Accelerating and Optimizing Your Carbon Capture, Utilization and Storage

EMERSON

Strategies to Mitigate Climate Change

As global demand for energy increases, decarbonization and environmental sustainability strategies to mitigate climate change require greater use of renewable energy and clean fuels, low carbon electrification, industry to make operational improvements and energy efficiency increases, improved waste and emissions management and greater investment in carbon capture, utilization and storage.

Carbon Capture, Utilization and Storage

Carbon capture, utilization and storage (CCUS) is the process of capturing carbon dioxide (CO_2) emissions at the source, preventing it from entering the atmosphere, or directly from the air. Once captured, CO_2 is then purified, liquefied and transported to a suitable storage location for long-term isolation from the atmosphere or utilized in other marketable industrial and commercial products.

CCUS has the potential to play a key role in reducing emissions from the hardest-to-abate industry sectors, particularly cement, steel and chemicals. For some industrial and fuel transformation processes, CCUS is one of the most cost-effective solutions available for large-scale greenhouse gas (GHG) emissions reductions – especially those inherently producing a relatively pure CO_2 stream.

The process of capturing carbon has been used within gas processing for decades to remove CO_2 from natural gas to improve purity. Since the 1970s, captured CO_2 has been piped to oil fields and utilized to enhance oil recovery. In more recent times, capture technology has been successfully coupled with underground injection and sequestration of CO_2.

Carbon Capture Methods

There are an increasing number of projects focused on testing the viability of large scale capture of CO_2 directly from the air, but the most cost-effective approach is to capture carbon from its point of source. At the point of source there are three main methods of extraction depending on the industrial process and the concentration of CO_2:

Low concentration

Post combustion capture – CO_2 is removed after combustion of the fossil fuel, captured from the flue gases (especially at power stations, but also other point sources).

Average concentration

Pre-combustion capture – partial oxidization of the fossil fuel prior to combustion results in carbon monoxide. Steam added produces CO_2, which is captured, and hydrogen that can be used as a fuel.

