Fact sheet

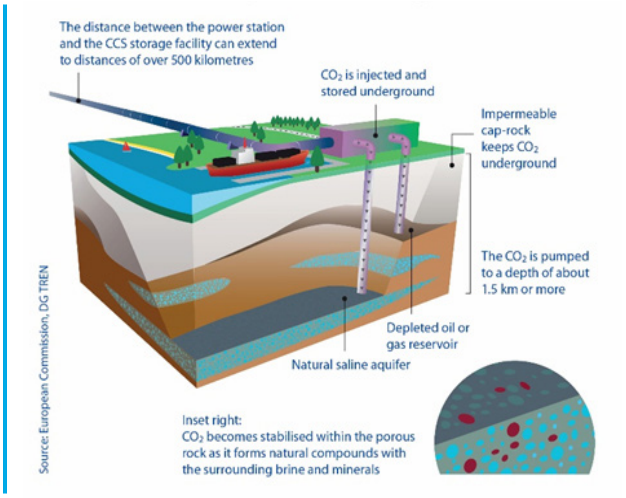
Carbon capture and storage (CCS)

The transition to a low-carbon world requires a transformation in the way we manufacture iron and steel. There is no single solution to CO_2-free steelmaking, and a broad portfolio of technological options is required, to be deployed alone, or in combination as local circumstances permit. This series of fact sheets describes and explores the status of a number of key technologies and issues.

What is CCS?

Carbon capture and storage (CCS) describes a suite of technologies that capture waste CO_2, usually from large point sources, transport it to a storage site, and deposit it where it will not enter the atmosphere.

Stored CO_2 is injected into an underground geological formation; this could be a depleted oil and gas reservoir or other suitable geological formation. CO_2 can also be injected into mature oil fields, driving out additional oil from the rock before being permanently stored. This is known as enhanced oil recovery (EOR) and is a form of carbon capture use and storage (CCUS).



Carbon Capture and Storage (CCS) - Source European Commission, DG TREN

CCS deployment now

There are currently 50 facilities in operation (three of which are dedicated transport and/or storage projects) and 44 are under construction (seven of these are for transport and/or storage). As of July 2024, the project pipeline includes 628 projects, a 60% year-on-year increase.

The global capacity for capturing carbon dioxide is poised to double to over 100 million metric tons per year once currently under-construction facilities become operational.

Natural gas processing is a significant application for CCS technology, with 16 of the CCS plants attached to natural gas processing plants, six in the hydrogen, ammonia or fertiliser sectors, three are in the power sector, and the remainder are scattered across a number of other sectors, including chemicals, hydrogen, and steel.[1]

CCS in the steel industry

Potential approaches

CCS could potentially be applied to all major point sources in the steel sector. Past studies have tended to focus on the blast furnace as the major point source of CO_2 on a conventional integrated steel plant, either using retrofitted CO_2 capture technology or by developing a new type of blast furnace. The European ULCOS programme represents a good example of the latter – proposing a radical new top gas recycling blast furnace design. CCS has not yet been applied to blast furnace steelmaking beyond pilot-scale projects.

Direct reduction plants can offer an easier route to CCS, as some plants incorporate CO_2 separation into their designs and emit a concentrated stream of CO_2 during normal operation. In these plants additional carbon capture equipment is not required.

Carbon capture can potentially be retrofitted to conventional DRI facilities.

Innovative coal-based smelt reduction plants such as the HIsarna process piloted at Tata Steel in the Netherlands are capable of producing a concentrated steam of CO_2, negating the need for CO_2 capture technology.

State of on-the-ground development

- The first phase of Baotou Iron and Steel Group's CCS project is undergoing cold commissioning ahead of the anticipated operation before the end of June 2025. Phase one of the 2Mt project will capture 500kt of CO2 for use in a number of CCUS applications.
- The DRI unit at Emirates Steel in Abu Dhabi is capable of capturing 800kt of CO2 per year, which is compressed, dehydrated and then pumped through 50 km of pipeline to be injected into a mature onshore oil field for EOR operations. The design of the DRI unit meant that a 90% CO2 waste stream was emitted during normal operations, so an additional capture step was not required.
- A similar plant in Venezuela emits a waste stream close to 100% CO2, but the captured CO2 is currently vented to atmosphere.
- CO2 is captured for use (see CCUS Fact sheet) from Ternium DRI facilities in Mexico.
- Carbon capture on the blast furnace have been studied in a number of research projects – these include the Japanese 'COURSE 50' project, the EU ULCOS programme and current projects in Germany (ROGESA, Saarstahl) and Sweden (STEPWISE).
- A Front End Engineering Design study is currently being undertaken by ArcelorMittal looking to design a carbon capture system capable of capturing 50-70% of CO2 emissions from blast furnace gas.
- ArcelorMittal is working with the Northern Lights consortium. This project could potentially see CO2 derived from steelmaking in Belgium and France shipped to Norway for geological storage. The company's DMX™ CCS project will lead to the construction of a demonstration capture unit at ArcelorMittal Dunkirk.
- In 2021, Tata Steel commissioned a 5 tonnes per day carbon capture plant at its Jamshedpur Works, extracting CO2 directly from the blast furnace gas.

Challenges

Scale up

Under the IEA's core 'Sustainable Development Scenario' (SDS), by 2070 about 75% of all the CO_2 produced globally in iron and steel is captured. For this to happen, an average of 14 steel plants operating with CO_2 capture need to be built every year from 2030 to 2070[2], amounting to over 15Gt of CO_2 being captured cumulatively by 2070. Currently installed CCS capacity accounts for 0.0007GT/year, so the scale up challenges are considerable.

Infrastructure

One of the challenges that faces CCS is how to transport significant volumes of compressed CO_2 from point sources to sites established for large-scale storage, especially offshore. Pipelines are one solution, but their viability depends on access to land, the volume to be transported and if the CO_2 comes from a variety of dispersed sources. The other option is to use dedicated sea tankers that can deliver CO_2 from one or more ports, either directly to an offshore storage site, or an intermediate shore-based facility connected via pipeline to the storage site.

Public acceptance

CCS is not universally embraced, and public perception and acceptance remain a bottleneck for its broad deployment. Many environmental NGOs dismiss CCS as high risk, unproven and fundamentally unnecessary.

Local communities have also rejected CCS, citing concerns around safety and impact on property value, though this varies by region. In many areas with a history of exploiting the subsurface (e.g. Saudi Arabia, Texas) community concern is low, however, in Europe development CO_2 storage is now exclusively offshore.

Evidence suggests that community concerns can be managed but with significant effort on the part of the project proponents.

Costs

The IEA found that innovative process routes (including CCS on the blast furnace, smelt reduction and gas-based DRI) can be expected to cost 10-50% more than conventional technology within a given regional context, noting this cost increase significantly exceeds profit margins from steelmaking today.

Regulatory issues

As an emerging technology, CCS regulation is still under development. For example, there is currently no framework in the EU to quantify and verify the CO_2 stored, and globally, there are still a lot of jurisdictions with little or no CCUS framework.

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[1] Global CCS Institute, Facilities, Global status report 2024
[2] International Energy Agency, Energy Technology Perspectives