Sustainable Business Hub

Interreg Baltic Sea Region

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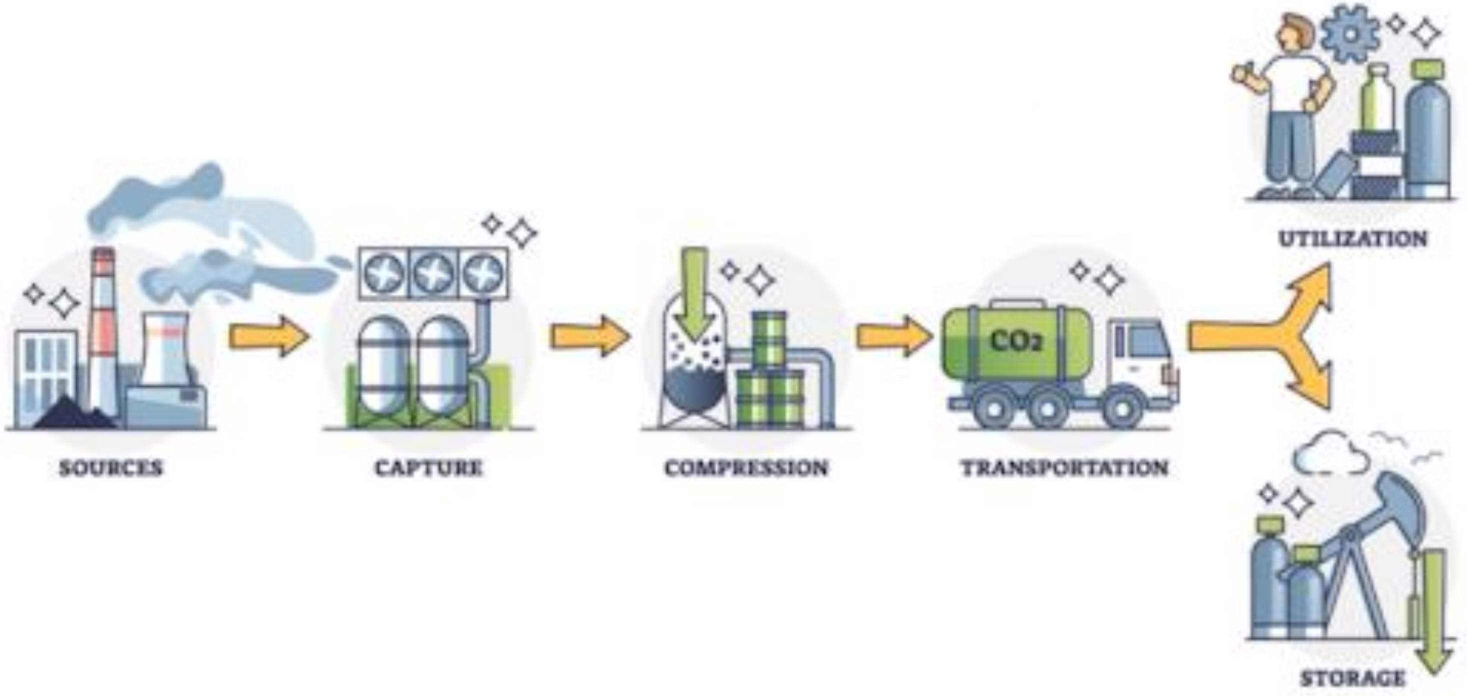
Module - Carbon Capture, Utilisation and Storage - CCUS

Carbon Capture, Utilisation and Storage



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Basics about Carbon Capture

Carbon capture techniques include:

- **Pre-combustion Capture**: This method involves converting fossil fuels into a mixture of hydrogen and CO2 before combustion. The process typically includes gasification of coal or reforming of natural gas.
- **Post-combustion Capture**: This method captures CO2 from the flue gases produced after the combustion of fossil fuels. Technologies used for post-combustion capture include.
- **Oxy-fuel Combustion**: In this process, fossil fuels are burned in pure oxygen instead of air. This results in a flue gas composed mainly of CO2 and water vapor, which can be easily separated.
- **Direct Air Capture (DAC):** DAC involves capturing CO2 directly from the ambient air, rather than from point sources like power plants or industrial facilities. This makes it a versatile approach that can be deployed anywhere.
- **Bioenergy with Carbon Capture and Storage (BECCS):** BECCS combines bioenergy production with CO2 capture and storage. Plants absorb CO2 from the atmosphere during growth, and when these plants are used for energy, the CO2 produced is captured and stored, resulting in negative emissions.

