Geological methods

Carbon dioxide storage in geological formations below the German North Sea

Carbon dioxide storage in the deep subsurface of the North Sea is technically feasible and has been practised for decades beneath Norwegian waters. Under the German North Sea, there are rock formations in which large quantities of carbon dioxide could presumably be stored, too. However, important questions remain, which are to be addressed and answered in the research mission CDRmare – with the aim of enabling a demonstration project for carbon dioxide storage in the geological subsurface of the German North Sea.

Storage for captured carbon dioxide emissions

> There is a consensus in climate research: Even with ambitious climate policies, humanity is still expected to release **5 to 15 percent** of current carbon dioxide emissions by the middle of the 21st century, further accelerating climate change. These **residual CO_2 emissions** will be generated, for example, in cement and steel production, in air and heavy-duty transport, in agriculture, and also in waste incineration.

> To offset these emissions, we will have to either capture the carbon dioxide directly at its source or remove it from the atmosphere at the same rate. The gas must then be safely stored. This technique is called **carbon capture and storage** (CCS).

> Carbon dioxide is a long-lived gas. Its extraction and storage must therefore be **effective and permanent**. Some key CO_2 removal methods, such as direct air capture and bioenergy generation with carbon capture and storage (BECCS), rely on **deep underground storage**.

CO_2 storage in sandstone formations of the German North Sea

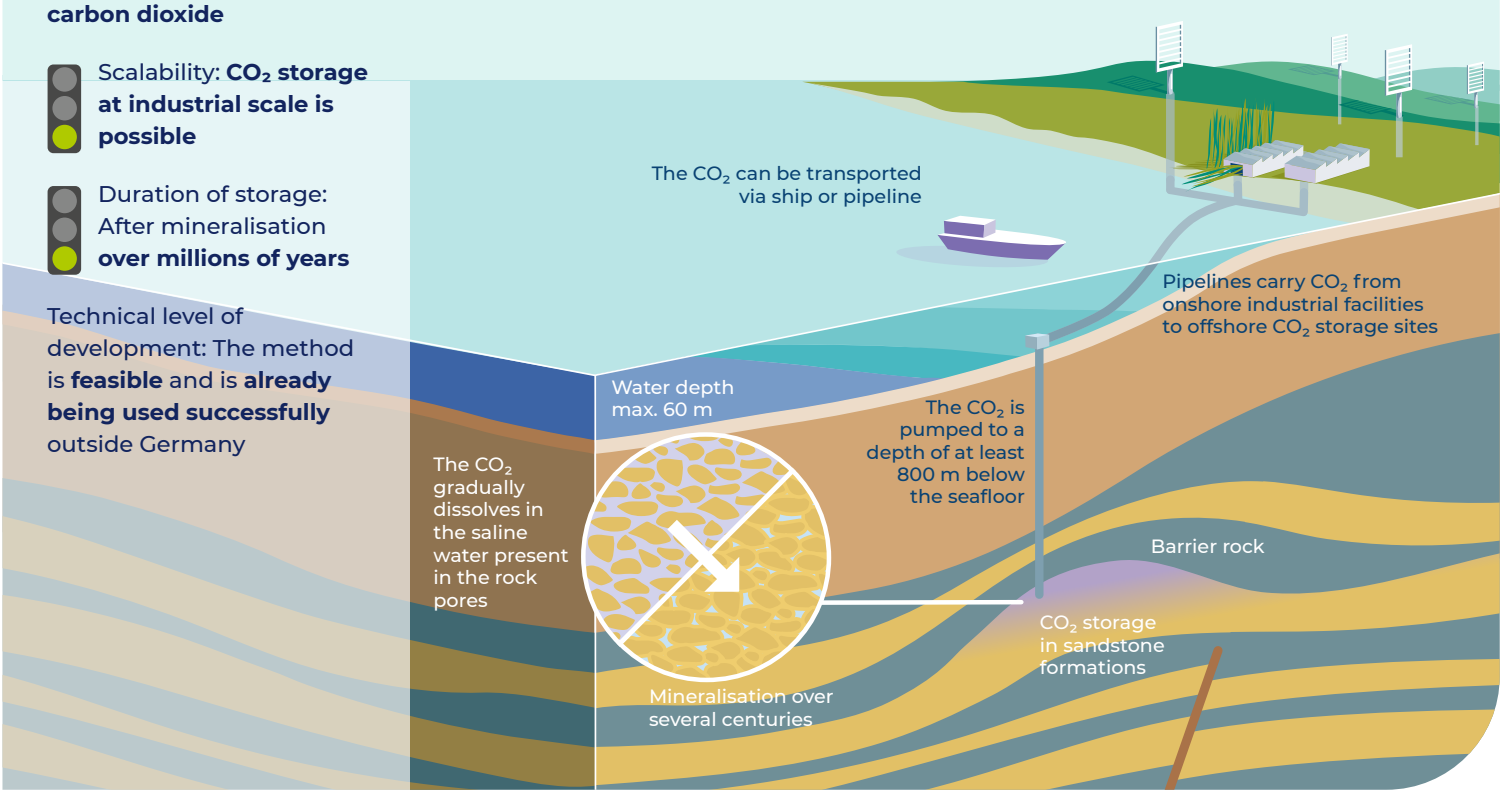
Costs associated with capture, liquefaction, transport, storage, monitoring: **approximately 50 to 150 euros per ton of carbon dioxide**