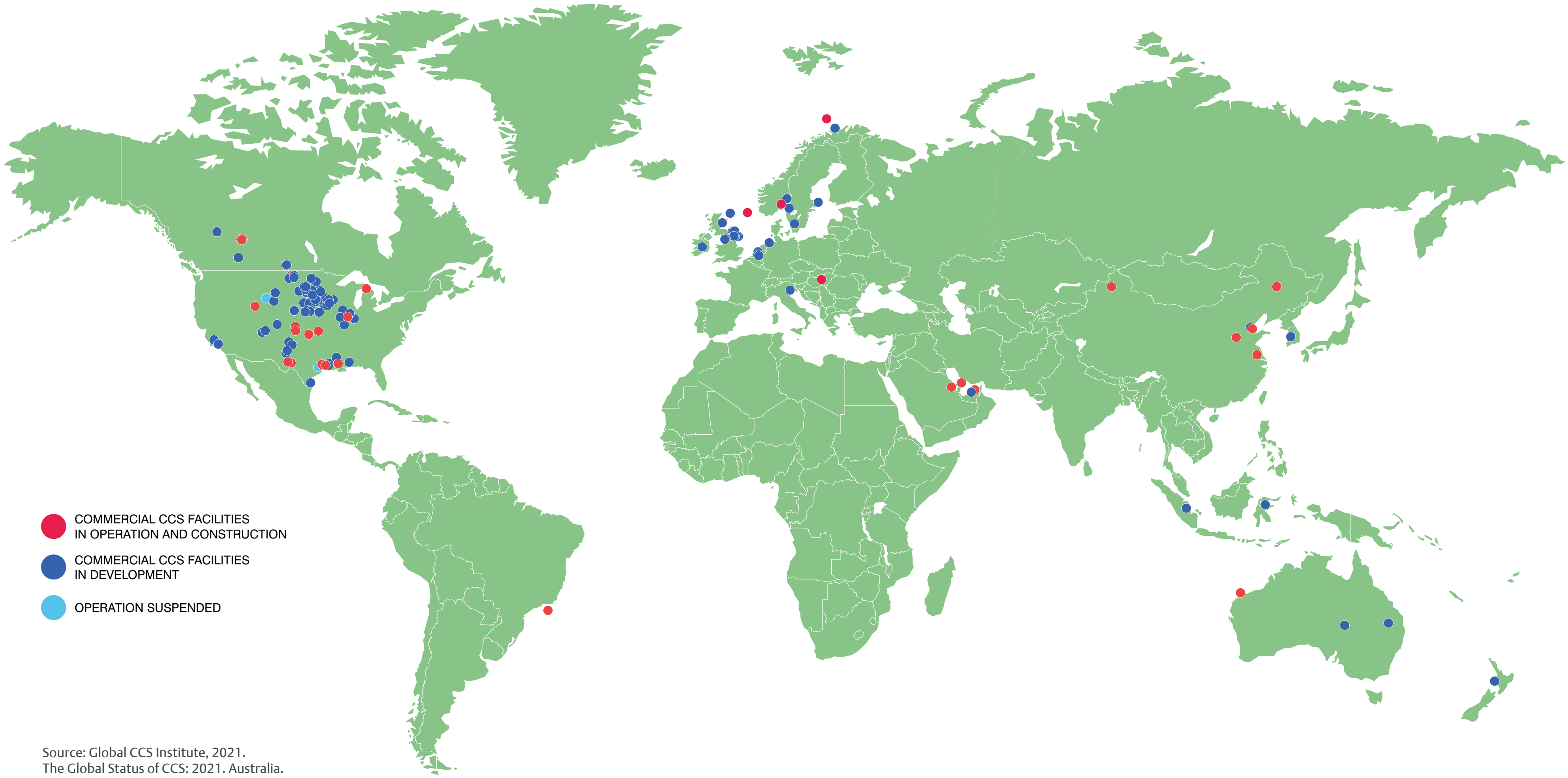
High concentration

Oxyfuel combustion – fossil fuel is burned in pure oxygen, creating a flu gas consisting almost entirely of CO_2.

Greater Investment in CCUS

CCUS may not be a new concept, but there has been significant interest in recent years, with the promise of a rapid scaling-up of investment, wider deployment and accelerated innovation.

To meet global climate mitigation targets, it is estimated that over 2000 large-scale CCUS facilities must be operating by 2050. According to the Global CCS Status Report 2021, there are currently only 135 commercial large-scale CCUS facilities operating and in various stages of development.



Source: Global CCS Institute, 2021.
The Global Status of CCS: 2021. Australia.

Role of Government

The private sector is well placed to manage technical, construction and operational performance risks, but government has an important role to play to enable CCUS deployment to scale up at the rate required to meet global climate targets. This includes financial support in the form of capital grants, operational subsidies or concessional loans for specific projects. Government can also support shared transport and storage infrastructure, which significantly lower the cost through economies of scale. Regulation can also play a role in supporting the deployment of CCUS by placing an implicit value on emissions.

Challenges Faced by CCUS Industry

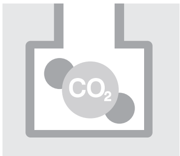
Carbon capture and storage is deemed a proven and safe technology. However, its deployment brings serious operational costs, challenging its business case.

Cost of Implementation and Operation

The upfront capital investment for capture technology, transport pipelines and geological storage can be prohibitive. There are also increased operational costs, with significant energy required to capture and compress the CO_2. Capturing CO_2 can also decrease the efficiency of the plant and increase water use. These inefficiencies and associated costs can ultimately render a CCUS project financially non-viable.

Transportation Challenges

New infrastructure is required to safely carry condensed and liquefied CO_2 to storage or utilization sites, with existing oil and gas pipelines unsuitable. Transporting CO_2 is expensive. Significant energy is required to compress the CO_2 and to maintain high pressure throughout pipelines. Impurities in the CO_2 stream, including water, can cause damage that leads to dangerous leaks and explosions as the compressed fluid rapidly expands to a gas. For transportation over longer distances, marine vessels are used, which requires buffer storage and loading/unloading with custody transfer capability.



Storage Considerations

Although there is potentially enough storage capacity available worldwide for at least the next century, especially in the United States, there is currently a lack of regulation and clarification on accountability to support lifelong storage.

Key Operating Challenges

The success of CCUS depends on the efficiency and cost-effectiveness of the capture process, reducing the cost of transportation and ensuring reliable containment. Within these different phases there are number of key challenges that must be addressed:

Carbon Capture

- Energy efficiency
- Process efficiency
- Equipment reliability

Transportation

- Compressor and pump reliability
- Liquefaction process efficiency
- Liquid phase instability
- Loss of containment

Storage

- Evaluating storage capacity
- Injection process efficiency
- Underground storage durability

Automation technology has a crucial role in the viability, safety, and effectiveness of CCUS.

Capture Process Efficiency

Post combustion amine-based absorption is the most mature carbon capture process. It consists of an absorber, where a chemical solvent captures CO_2 from the flue gas, and a stripper where the chemical solvent is regenerated, and the CO_2 is extracted. CO_2 capture efficiency is dependent on the solvent circulation rate. Increasing the circulation rate increases the energy required for the stripper reboiler. There is therefore a trade-off between the capture efficiency and energy cost to regenerate the solvent. Meeting the target CO_2 capture rate in the most efficient manner is the challenge.

Automation solutions:

- Online analysis allows process optimization through multivariable control and analytics
- Advanced controls and alarm management software helps optimize operational performance, while digital twin technology improves operator performance
- Energy management information systems that detect poor performance can reduce site energy usage by up to 15%
- Coriolis density meters automate lean amine concentration measurement to determine solvent circulation rate to achieve desired capture efficiency at lowest cost
- Precise control of rotating equipment can reduce energy consumption, while online machinery health monitoring reduces downtime
- Pressure safety valves offering greater stability and tightness reduce leakages and minimize discharges

Liquefaction Efficiency

Liquefaction is an essential process for long distance transportation of CO_2 and consists of a series of compressor stages and cooling. Efficiency of the liquefaction process depends on reliable measurement and control. Increasing the visibility within each stage of the process is crucial, but the cost of infrastructure required to support sensors for collecting actionable data can be high.

