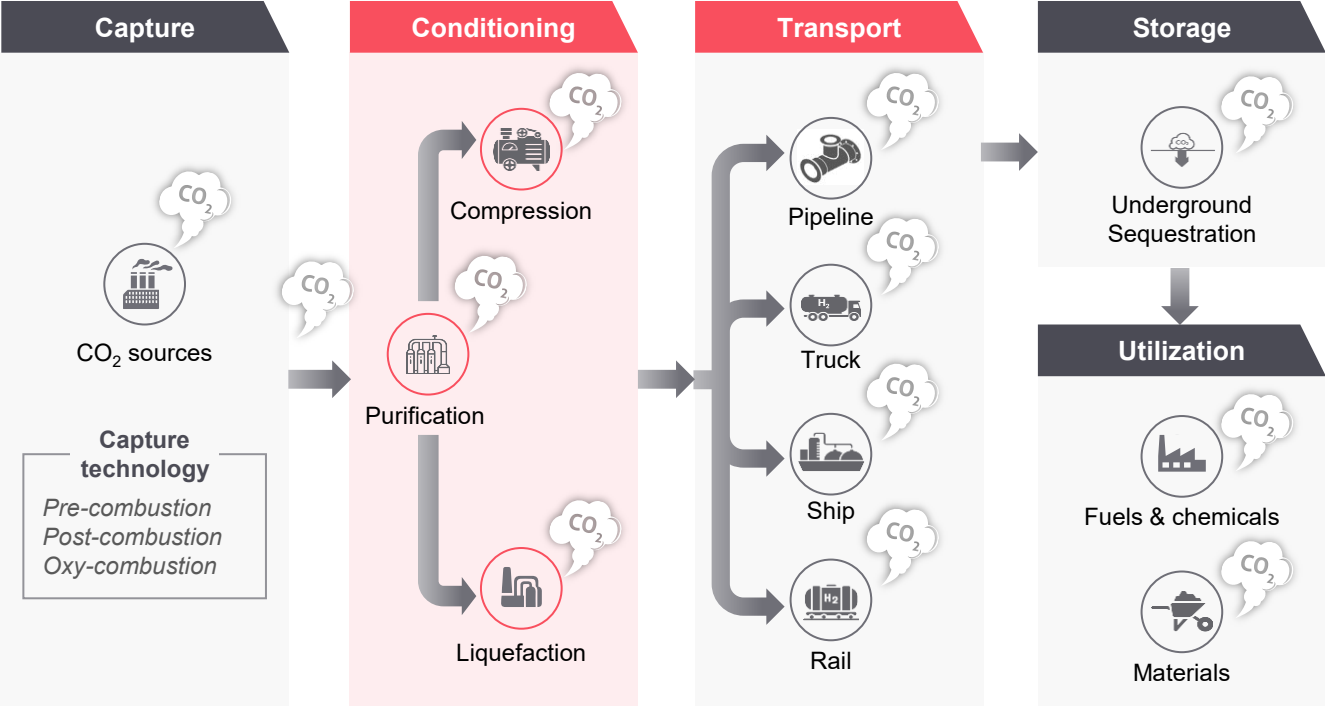


CO<sub>2</sub> MONITORING

Carbon visibility across CCUS value chain

CCUS Value Chain: Emission Sources

CO<sub>2</sub> monitoring is the systematic measurement and analysis of carbon dioxide (CO<sub>2</sub>) levels at each stage which ensures safety, environmental protection, regulatory compliance and operational efficiency and for that emission source identification is of utmost importance.



The Need for CO<sub>2</sub> Monitoring

CO<sub>2</sub> is an odorless, colorless, and denser-than-air gas that is hazardous for humans, animals and the planet.

At concentrations above **5%**, CO<sub>2</sub> is toxic to humans and animals. Breathing high concentrations of CO<sub>2</sub> does not cause hypoxia; rather, it results in CO<sub>2</sub> intoxication in body tissues, which can lead to death..

A large-scale leakage of stored CO<sub>2</sub> can undo years of effort in capturing and storing CO<sub>2</sub>. Adding large amounts of CO<sub>2</sub> back into the atmosphere.

