Role of CO_2 Geological Storage in Reaching Climate Targets in the Baltic Sea Region: Technological Prospects and Regulatory Challenges

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European Union is planning to reduce at least 55% of greenhouse gas emissions (GHGE) by 2030 compared to 1990 and 40% of GHGE by 2030, compared to 2005 with a final target to reach climate neutrality by 2050 (EC 2023). CO_2 capture, transport, use and storage (CCUS) is one of the available technologies permitting to reach ambitious European climate targets. The Net Zero Industry Act proposed by the European Commission (EC) is planning geological storage of 50 Mt of CO_2 annually by 2030 (EC 2024).

Baltic Sea Region (BSR) countries, following increased EC requirements to national energy and climate plans (NECP), made noticeable progress in the implementation of CCUS. However, there is a significant difference in national policies, regulations, and support in the Nordic and Baltic States.

The most exciting jump into CCUS deployment was made in Denmark. The country implemented supporting CCUS policies and regulations and granted exploration permits to two CO_2 geological storage (CGS) sites offshore (Greensand and Bifrost depleted hydrocarbon fields) and pilot and demonstration CO_2 injection permits to the Greensand site. The governmental and public funds are supporting CCUS R&D projects in Denmark including CO_2 capture, utilization, Bio-CCS, CGS onshore and cross-border transport and storage.

Sweden and Finland are developing CCUS projects supported by the EU Innovation Fund, including CO_2 transport by ship for CGS under the seabed in the North Sea. Den-

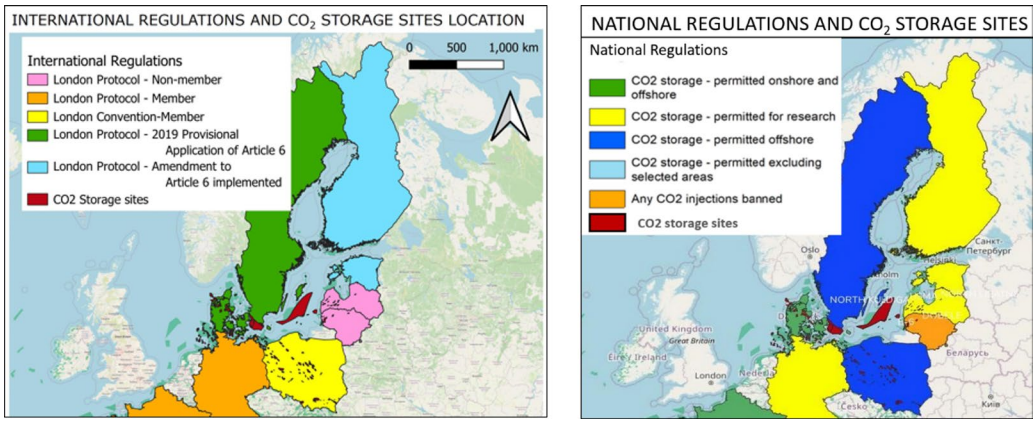


Figure 1. Implementation of London Protocol (left) and EU CCS Directive (right) in the Baltic Sea Region countries and location of CO_2 storage sites.

mark and Sweden have implemented national and international regulations needed for cross-border CO_2 transport and storage (Fig. 1).

Significant progress is reported in Poland, where CGS is already permitted offshore and the process to permit industrial-scale CGS onshore is in progress.

In contrast to the Nordic Region and Poland, implementation of the CCUS technology in the Baltic States is much more uncertain. Large plants in Estonia, Latvia, and Lithuania need to implement CCUS, while the governmental and policy support is very far from the needs of the large industrial CO_2 emitters. At present, industrial CGS is banned in all Baltic States (Fig. 1, right). Latvenergo power plants (PP) and Schwenk Cement Latvia (SC) planned to implement CCUS projects with CGS in Latvia. They communicated with Latvian policymakers about their need to raise the ban on CGS. However, the regulatory situation in Latvia has not yet changed. SC, the owner of the cement plants in Latvia and Lithuania,