Scalability: **CO_2 storage at industrial scale is possible**

Duration of storage: After mineralisation **over millions of years**

Technical level of development: The method is **feasible** and is **already being used successfully** outside Germany

For storage in the ocean's subsurface, liquid carbon dioxide is transported by pipeline or by ship to the relevant ocean site and injected through one or more boreholes into deep porous sandstone formations. In the rock pores, the carbon dioxide then spreads and collects at the highest point of the reservoir under the barrier layer. Over time, the carbon dioxide dissolves in the formation water and reacts with minerals contained in the surrounding sandstone. In this process, minerals (carbonates) are formed in which the carbon dioxide is permanently bound. However, several centuries pass before this happens.



Technically feasible, planned in many locations

> The safe and permanent storage of large quantities of carbon dioxide in the deep subsurface of the North Sea is **technically feasible** and has already been successfully practiced under Norwegian waters for more than two decades.

> In the Netherlands, Denmark, Great Britain as well as in Norway, various companies are currently planning **further large-scale projects in the North Sea** because the capture and storage of carbon dioxide in the seabed is now economically viable due to the rising prices for CO_2 emission certificates.

The geological subsurface of the North Sea offers great CO_2 storage potential

> The North Sea has massive sandstone formations in its deep subsurface and thus offers good **geological conditions** for carbon dioxide storage. Its shallow water depth also facilitates the installation of the necessary technical infrastructure.

> It is estimated that around **150 billion metric tons** of carbon dioxide could be stored in the deep subsurface of the entire North Sea. The potential storage reservoirs in German waters would account for 3.6 to 10.4 billion metric tons. To put this into perspective, it is estimated that Germany will produce residual emissions of 0.04 to 0.1 billion metric tons of carbon dioxide per year in the future.

Risks are known, but strategies for solving them are missing

> The **risks** of the technology to humans and the environment are well known. They include:

- the unintentional **escape of the stored carbon dioxide** from the reservoir rock (leakage) and the resulting acidification of near-bottom water masses;
- **contamination of the marine environment** by very salty formation water, as well as by **heavy metals and other substances harmful to the environment** that could be contained in the formation water displaced from the reservoir rock in the course of carbon dioxide injection;
- **seismic events** at depth, which could threaten the functionality and stability of seabed-anchored infrastructure; and
- **noise disturbance** to marine organisms during the search for suitable storage structures, construction of the facilities, and long-term monitoring of the carbon dioxide storage facilities.

Monitoring and mitigation concepts have been developed for CCS projects in neighboring countries, but they must now be adapted to conditions in the German North Sea and, if necessary, supplemented. In addition, **strategies for dealing with possible conflicts** of use in the North Sea (e.g. offshore wind farms) are needed.

Germany's legal position on carbon dioxide storage in the seabed is in need of clarification

> International agreements allow coastal states to store carbon dioxide in the geological subsurface of marine areas under their jurisdiction. In Germany, however, **the legal situation requires clarification** and makes CO_2 storage projects difficult. In order to be able to carry out such projects, it would be necessary, among other things, to **amend the Carbon Capture and Storage Act**. In addition, experts recommend that German marine spatial planning be extended to the deep subsurface.

CDRmare provides answers, and concepts for safeguarding and action

> As part of the research mission CDRmare, **solutions and options for action** are developed for open geological, technical and legal questions of CO_2 storage in the deep subsurface of the German North Sea. **Monitoring and precautionary concepts for risk mitigation** are also investigated. Moreover, the researchers estimate the **costs** involved. By doing so, they create the scientific basis for a comprehensive demonstration project.

The necessary research work is carried out in the CDRmare subproject »GEOSTOR – Submarine Carbon Dioxide Storage in Geological Formations of the German North Sea«.

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