Carbon capture utilization and storage

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The Intergovernmental Panel on Climate Change (IPCC) defines CCS as:

"A process in which a relatively pure stream of carbon dioxide (CO2) from industrial and energy-related sources is separated (captured), conditioned, compressed and transported to a storage location for long-term isolation from the atmosphere."[15]: 2221

Around 1% of captured CO2 is used as a feedstock for making products such as fertilizer, fuels, and plastics.[16] These uses are forms of carbon capture and utilization.[17] In some cases, the product durably stores the carbon from the CO2 and thus is also considered to be a form of CCS. To qualify as CCS, carbon storage must be long-term, therefore utilization of CO2 to produce fertilizer, fuel, or chemicals is not CCS because these products release CO2 when burned or consumed.[17]

Some sources use the term CCS, CCU, or CCUS more broadly, encompassing methods such as direct air capture or tree-planting which remove CO2 from the air.[18][19][20] In this article, the term CCS is used according to the IPCC"s definition, which requires CO2 to be captured from point-sources such as the flue gas of a power plant.

The use of CCS as a means of reducing anthropogenic CO2 emissions is more recent. In 1977, the Italian physicist Cesare Marchetti proposed that CCS could be used to reduce emissions from coal power plants and fuel refineries.[24][25] The first large-scale CO2 capture and injection project with dedicated CO2 storage and monitoring was commissioned at the Sleipner gas field in Norway in 1996.[8]: 25

In 2020, the International Energy Agency (IEA) stated, "The story of CCUS has largely been one of unmet expectations: its potential to mitigate climate change has been recognised for decades, but deployment has been slow and so has had only a limited impact on global CO2 emissions."[8]: 18

Eighteen facilities were in the United States, fourteen in China, five in Canada, and two in Norway. Australia, Brazil, Qatar, Saudi Arabia, and the United Arab Emirates had one project each.[5] As of 2020, North America has more than 8000 km of CO2 pipelines, and there are two CO2 pipeline systems in Europe and two in the Middle East.[8]: 103-104

After the CO2 has been captured, it is usually compressed into a supercritical fluid and then injected underground. Pipelines are the cheapest way of transporting CO2 in large quantities onshore and, depending on the distance and volumes, offshore.[8]: 103-104 Transport via ship has been researched. CO2 can also be transported by truck or rail, albeit at higher cost per tonne of

CO2.[8]: 103-104

CCS processes involve several different technologies working together. Technological components are used to separate and treat CO2 from a flue gas mixture, compress and transport the CO2, inject it into the subsurface, and monitor the overall process.

There are three ways that CO2 can be separated from a flue gas mixture: post-combustion capture, pre-combustion capture, and oxy-combustion:[32]

Absorption, or carbon scrubbing with amines is the dominant capture technology.[8]: 98 Other technologies proposed for carbon capture are membrane gas separation, chemical looping combustion, calcium looping, and use of metal-organic frameworks and other solid sorbents.[36][37][38]

Impurities in CO2 streams, like sulfur dioxides and water vapor, can have a significant effect on their phase behavior and could cause increased pipeline and well corrosion. In instances where CO2 impurities exist, a scrubbing separation process is needed to initially clean the flue gas.[39]