

Transversal intersectoral decarbonisation as GHG balance (D6.2)

CEEES (CO₂ based Electrothermal Energy and Geological Storage system) is a cross-sectoral technology for clean, cheap and large-scale storage of renewable energy based on transcritical CO₂ cycles, intermediate CO₂ storage in geological formations and geothermal heat extraction. Due to the central role of CO₂ within the storage concept, the task “Transversal intersectoral decarbonisation as GHG balance” studied suitable CO₂ sources, relevant transport infrastructure as well as existing national energy infrastructures for the regional cases of Germany and Spain as a potential CO₂ supply/distribution framework for CEEES deployments.

Large stationary CO₂ emitters from hard-to-abate industries were identified and clustered into regional clusters and checked for their proximity to potential geological storage sites as well as other relevant infrastructures. An EU-wide emission database, including information on emission types, operators, quantities and their exact locations, was established based on the Emissions Trading System of the European Commission for the year 2022 (**EU ETS, 2024**). Large, hard-to-abate industries (refineries, iron and steel manufacturing, production of other metals, cement and lime production, non-metallic minerals production, pulp and paper and production of chemicals) accounted for total CO₂ emissions of 474.8 Mt within the framework of the EU in 2022 (exclusion of emitters < 50 kt and emitters from fuel combustion).

Utilizing a density-based clustering algorithm including noise and therefore outlier detection was employed to identify regional emitter clusters that feature minimal distances between single emitters for selection of potential CEEES deployment sites as shown for the case of Germany (Figure 1).

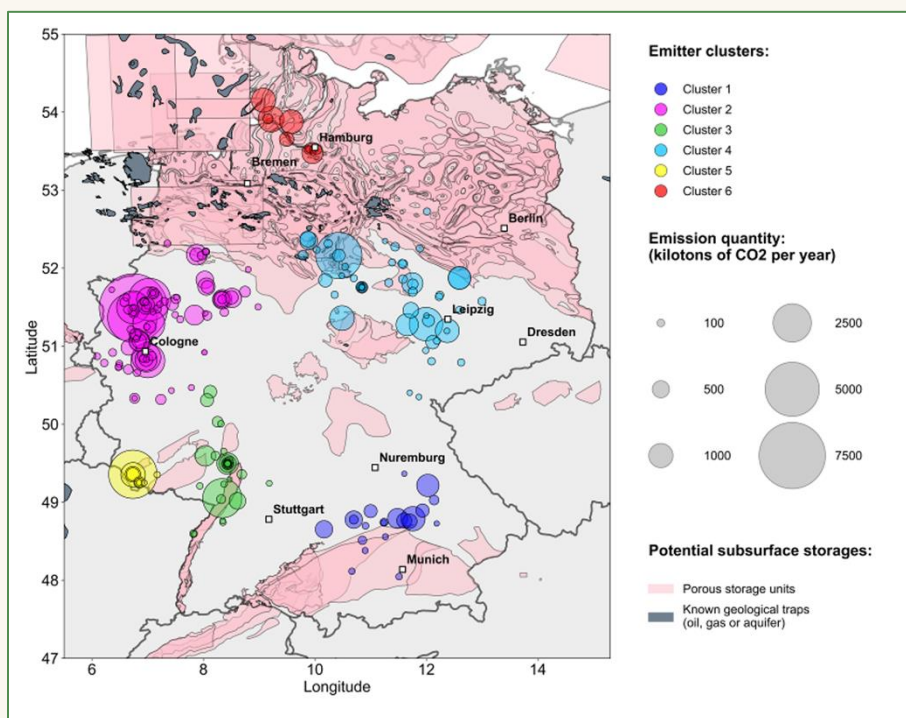


Figure 1. Identified emitter clusters in relation to potential aquifer CO₂ storage sites for Germany.



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Proposed storage sites are deep saline aquifers and saline formations, with aquifers being focused on here. Germany possesses numerous favourable sedimentary basins suitable for deep saline aquifer CO₂ storage, primarily the North German Basin, the Upper Rhine Graben, and the South German Molasse Basin. Especially deep saline aquifers, porous rock formations filled with saltwater, offer large scale CO₂ storage potential of about 9 Gt in Germany (**Knopf, 2010**). Other porous stores, such as depleted oil and gas fields, provide an estimated additional storage potential of about 2.8 Gt (**Knopf, 2010**). For the regional case of Germany, 274 emitting industrial installations with total annual CO₂ emissions of 102.2 Mt were identified, with most of the emissions originating from very large emitters and being related to the production of pig iron or steel and refining of mineral oil (48.1 Mt in total). The most beneficial sites will be situated in the northern and southern/south-western (Alpine foreland, Rhine valley, etc.) part of Germany due to the relative abundance of saline aquifer storage space and as those regions are projected to offer minimal CO₂ transportation costs and therefore improved CEEGS process economics and hence electricity costs..

