

Member State report on Implementation of Directive 2009/31/EC on the geological storage of carbon dioxide (“CCS Directive”)

Changes, reviews and updates of national implementation legislation

1. *Are there any changes to national legislation, permitting system or competent authorities that have taken place since the last report on implementation of the CCS Directive in your country?*
 - a. *Act no. 2608 of 28th of December 2021 on amendment of the Danish Marine Environment Protection Act. (unofficial translation).* This Amendment Act entered into force on the 1st of January 2022 and authorizes the Minister of Environment to exempt geological storage of CO₂ from the prohibition of dumping and prohibition on transport of materials and substances for dumping (see answer 1d). Furthermore, the amendment authorizes the Minister for Climate, Energy and Utilities (after due orientation of the Minister of Environment) to enter into agreements with other countries on transportation of CO₂ with the purpose of geological storage beneath the seabed.¹ Moreover, the Minister for Climate, Energy and Utilities can (after due orientation of the Minister of Environment) institute rules regarding the implementation of such agreements. This amendment and the Executive Order mentioned in 1d are not direct implementations of the Directive. These legislative measures were taken in order to ensure that CCS-activities are not in contravention of Danish legislation.
 - b. *Act no. 803 of 7th of June 2022 on amendment of Law on the use of the Danish Subsoil (unofficial translation).* This Amendment Act entered into force on the 1st of July 2022 and authorizes the Minister for Climate, Energy and Utilities to institute regulation regarding geological storage of CO₂ of under 100 kilotonnes, undertaken for research, development or testing of new products and processes (outside the scope of the Directive). Furthermore, the amendment warrants the participation of the Danish State, or a company owned by the Danish State, in CO₂ storage operations.
 - c. *Executive Order no. 1050 of 27th of June 2022 on administration of international nature conservation areas and the protection of certain species in connection when conducting pre-investigations, exploration and production of hydrocarbons, storage in the subsoil, pipelines, etc. offshore (unofficial translation).* This Executive Order entered into force on the 1st of July 2022 and warrants that geological storage of CO₂ – within the scope of the Danish Subsoil Act and storage of under 100 kilotonnes within the scope of the Executive Order mentioned in answer 1h – (among other projects) are within the scope of this Executive Order. Furthermore, the Executive Order states that if projects within the scope can be assumed to have

¹ On 26th of September 2022, Denmark and Belgium signed a Memorandum of Understanding regarding cross border transportation of CO₂ with the purpose of permanent geological storage.

<https://kefm.dk/Media/638000596525014193/Bilateral%20arrangement%20DK-BE.pdf>

a significant impact on international nature conservation areas within or outside the Danish area, such projects are required to accompany an application with an Appropriate Assessment of its implications for the site. This Appropriate Assessment should demonstrate that the activity will not lead to significant impacts on Natura 2000 or annex IV species.

- d. *Executive Order no. 934 of 15th of June 2022 on exemption of geological storage of CO₂ beneath the seabed and transport of CO₂ for geological storage beneath the seabed from the prohibitions in the Danish Marine Environment Protection Act on dumping and transport of substances and materials for dumping (unofficial translation).* This Executive Order entered into force on the 1st of August 2022 and exempts geological storage of CO₂ beneath the seabed and transportation of CO₂ for geological storage beneath the seabed from the prohibitions on dumping and transport of substances and materials for dumping in the Danish Marine Environment Protection Act
- e. *Executive Order no. 1165 of 11th of August 2022 on certain areas in Denmark, which are open to continuous granting of permits for exploration and storage of carbon dioxide (unofficial translation).* This Executive Order entered into force on the 15th of August 2022 and it determines that the area on the Danish continental shelf west of 6° 15' E and north of 56° 00' N was open for applications for permits for exploration and storage of carbon dioxide from the 15th of August 2022 to the 1st of October 2022. Furthermore, the Executive Order warrants that applications for permits for exploration and storage of carbon dioxide can be submitted to the Danish Energy Agency (DEA) on an annual basis in the period from the 15th of August to the 1st of October in the same year. Submitted applications are reviewed after the end of the deadline and the Minister for Climate, Energy and Utilities will grant permits after having presented the applications to the Climate, Energy and Utilities Committee established by the Danish Parliament.
- f. *Act no. 1592 of 28th of December 2022 on amendment of Law on Nordsøenheden and Nordsøfonden (unofficial translation).* This Amendment Act entered into force on the 1st of January 2023 and warrants the participation of "Nordsøfonden" (a company owned by the Danish state) in any sort of CO₂ storage activities. As a result, Nordsøfonden will be participating in every storage permit on behalf of the Danish state with a share of 20 percent, and is participating in the currently three granted permits in the North Sea (the granting of these permits is described further under question 9).
- g. *Act no. 1593 of 28th of December 2022 on amendment of Law on promotion of efficient energy use and reduction of greenhouse gasses (unofficial translation).* This Amendment Act entered into force on the 1st of January 2023 as well and warrants that the Ministry of Climate, Energy and Utilities can hold tenders for state aid for the capture, transport, utilization and storage of carbon dioxide. In addition, before this Amendment Act, municipalities could not participate in the capture of carbon dioxide due to Danish legislation regarding municipalities' inability to provide

