

Carbon capture and storage (CCS)

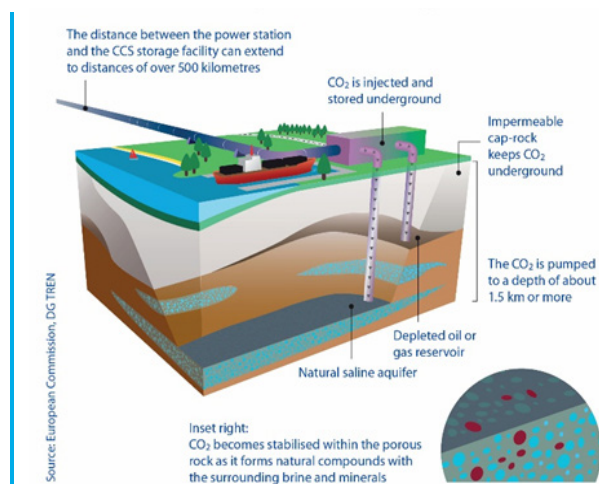


The transition to a low-carbon world requires a transformation in the way we manufacture iron and steel. There is no single solution to CO₂-free steelmaking, and a broad portfolio of technological options is required, to be deployed alone, or in combination as local circumstances permit. This series 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 CO₂, usually from large point sources, transport it to a storage site, and deposit it where it will not enter the atmosphere.

Stored CO₂ is injected into an underground geological formation; this could be a depleted oil and gas reservoir or other suitable geological formation. CO₂ 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 33 commercial CCS facilities operating globally. Most of these (19) are located in North America and the overwhelming majority use captured CO₂ in EOR operations. Fourteen of the CCS plants are attached to natural gas processing plants, 1 is in the power sector, and the remainder are scattered across a number of other sectors including chemicals, hydrogen, fertiliser 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 CO₂ on a conventional integrated steel plant, either using retrofitted CO₂ 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 CO₂ separation into their designs and emit a concentrated stream of CO₂ 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 stream of CO₂, negating the need for CO₂ capture technology.

State of on-the-ground development

- The DRI unit at Emirates Steel in Abu Dhabi is currently the only operational CCS plant in the iron and steel sector. This plant 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 CO₂ produced globally in iron and steel is captured. For this to happen, an average of 14 steel plants operating with CO₂ capture need to be built every year from 2030 to 2070², amounting to over 15Gt of CO₂ 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 CO₂ 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 CO₂ comes from a variety of dispersed sources. The other option is to use dedicated sea tankers that can deliver CO₂ 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 CO₂ 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 CO₂ stored, and globally, there are still a lot of jurisdictions with little or no CCUS framework.

March 2023 | AP/AE

¹ Global CCS Institute, Facilities, [co2re.co](https://www.co2re.co)

² International Energy Agency, [Energy Technology Perspectives](#)