Spain features four main geological domains related to potential formations for deep saline aquifers: (1) the Cantabrian Range and Duero Basin; (2) the Pyrenees and Ebro Basin; (3) the Iberian Range, and Tajo and Almazán Basins; and (4) the Betic Cordillera and Guadalquivir Basin. In 2022, the selected hard-to-abate industries (132 installations) reported annual CO₂ emission of 44.6 Mt, which were mainly attributed to the refining of mineral oil and production of cement (25.18 Mt in total). The identified emitter clusters and potential aquifer storage sites for Spain are displayed in Figure 2.

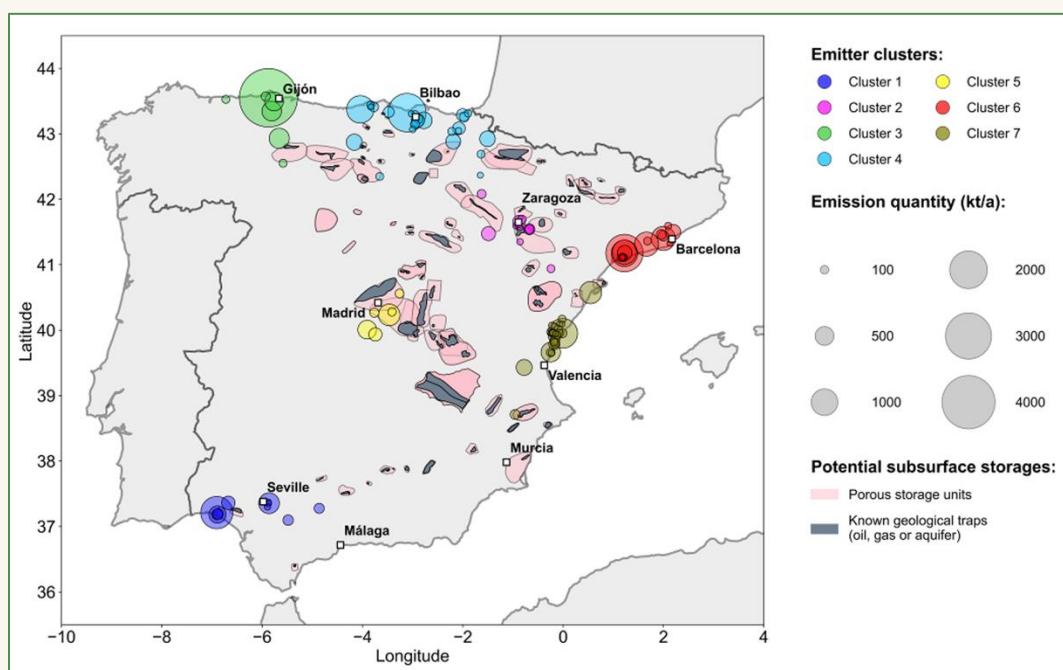


Figure 2. Identified emitter clusters in relation to potential aquifer CO₂ storage sites for Spain.



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The regional case of Spain revealed that most of the potential emission clusters are to be found in coastal areas, while suitable storage sites are mostly located in the interior of the country. Promising areas for defining scenarios are located around the cities of Madrid and Zaragoza, while less suitable clusters (Barcelona, Valencia), although being of the largest quantity, might require dedicated CO₂ transportation structures for future CEEGS deployments.

The conducted studies showed that a significant part of the national GHG balances with respect the emission subset of the manufacturing and construction sector (Germany: 155.7 Mt/a; Spain: 55.0 Mt/a) could be covered in case of a full utilization of the analysed emissions, allowing for a specific GHG reduction potential of 52.9 % (Germany) and 60.2 % (Spain).

References:

EU Emissions Trading System (EU ETS), 2024 Union Registry - European Commission (europa.eu).

Knopf, 2010. S. Knopf, F. May, C. Müller, J.P. Gerling. "Recalculation of Potential Capacities for CO₂ Storage in Deep Aquifers", BGR, Hannover, pp. 76 – 80, 2010.

For more details, please consult Deliverable 6.2: <https://ceegsproject.eu/d62>

How do I find out more about the project?

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