financial guarantees and obligations in relation to entering into a contract about state aid. Due to this Amendment Act it is now possible for municipalities to provide financial guarantees regarding a) the execution of the capture of carbon dioxide and b) the execution of transport, utilization and storage of the captured carbon dioxide handled by a third party. The decision to commit financially must be made by the city council in question.

- h. *Act no. 1594 of 28th of December 2022 on amendment of Law on gas supply, Law on Energinet and Law on electricity supply (unofficial translation)*. This Amendment Act also entered into force on the 1st of January 2023 and warrants that Energinet (a company owned by the Danish state) can handle projects regarding transport network (as defined in the Directive) and storage sites (as defined in the Directive).
 - i. For good measure, *Executive Order no. 974 of 22nd of June 2022 on geological storage of CO₂ of under 100 kilotonnes, undertaken for research, development or testing of new products and processes (unofficial translation)* should be mentioned. Despite the Directive not applying to such storage, it seems relevant to mention in regards to the legislative situation in Denmark. Without going into further details, a permitting system for such storages has been established under Danish law through this Executive Order.
2. *Are there processes in place for storage permit applicants to engage pro-actively with the competent permitting authorities regarding relevant applications? If yes, please provide details.*
- a. There are no formal processes in place for applicants to engage pro-actively with the competent permitting authorities. With that being said, any potential applicant is welcome to inquire with these authorities about questions they may have regarding the applications before the tendering round begins.
 - b. A holder of an exploration permit can notify the DEA of a promising neighbouring area to the area within their permit. Based on geological or storage considerations, the Minister for Climate, Energy and Utilities can grant exploration permits in such neighbouring areas, provided other holders in adjacent areas are also allowed to apply for such permits under such circumstances.
3. *Please provide the name, email address and telephone of the contact point at the competent authority responsible for fulfilling the duties established under the Directive.*
- a. Danish Energy Agency (Energistyrelsen), +45 33 92 67 00, ens@ens.dk.
4. *Are there any issues that the competent authority would like to discuss with other competent authorities in relation to the practical implementation of the Directive and in particular the national permitting procedures in the Information Exchange Group under the auspices of article 27(2)?*

- a. The competent authority in Denmark is the DEA. The DEA is curious regarding the following aspects in relation to the practical implementation of the Directive and the national permitting procedure of other countries:
 - i. We wish to learn more about other member states' high-level procedures for CO₂-permitting for exploration and storage. If there are some general flow-charts that member states can share, it would be highly valuable.
 - ii. Do other member states have any opinions on whether CO₂-permitting for exploration and storage should be divided/focused after reservoir types (e.g. saline aquifers, depleted oil and gas fields etc.)? By extension, would other member states issue a permit for CO₂-storage in two different types of reservoir and/or different levels of maturity (e.g. chalk vs. sandstone) within the same license area, or would other member states prefer to divide it according to different reservoir types, as it has been done in Denmark?
 - iii. How have other member states implemented monitoring requirements in accordance with the Directive?
 - iv. How have other member states interpreted Article 18(1), litra a and b?