In the following, the focus will be on **Post-combustion Capture.**

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The basic technical steps in CCUS (1)

The basic technical steps in carbon capture involve the following processes:

Capture: The method captures CO_2 from the flue gases emitted after combustion at industrial or power generation processes (post-combustion capture) include three primary methods :

- Absorption: CO_2 is absorbed using solvents such as amines.
- Adsorption: CO_2 is adsorbed onto solid materials like activated carbon or zeolites.
- Membrane Separation: CO_2 is separated from other gases using selective membranes.

Compression of CO_2: After separation, the CO_2 is compressed to a supercritical state, where it has properties of both a liquid and a gas. This increases the density of the CO_2, making it easier and more economical to transport and store.

Transport: The compressed CO_2 is transported to a storage site. This is typically done via pipelines, although it can also be transported by ships, trucks, or trains, especially over shorter distances or when pipeline infrastructure is not available.

The basic technical steps in CCUS (2)

Storage or Utilization: The captured CO_2 is then either stored or utilized. Storage involves injecting the CO_2 into underground geological formations, such as:

- Depleted Oil and Gas Fields: These are former oil and gas reservoirs that have the capacity to securely hold CO_2.
- Deep Saline Aquifers: These are porous rock formations filled with salty water located deep underground.

Captured CO_2 can be utilized in various industrial processes, such as enhanced oil recovery (EOR), production of chemicals, or as a feedstock for producing synthetic fuels.

Barriers for CCUS

The development of CCUS facilities faces several challenges, including:

- **high costs**: CCS involves substantial capital and operational expenses, particularly for CO2 capture and compression, making it economically demanding without financial incentives.
- **infrastructure needs:** Extensive infrastructure, including pipelines and storage sites, is required. This necessitates significant investment and coordination across sectors and regions to develop and maintain.
- **regulatory issues:** Evolving and inconsistent regulations can deter investment and complicate project approvals. Clear, harmonized regulatory frameworks are essential to address safety, liability, and environmental concerns, ensuring long-term project viability.

Increasing governmental support, funding, and technological advancements are helping to overcome the barriers. The Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA) have identified CCS as a critical component in achieving global climate targets, leading to a rapid development in CCS projects and research.

Operational facilities, examples

The development of carbon capture and storage facilities is progressing, with several operational facilities around the world and many more in various stages of planning and development.

Sleipner CO2 Storage Project (Norway): Operational since 1996, this project captures and stores about 1 million tonnes of CO2 per year from natural gas processing in a saline aquifer beneath the North Sea.

Boundary Dam Carbon Capture and Storage Project (Canada): This project, operational since 2014, retrofitted a coal-fired power plant to capture around 1 million tonnes of CO2 annually, which is used for enhanced oil recovery (EOR).

Gorgon CO2 Injection Project (Australia): Operational since 2019, this project is part of a natural gas development and aims to capture and store up to 4 million tonnes of CO2 per year in a deep saline aquifer.

Quest Carbon Capture and Storage Project (Canada): Operating since 2015, it captures and stores approximately 1 million tonnes of CO2 per year from an oil sands upgrader.

Facilities under development, examples

There are numerous CCS projects in various stages of development, reflecting growing interest and investment in this technology. Some key projects include:

Northern Lights (Norway): A joint venture by Equinor, Shell, and TotalEnergies, this project aims to create a full-scale CCS value chain in Europe. The first phase is expected to be operational by 2024, with a capacity to store 1.5 million tonnes of CO2 per year.

Porthos Project (Netherlands): Planned to be operational by 2026, this project will capture CO2 from industrial sources in the Port of Rotterdam and store it in depleted gas fields beneath the North Sea, with a capacity of 2.5 million tonnes of CO2 annually.