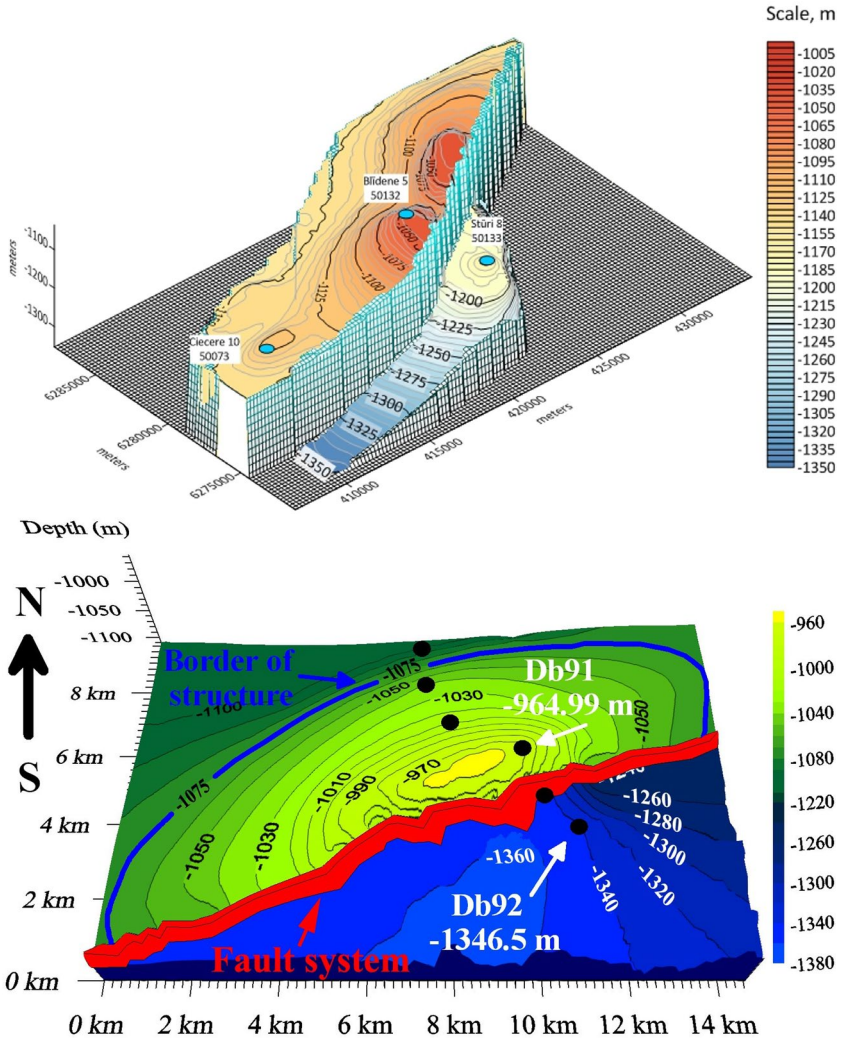
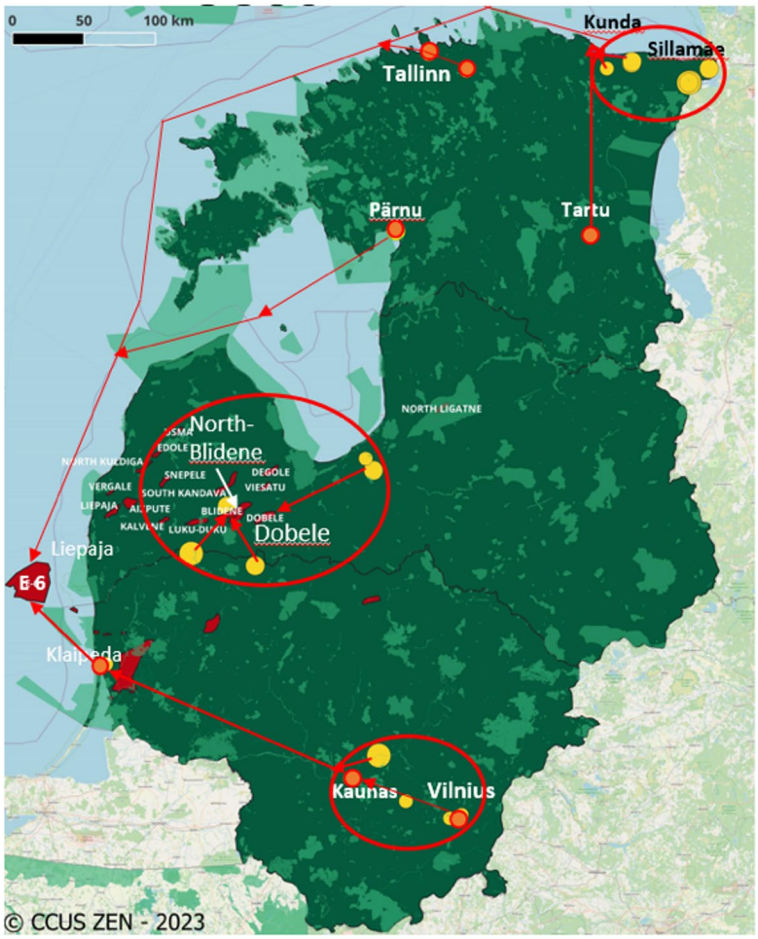