Selection of areas for storage sites (Article 4)

5. *Which areas are determined from which storage sites may be selected pursuant to Article 4(1) until April 2023?*
 - a. The area on the Danish continental shelf west of 6° 15' E and north of 56° 00' N was open for applications for permits for exploration and storage of carbon dioxide from the 15th of August to the 1st of October 2022. Future offshore tender rounds will happen in the same period, every year, pursuant to article 1 of Executive Order no. 1165 of 11th of August 2022. The areal extend of the next offshore tender round is not yet decided.
 - b. The DEA is currently conducting a Strategic Environmental Assessment (SEA) regarding selected areas in nearshore areas and on the Danish mainland (for the purpose of possible onshore storage). The SEA is expected to be published in Q3/Q4 2023. Upon the finalisation of the SEA, 0-8 specific areas will be selected from which storage sites may be selected. As of this report, it is too early to conclude how many of the possible eight sites – and which sites specifically – will be selected. It is possible that the application period for any nearshore or onshore areas will deviate from the offshore application period mentioned above.

6. *Will additional areas be determined from which storage sites may be selected in the period until the next report at the end of 2027, if so, which geological type of areas are considered (e.g., saline aquifers, depleted or not depleted gas & oil fields, mafic rocks) from a geological point of view and what are the next steps? Details on which territories are considered, including their location (geospatial information), and why this has been done, would be appreciated though not obliged.*

- a. Yes, it is expected that additional areas from which storage sites may be selected will be determined before the next reporting. We expect to hold tenders regarding 1-8 onshore and nearshore areas from which storage sites may be selected in 2024.
 - b. All these areas are saline aquifers. Geological Survey of Denmark and Greenland (GEUS) has prepared a memo containing geological characterization of these 8 areas. This memo has been attached as Annex 2.
7. *Are there information about environmental and/or health risks relating to the geological storage of CO₂ in accordance with the applicable Community legislation available to the public? If so, please provide the relevant URL(s).*
- a. Information regarding environmental and/or health risks are available to the public. Some can be found on the website of the DEA, others on the website of GEUS:
 - i. The DEA's website has an entire section dedicated to CCS and a subsection regarding environmental and health aspects of CCS.²
 - ii. A report on "CCS – international experiences – safety, nature and environment" (in Danish), conducted by COWI (consulting company).³ Linked to on the DEA's website.
 - iii. Norwegian experiences with safe CO₂-storage from the Sleipner Project (in English).⁴ Linked to on the DEA's website.
 - iv. Website regarding safe seismic acquisition by GEUS (in Danish).⁵ Linked to by QR-code in pamphlet handed out at citizens' meetings.
 - v. An entire issue of the magazine "geoviden" dedicated to CCS is freely available (in Danish).⁶ Linked to on GEUS' website.
 - b. In addition, it should be noted that the DEA began a SEA in 2022 (as mentioned under 5b). In this process, the DEA has organized and held four citizens' meetings regarding nearby planned CCS-operations, with the objective of involving and engaging with the public regarding the environmental and health aspects off particularly onshore CO₂-storage. Furthermore, the DEA assisted GEUS in four citizens' meetings organized and held by GEUS with the same objectives. This public engagement was not obligatory at this early stage, but the DEA opted to include the public as early in the process as possible, in order to get the public's perspective on what should be included within the scope of the SEA, and to meet possible worries head-on. When a draft of the SEA is finished (expected ultimo Q1 2023), the public will once again be included in a hearing process in Q2 2023, before the final SEA will be published in Q3/Q4 2023.

Exploration permits (Article 5)

² <https://ens.dk/ansvarsomraader/ccs-fangst-og-lagring-af-co2/miljoe-og-sikkerhedsaspekter-ved-ccs>

³ https://ens.dk/sites/ens.dk/files/CCS/rapport_om_ccs_erfaringer_med_sikkerhed_natur_og_miljoe.pdf

⁴ <https://blog.sintef.com/sintefenergy/ccs/the-safety-of-co2-storage/>

⁵ <https://arcgisportal.cowi.com/portal/apps/storymaps/stories/413a7cad953749659f0c855c6b809668>

⁶ <https://www.geoviden.dk/co2lagring>

8. *Are there areas or specific sites where no exploration permits are required to generate the information necessary for the selection of storage sites, pursuant to Article 5?*
- a. An exploration permit is required before being granted a full-scale CO₂-storage permit. Before the DEA grants a CO₂-storage permit, the storage site needs to reach an acceptable level of maturity. This is to ensure knowledge concerning the characteristics, safety and potential environmental risks of the storage site. This maturity level is assured through a period of exploration, hence an initial exploration permit is needed to progress to a storage permit.
 - b. It is also possible to get a permit for storage of under 100 kilotonnes. This can help a potential applicant pursuant to Article 5 of the Directive to understand the potential of the storage site.
9. *How many exploration permits have been given pursuant to Article 5 since your last reporting?*
- a. Denmark has conducted its first tendering process for offshore licenses for full-scale exploration and storage of CO₂ in the aforementioned delimited area on the Danish continental shelf. Three exploration permits pursuant to article 5 have been given; one to a consortium of INEOS and Wintershall DEA, two to TotalEnergies.

