it will likely follow existing **CO_2 storage and geothermal energy regulations**, which require:

- **Environmental impact assessments**
- **Government permits** for CO_2 injection and storage
- **Safety and monitoring plans** to prevent environmental risks

There are other similar projects that can serve as references. Fervo Energy is developing the **multi-phase Cape Station** geothermal project in **Utah, USA**. **Phase I** is set to begin operations in **2026**, delivering **400 MW of 24/7 carbon-free geothermal power** to the grid.

How do I find out more about the project?

Video explainer: https://youtu.be/y94fHCM__us

Project Brochure: https://tinyurl.com/2p9hc9n4

Project Website: https://ceegsproject.eu/

Social Media:
Facebook: https://www.facebook.com/ceegsproject
X: https://twitter.com/ceegsproject
LinkedIn: https://www.linkedin.com/company/ceegs-project/
Instagram: https://www.instagram.com/ceegsproject/
YouTube: https://www.youtube.com/channel/UCDcsrOEr4MQssP8IH4dKVWQ

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