Automation solutions:

- Smart wireless networks reduce installation costs and enable continuous monitoring to support timely response to issues.
- Control systems offering seamless integration of plant visualization tools help to maintain full asset visibility.
- Advanced alarm management tools support improved operator effectiveness.

Compressor Reliability

CO_2 must be compressed to a pressure between 1,500 and 2,200 psi. Compressors are key assets used across all phases of CCUS, with unexpected failures resulting in capacity outage, equipment damage, excessive maintenance and costs, and scheduling delays. Online monitoring has traditionally been deemed cost-prohibitive or too difficult.

Automation solutions:

- Continuous compressor health and performance monitoring with pervasive sensors and data analytics provides visibility to health and performance, mitigating risk of downtime and/or incidents.
- Optimized digital valve solutions ensure stable flow to the compressor, preventing damage and increasing compressor life.
- Appropriate pressure safety valves allow operation nearer to optimal pressure setpoints and reduce fugitive emissions.

Loss of Containment

Loss of containment undermines the whole purpose of capturing CO_2. A leak as a result of corrosion and erosion is a significant concern during all phases of CCUS. In an amine carbon capture unit, carbonic acid attack is possible where water vapor condenses in the presence of CO_2. Two-phase flow at the feed to the stripper also results in erosion concerns. Sheer rates, turbulence and steam velocities are also key for corrosion and erosion control. Within liquefaction, water content in CO_2 can lead to leaks and must be controlled. Being able to detect and localize pipeline leaks in real time enables you to address the issue quicker.

Automation solutions:

- Understand the impact of corrosion and maintain a leak-free process by continuously monitoring wall thickness across pipes using wireless ultrasonic sensors.
- Real-time monitoring and alarm solutions to quickly identify leaks and ruptures.
- Software solutions aggregate disparate pipeline and asset integrity-related data that helps identify issues and perform more accurate risk modeling.
- High performance valves with superior sealing, packing monitoring and potential leak points addressed to minimize fugitive emissions.

CO_2 Integrity

Maintaining CO_2 in its liquid state is critical, but can prove difficult. CO_2 purity is important to maintain the single phase without requiring extra energy. Impurities and humid conditions can cause the formation of dry ice. Humidity also brings the risk of corrosion and potential leaks. Having an accurate analysis of the stream is crucial for operations and safety.

Automation solutions:

- Continuous analysis technology enables reliable inline gas analysis to be performed remotely.
- Perform challenging multiphase flow and density measurements as CO_2 is in or near supercritical state using Coriolis meters.

Storage Capacity

Underground carbon storage project success depends on reliable estimates of CO_2 storage capacity. The highly variable nature of geological settings and rock characteristics make the storage capacity assessment challenging. A thorough integration of subsurface information coming from multiple sources and disciplines is key to develop predictive estimates of the carbon volume that can be injected and stored in the geological formation.

Automation solutions:

- Advanced seismic processing and imaging software solutions enable accurate images of geological features and delineation of the underground storage complex.

Storage Integrity

Reliability of the storage process is key, as CO_2 leakage can undermine the value of carbon storage as a mitigation option. Reliable assessment of the long-term storage containment integrity is critical to business decisions regarding site selection and development. To minimize the risk of leakage, it is important to verify that injected CO_2 is contained within the storage complex. Monitoring is essential to effectively respond to events jeopardizing the storage process reliability.

Automation solutions:

- Downhole gauges provide continuous, real-time data from the storage reservoir, ensure wellbore integrity and process reliability.
- Software analyzes and interprets subsurface changes observed on seismic data through the project lifetime.

Selecting The Right Automation Partner

Partnering with a supplier able to provide a complete portfolio of automation solutions together with extensive project expertise can help to reduce project complexity, drive operational efficiency and maximize containment reliability.

Emerson's advanced automation technologies, designed specifically to monitor and control the capture process, liquefaction, compression, pipeline transfer, loading and unloading, buffer storage and underground containment, help to ensure operational certainty by delivering advanced control, increased process visibility and actionable information for improved decision-making.

Emerson's Project Certainty methodology and technologies, combined with extensive industry expertise available globally, reduces project risk and helps to ensure delivery of large-scale capital projects, on time and within budget.

Transition to Low Carbon Future

Emerson enables customers to achieve their ambitious decarbonization goals by helping them overcome technical challenges and scale up solutions. This includes optimizing the production of low-carbon power and low-carbon fuels such as hydrogen, electrifying end-uses, reducing the energy use of buildings and industrial sites, minimizing waste generation and material use, preventing emissions leakage, and capturing and storing CO_2.

To increase the viability of CCUS and meet the need for expanded operations, we continue to develop innovative solutions to ensure more efficient capture, safe and lower-cost transportation, and reliable containment.

Emerson.com/SustainabilityContentHub

EMERSON