Storage permits (Article 10)

10. *Member States shall make the permit applications available to the Commission within one month after receipt. Are there any plans of potential operators to apply for storage permits pursuant to Article 7? If yes, please provide an approximate timing.*
- a. Within the next 5 years (2028) depending on the results of the work programmes of the current applicants. Each of the three explorations permits given, as of this report, have a time limit of 5 years. If the applicants wish to establish CO₂ storage sites within the areas defined in their exploration permits, they will need to submit an application for storage within the duration of their exploration permit, i.e. within the next 5 years.

Third-party fair and open access (Article 21)

11. *What measures – if any – have been taken to ensure that potential users are able to obtain fair and open access to transport networks and to storage sites for the purposes of geological storage of the produced and captured CO₂? (Article 21)*
- a. Article 21 of the Directive has been implemented into the Danish Subsoil Act Furthermore, parties to a dispute regarding access can refer the dispute to the Danish Minister for Climate, Energy and Utilities (see below)
 - b. Further legislative work regarding this is expected to progress in 2023 currently pending political deliberation.
12. *Are you aware that prospective transport operators and/or storage operators have refused access to their facilities on the grounds of lack of capacity?*

- a. As of this report, there are no operational transport or storage projects in Denmark within the scope of the Directive; hence, this issue has not arisen.

13. *What measures – if any – have been taken to ensure that the operator refusing access on the grounds of lack of capacity or a lack of connection makes any necessary enhancements as far as it is economic to do so or when a potential customer is willing to pay for them? (Article 21)*

- a. As of this report, there are no operational transport or storage projects in Denmark within the scope of the Directive; hence, this issue has not arisen.
- b. Articles 20 and 21 of *Executive Order no. 1425 of 30th of November 2016 on geological storage of CO₂ etc. (unofficial translation)* warrants that a dispute regarding access can be referred to the Minister for Climate, Energy and Utilities of Denmark by a party of the dispute. The parties in dispute shall report all necessary information regarding the dispute to the Minister, who will then settle the dispute.

Transboundary cooperation (Article 24)

14. *Is there any experience or plans for transboundary CO₂ transport or CO₂ storage sites or storage complexes? Please provide details on the status of preparations, if any.*

- a. There is currently no such concrete plans regarding transboundary CO₂ transport, storage sites or storage complexes within the scope of the Directive.
- b. There is however more concrete experience with transboundary CO₂ transport outside the scope of the Directive. A consortium of among others INEOS and Wintershall has been given a permit to store 15.000 tonnes of CO₂ that has been captured in, and transported via ship from, Belgium. This permit has been given pursuant to the aforementioned Executive Order no. 974 of 22nd of June 2022. In advance of the issuance of this permit, the Minister for Environment of the Flemish Region, the Federal Minister for the North Sea of Belgium and the Minister for Climate, Energy and Utilities of Denmark signed a Memorandum of Understanding (MoU). In this MoU it is described that the MoU is an arrangement in the sense of article 6, paragraph 2, of the London Protocol (1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, as amended by Resolution LP, 3(4)). The MoU applies to cross border transportation of CO₂ between the participants of the MoU with the purpose of permanent geological storage. Moreover, two projects, the Bifrost led by TotalEnergies, and Danish Norne led by Fidelis New Energy Europe, have however applied for PCI status. Both projects plan to have transboundary CO₂ transport.

CO₂ capture readiness (Article 33)

15. *How many combustion plants with a rated electrical output of 300 MW or more have received a permit since the last implementation report? What was the outcome of the assessment under Article 36 of Directive 2010/75/EU? In case of negative assessment, have*

the combustion plants set aside suitable space irrespectively? Please provide detail for each permit according to Annex 2.

- a. No such combustion plants have received a permit in Denmark since the last implementation report.