Figure 2. 3D models of the top of the Cambrian Wuliuan Deimena Formation sandstones in the Latvian onshore storage sites (top – North-Blidene and Blidene, bottom – Dobele).

signed in 2024 the contract with a capture technology provider. SC plants participate in the CCS Baltic PCI (European Project of Common Interest) recently included in the EC list of 14 PCI projects on CCS infrastructure. Two cement plants are planning to capture and transport 1.5 Mt of CO_2 emissions annually to the Klaipeda Port by trucks and then by ships for CGS offshore in the Nordic countries.

CCUS ZEN project proposed possible onshore and offshore scenarios for the Baltic States with CGS in the Latvian Cambrian Wuliuan Deimena Formation sandstones, which have very good geological and reservoir properties for CGS. Latvia has enough storage



N	Cluster Name	Number of emitters	Fossil CO_2 Mt	Bio- CO_2 Mt	Total CO_2 Mt	Storage site	Capacity Opt/Cons. Mt	Trans-port	Distance km
1	Latvian Onshore	3	1.0		1.0	Dobele	106/21	Pipelines	150
2	Lat-Lit Onshore	3	3.25		3.25	North-Blidene & Blidene	267/35.6 29.6/17.8	Pipelines	15-185
3	Est-Lit Offshore E6	20	9.45	2.21	11.66	E6A	365/146	Pipelines Ship	30-140 80-645
	Total produced	26	13.7	2.21	15.91	Total	767.6/220.4		
	Total stored	26	13.02	2.1	15.23				

Figure 3. Baltic offshore and onshore scenarios and their technical parameters (Shogenova et al. 2023).

capacity for all Baltic large CO_2 emissions (Shogenova et al. 2023, Figs. 2, 3). Although the old oil shale PP could be soon closed, there is still a need to capture CO_2 from the chemical, cement and waste-to-energy plants and some new PP, like Auvere PP and planned new gas PP in Estonia. Using biomass and co-combustion with bio-waste gives the way for bio-CCS and negative emission scenarios. According to the EU regulations, Auvere PP was built "capture-ready", meaning that it has space for CO_2 capture. The Baltic offshore cluster includes the large Estonian and Lithuanian fossil and bio-CO_2 emitters, including the Klaipeda waste-to-energy plant and other plants located in central and SE Lithuania. The CO_2 could be transported from CO_2 emitters by pipelines to the port and then by ship to the E6 structure, located 80 km from the Klaipeda Port. Estonian NE cluster, composed of seven emission sources (four plants produced only fossil emissions and three power co-generation plants using both oil shales and biomass for energy production) can use CO_2 pipeline or truck/train transport to Sillamäe and Kunda ports and then ship CO_2 to the E6 storage site in Latvia (615 km by ship from Sillamäe). This cluster can capture and store annually 11.1 Mt CO_2, including 9 Mt of fossil- and 2.1 Mt of bio-CO_2. The Baltic onshore cluster includes four of the largest Latvian CO_2 emitters and two Lithuanian plants located close to the Latvian-Lithuanian border (Orlen refinery and Akmenes cement plant, owned by the Schwenk). The cluster will store annually 3.1 Mt CO_2 from three plants (Latvian and Lithuanian Schwenk-owned cement plants and Orlen refinery) in the North-Blidene and Blidene structures. Two Latvian PP (Latvenergo) and one Rigas Siltums plant located in the Riga region will transport about 0.95 Mt CO_2 in the Dobele storage site in western Latvia using up to 150 km of CO_2 pipelines.

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