Summit Carbon Solutions (USA): This project involves capturing CO2 from ethanol plants in the Midwest and transporting it via a pipeline network to North Dakota for storage in deep saline formations. It aims to capture and store up to 12 million tonnes of CO2 per year.

CCUS in the Commit Climate countries (1)

Sweden: The development of carbon capture and storage (CCS) facilities is advancing as part of the nation's goal to achieve climate neutrality by 2045. Key projects include:

- **Sysav** is developing a CCUS-project in Malmö for waste incineration facility targeting 400,000 tonnes of CO2 capture per year by 2030.
- **CNetSS**, a collaboration between major companies like Sysav, E.ON, Växjö Energi, Öresundskraft, Copenhagen-Malmö-Port and Nordion, focusing on creating a CO2 transport infrastructure in the south of Sweden
- **Stockholm Exergi** is developing a bioenergy with carbon capture and storage (BECCS) project at its Värtaverket plant, targeting around 800,000 tonnes of CO2 capture per year by 2030.
- **Northern Lights project.** Swedish industries, particularly those in the cement and steel sectors, are exploring the possibility of exporting captured CO2 to be stored in the Northern Lights offshore storage site in the North Sea
- **Preem CCS,** which aims to capture up to 500,000 tonnes of CO2 annually from Sweden's largest oil refinery.

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CCUS in the Commit Climate countries (2)

Poland is progressing with CCS, particularly at the Bełchatów Power Plant, which is investigating CCS feasibility and pilot projects to integrate with its coal power operations.

Estonia is examining the use of oil shale formations for CO_2 storage, while

Estonia, Latvia, and Lithuania explore regional CCS projects in collaboration with North Sea initiatives

EU and CCUS

The development of CCUS in the EU is progressing significantly, driven by robust policy support and substantial funding. The European Commission's strategy aims to capture at least 50 million tonnes of CO2 annually by 2030, increasing to 280 million tonnes by 2040 and up to 450 million tonnes by 2050.

Funding initiatives such as the Innovation Fund and Horizon Europe have supported nearly 100 projects with over EUR 4 billion in contributions, focusing on technology deployment and infrastructure development across the CCUS value chain.

Challenges remain, including the need for efficient project timelines, coordinated infrastructure, and overcoming regulatory and financial hurdles. Cross-border projects like Northern Lights are crucial for fostering collaboration and addressing these challenges.

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CCUS Zen network (1)

CCUS ZEN is exploring the potential for accelerating deployment of CCUS in two regions with lower maturity level for CCUS compared to the current development in the North Sea region:

- **The Baltic Sea region** covering Denmark including its inland waters and the easternmost North Sea, Sweden, Finland, Germany, Estonia, Latvia, Lithuania, Poland and the Baltic Sea.
- **The Mediterranean Sea region** covering France, Italy, Turkey, the Mediterranean Sea and selected onshore storage locations in Greece and Spain.

Transfer of knowledge and best practices from the CCUS projects in the North Sea region will facilitate development of CCUS value chains in the Baltic Sea and Mediterranean Sea regions.

CCUS Zen network (2)

CCUS ZEN’s mission is to contribute to the accelerated deployment of CCUS throughout Europe by enabling mutual, continuous learning between different stakeholder types and between European regions. It will do this by drawing on learnings from ongoing and past projects; creating a shared understanding of mission-critical implementation elements that need to work together like clockwork; and building a coherent ecosystem of CCUS actors in Europe that are capable of credibly delivering the requisite contribution to European climate policy.

Resources

Useful links addressing CCUS:

- Global institute - https://www.globalccsinstitute.com/
- IEA - https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage
- Energypost.se - https://energypost.eu/europes-carbon-capture-pipeline-40-projects-but-wheres-the-policy-support-and-market-creation/
- Örsted - . https://orsted.com/en/what-we-do/renewable-energy-solutions/bioenergy/carbon-capture-and-storage
- EUCIEA - https://cinea.ec.europa.eu/news-events/news/industrial-carbon-management-interactive-stories-new-tool-discover-eu-funded-projects-ccus-sector-2024-02-13_en
- Climate action - https://climate.ec.europa.eu/eu-action/carbon-capture-use-and-storage_en
- CCUS Zen - https://ccuszen.eu/

Thank you!

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