Further questions

16. What other national programmes are in place or planned to support research, demonstration and deployment of CCS?

- a. Denmark has established the CCUS Fund of 16.6 billion DKK. Applicants can apply for funding for the entire value chain (capture, transportation and storage) of both fossil and biogenic CO₂. The first tendering round has been completed and the DEA is currently evaluating the two BAFO's received.
- b. 2.6 billion DKK has been set up in a fund earmarked for negative emissions from capture of CO₂ from biogenic sources and subsequent geological storage (NECCS). The DEA is currently planning and designing a tender round for this NECCS fund.
- c. Executive Order no. 974 of 22nd of June 2022 on geological storage of CO₂ of under 100 kilotonnes, undertaken for research, development or testing of new products and processes (as mentioned under answer 1h). On the 6th of December 2022, the DEA granted the first permit pursuant to this Executive Order.
- d. Through the Green Tax Reform, it was decided to set aside funds amounting to 17,2 billion DKK.

17. Are there any ongoing national or European research projects that may have relevance to the Directive?

- a. Project Greensand
 - i. The purpose of the project is to generate necessary knowledge of the full CCS value chain for subsequent full-scale storage. The project has received ~ 206.5 million DKK in funding from the Danish technological development and demonstration program (EUDP).
- b. Project Bifrost
 - i. The purpose of the project is to generate necessary knowledge of the full CCS value chain for subsequent full-scale storage. The project has received ~ 75.5 million DKK in funding from EUDP.
- c. DTU (Danish Technological University) Offshore research programme
 - i. The DTU Offshore research programme focuses on three CCS themes; 1) possibility of storage in chalk formations of hydrocarbon areas, 2) monitoring of the movement of the plume and potential leaks and 3) recycling of existing wells in oil and gas reservoirs.
- d. COLLATE
 - i. The purpose of the project is to develop/optimize methods, skills and equipment for analysis and simulation related to CCUS. The project has received ~ 18 million DKK in funding from EUDP.

- e. CHOCO2LATE
 - i. The purpose of the project is to develop on the Direct Air Capture (DAC) technology by developing an innovative air scrubber and calcination technology. The project has received ~ 11.5 million DKK in funding from EUDP.
- f. INNO-CCUS
 - i. INNO-CCUS is a research and innovation partnership and was established as a mean to secure advancements of CCUS solutions. The partnership has several projects regarding capture technologies, storage technologies, public acceptance etc. The partnership received ~ 275 million DKK in funding through the Danish research reserve.
- g. CORC
 - i. CORC is a research center with several different research projects with the aim to develop new fundamental understandings and technology platforms for capturing and converting CO₂ for storage and utilisation.

18. Are there other plans to support further appraisal of CO₂ storage sites, to prepare for CO₂ transport infrastructure or for CO₂ hubs and clusters?

- a. Deal on distribution of the Danish research reserve from the 28th of February 2023 allocated 121.5 million DKK to GEUS to support their efforts in mapping potential CO₂ storage sites and analysis of storage sites onshore, nearshore and offshore in expired oil and gas fields.

Annex 1:

The following points from box 6 of annex 1 have been deemed answerable:

- *The annual aggregated projection of inherent process emissions that will have to be abated through CO₂ capture:*
 - o 2025: 1381 kilotonnes of CO₂ pa.
 - o 2030: 1377 kilotonnes of CO₂ pa.
 - o 2040: 1349 kilotonnes of CO₂ pa.
- *The annual biogenic and direct air CO₂ that will be available for geological storage of CO₂:*
 - o Denmark has not created projections regarding DACSS due to the lacking maturity of the technology. The projections below are therefore only concerning biogenic CO₂.
 - 2025: 15.306 kilotonnes of CO₂ pa.
 - 2030: 12.858 kilotonnes of CO₂ pa.
 - 2040: 9.997 kilotonnes of CO₂ pa.
- *The geological CO₂ storage capacity that can be made operationally available annually:*
 - o The answer to this question relies on the expected national injection rate, which has far too much uncertainty. Based on the storage projects that have been granted exploration and storage permits, the annual injection rate can reach 13 million tonnes in 2030.
 - o The theoretical CO₂ storage capacity in Denmark is estimated to be 12-22 gigatonnes (estimated by GEUS in 2020).
 - o A variety of project developments have taken place since 2020 and as of March 2023, Denmark has granted three exploration permits in relation to the offshore projects Greensand and Bifrost, as well as a pilot- and demonstration permit for the injection of less than 0.1 million tons of CO₂ to the Greensand project. The expected storage capacity of the Greensand project is up to 1.5 million tons of CO₂ per year from 2025-2026 and up to 8 million tons of CO₂ per year from 2030. For the Bifrost project 2-3 million tons of CO₂ per year from 2029-2030 and 10-15 million tons of CO₂ per year from 2030-2032 is expected. Other projects are emerging onshore as well, such as the Danish Norne project, which expects to store 2.3 million tons of CO₂ per year by 2026 and 18.7 million tons of CO₂ per year by 2030, as well as the Ruby project which anticipates injection from 2027 with an injection capacity of 1 million tons of CO₂ per year increasing to 5-10 million tons of CO₂ per year by 2030. Lastly, a smaller onshore project in Stenlille has been announced with the purpose of gaining knowledge about the Danish onshore possibilities. The combined capacity of these projects is then expected to be approximately up to 52 million tonnes in 2030-2032. Given Denmark's approach to develop CCS on market-based terms, the mentioned are not an extensive list of projects, but an overview of some of the known project developments. More projects whom are in line with the general CCS framework in Denmark might emerge. The Bifrost and Danish Norne projects have recently applied for PCI status.

- *Annual CO₂ storage capacity that may become available at the end of exploitation of hydrocarbon reservoirs:*
 - The theoretical CO₂ storage capacity that may become available at the end of exploitation of hydrocarbon reservoirs in Denmark is estimated to be 0.9-1.3 Gt (only chalk fields) and 0.15-0.5 Gt (Siri Canyon complex).
- *Public funding support available for investment in CO₂ capture, transport and storage:*
 - The CCUS Fund – SA.102777 State aid scheme for Carbon Capture and Storage in Denmark⁷.
 - NECCS⁸
 - Green Tax Reform⁹
 - The development of CCS has also been supported by general research and development funds including the technological development and demonstration program (EUDP). Several projects have received funding from EUDP (see examples under answer 17).

⁷ https://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=3_SA_102777

⁸ <https://ens.dk/presse/energistyrelsen-inviterer-til-anden-runde-af-markedsdialog-om-neccs-puljen>

⁹ <https://fm.dk/media/26070/aftale-om-groen-skattereform-for-industri-mv-a.pdf>

Annex 2:



To: David Lund Hansen & Tanni Juul Abramovitz, DEA
From: Ulrik Gregersen & Nina Skaarup



12-EN-23-01
J.nr. GEUS 451103101
Ref. UG

23.03.2023

Geological characterization of Danish onshore and nearshore structures selected for maturation for potential CO₂ storage

The Danish Government and Parliament decided a new climate law in June 2020 followed by a strategy in 2021 for green transition, that included geological storage of CO₂. Eight deep structures were decided by the authorities to be matured and GEUS initiated an initial maturation with seismic acquisition and mapping from 2022 of the structures: Stenlille, Havnsø, Gassum, Rødby, Thorning, Jammerbugt, Lisa and Inez (Fig. 1). The first five are onshore structures, and the last three are offshore structures in the eastern North Sea.

Acquisition is carried out for all structures except for the Inez and Lisa structures, where sufficient modern seismic data exist for the initial maturation. After the initial maturation with acquisition and mapping, further maturation and risk evaluation should be carried out in the further process prior to selection for CO₂ storage. Previous screening work by GEUS have identified the geological structures with potential for storage of CO₂, including Larsen et al. (2003), Anthonsen et al. (2014), Hjelm et al. (2022) and Mathiesen et al. (2022), which are the basis for selecting the eight structures for the ongoing initial maturing. The main geological type and characteristics of the eight structures are described briefly below.

The structures were selected for the initial maturation, based on the screening studies mentioned above, as they are mostly large 4-way dip closures with sandstone reservoirs covered by a km-thick sedimentary succession, with primary mudstone seals in the lower parts of the cover. Stenlille is the smallest structure but covered by the most comprehensive database onshore Denmark, and natural gas has been stored safely for more than 30 years in the Gassum Formation and may be a demonstration site for storage of CO₂.

The geological main type for all the eight structures selected for the initial maturation can be characterized as trap structures defined by 4-way dip closures with saline aquifer sandstone reservoirs below thick mudstone seals. All potential primary storage reservoirs are buried deeper than 1200 m by sedimentary successions, which in the lower part consists of a thick primary seal formation (mostly 100s meter thick) overlain by secondary seals.

GEUS
Geological Survey of
Denmark and Greenland
Oester Voldgade 10
DK-1350 Copenhagen K
Denmark

Phone +45 38 14 20 00
Fax +45 38 14 20 50

CVR-no. 55 14 50 16
EAN-no. 5798009814814

geus@geus.dk
www.geus.dk

GEUS is a research and advisory institution in the Danish Ministry of Climate, Energy and Utilities

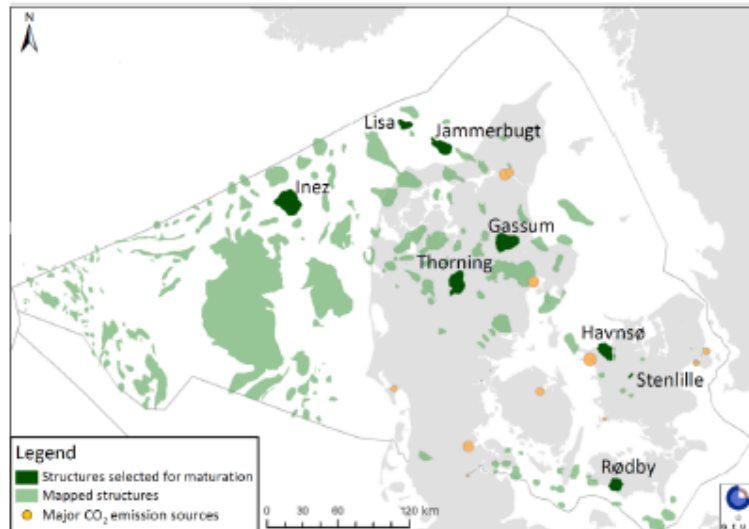


Fig. 1. Structures (names) selected for maturation 2022–2024, other mapped structures, and locations of major CO₂ emission sources.

The primary reservoir formation is for all structures except Rødby the Upper Triassic to Lower Jurassic Gassum Formation. The Lower to low-ermost Middle Triassic Bunter Sandstone Formation is the primary res-ervoir formation of the Rødby structure. Structures also contain secondary reservoirs, mostly Bunter Sandstone Formation, and in Jutland and the North Sea also the Skagerrak, Frederikshavn or/and Haldager Sand formations.

The primary seal succession for the Gassum Formation is thick mud-stones of the mainly Early Jurassic Fjerritslev Formation. The mudstone-dominated Middle Triassic Ørslev Formation is the primary seal for the Bunter Sandstone Formation.

Most of the structures were mainly formed into gentle domes by the growth of underlying salt pillows and by some tectonism and uplift. Faults are identified in the structures and further identification and de-scriptions require more data.

Seismic acquisition with updated mapping is part of the initial maturation as the database is sparse and of poor quality for most of the structures. The seismic data coverage is sufficient for the initial maturation over the Inez and Lisa structures, whereas data will be acquired for all the other structures for updated mapping. The geology is known from wells in or nearby the structures, and the drilled structures are Stenlille (20 wells), Gassum (1 well), Rødby (2 wells), Lisa (1 well), and Inez (1 well).

References

Anthonsen, K.L., Aagaard, P., Bergmo, P.E.S., Gislason, S.R., Lothe, A.E., Mortensen, G.M. and Snæbjörnsdóttir, S.Ó. 2014. Characterisation and selection of the most prospective CO₂ storage sites in the Nordic region. *Energy Procedia* 63, 4884–4896. <https://doi.org/10.1016/j.egypro.2014.11.519>

Hjelm L., Anthonsen K.L., Dideriksen K., Nielsen C.M., Nielsen L.H. and Mathiesen A. 2022. Capture, Storage and Use of CO₂ (CCUS). Evaluation of the CO₂ storage potential in Denmark. Vol.1: Report & Vol 2: Appendix A and B [Published as 2 separate volumes both with Series number 2020/46]. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2020/46; GEUS. 141 pp. <https://doi.org/10.22008/gpub/34543>

Larsen, M., Bidstrup, T., Dalhoff, F. 2003. Mapping of deep saline aquifers in Denmark with potential for future CO₂ storage. Geological Survey of Denmark and Greenland, Rapport 2003/39, 83 pp.

Mathiesen, A., Dam, G., Fyhn, M.B.W., Kristensen, L., Mørk, F., Petersen, H.I. and Schovsbo, N.H. 2022. Foreløbig evaluering af CO₂ lagringspotentiale af de saline akviferer i Nordsoen. Danmark og Grønlands Geologiske Undersøgelse Rapport 2022/15, 151 pp. + App.