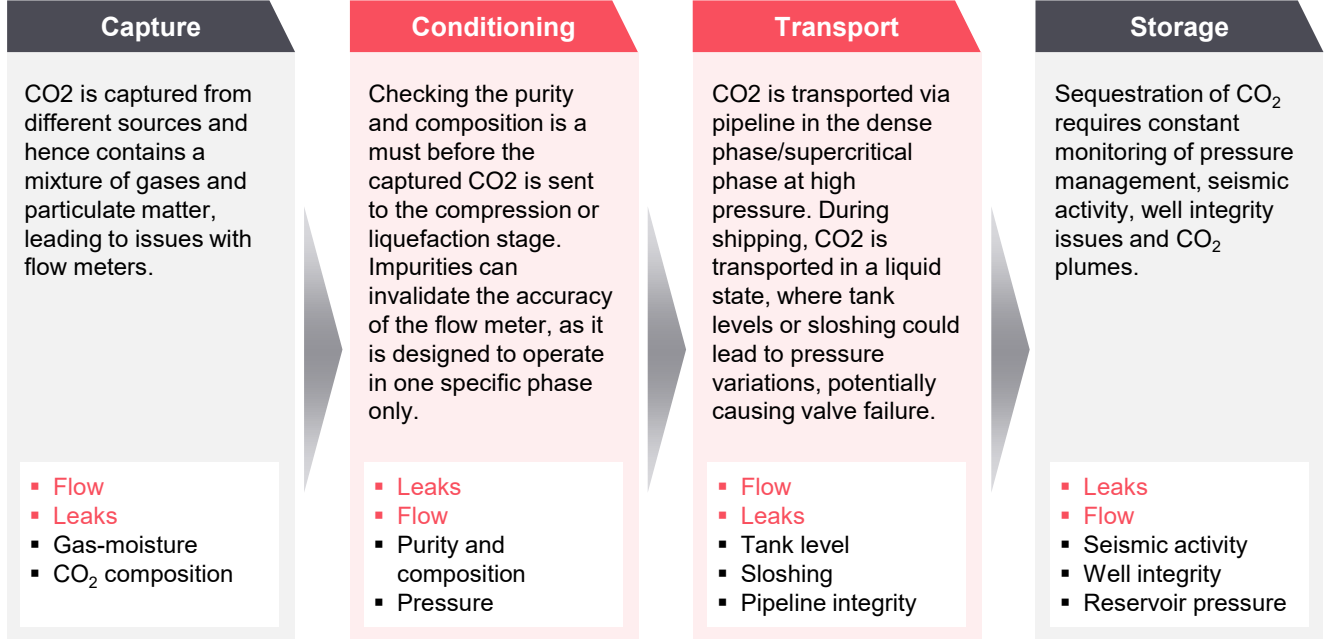
A CO<sub>2</sub> leak could be catastrophic because CO<sub>2</sub> is **60% denser than air** and will therefore travel at low levels, displacing oxygen and creating toxic conditions on inhabited land.

CO<sub>2</sub> leaked in undersea storage facilities could react with seawater to form **carbonic acid**, leading to ocean acidification and local ecological damage .

Source: Dräger

CCUS Value Chain: What is Measured

It is very important for the flow rate of CO<sub>2</sub> to adhere to the desired design specifications. Monitoring real-time leak detection is crucial to avoid fugitive emissions, and the placement of flow meters and leak detectors is essential at all stages of the CO<sub>2</sub> value chain.



The Evolution of Flowmeter Technologies

**ULTRASONIC**

100 bar

- It involves measuring time differences between upstream and downstream ultrasonic pulses.
- Can process 0.1 - 500 m<sup>3</sup>/min of CO<sub>2</sub>.
- Considered least suitable due to CO<sub>2</sub> acoustic attenuation.

**CORIOLIS**

400 bar

- The most versatile CO<sub>2</sub> flow meter as these can detect phase shift and operate on multiphase streams.
- Can process 0.01 Kg/min - 1000 Kg/min of CO<sub>2</sub>

**MAGNETIC RESONANCE**

Wide range

- This emerging technology precisely measures CO<sub>2</sub> flow in pipelines.
- The CO<sub>2</sub> stream is exposed to a magnetic field and radiofrequency (RF) pulses, and the response is analyzed to determine flow parameters.

Current and Emerging Leak Detection Technologies

**Photoacoustic CO<sub>2</sub> detector**

- Photoacoustic detector operates on the photoacoustic effect which generates sound waves to identify and measure possible CO<sub>2</sub> leaks.
- Detect CO<sub>2</sub> concentrations at parts per billion (ppb) levels, hence highly sensitive.
- Ideal for detecting very low concentration leaks.

**Ultrasonic gas leak detector**

- Ultrasonic detectors use an array of microphone sensors to detect the high-frequency hissing sound of compressed gas leaks.
- They are effective for detecting larger leaks and useful in noisy industrial environments.
- However, they may give false alarms due to indistinguishable noises from compressors and other sources.

**Robotic leak detector**

- Robots equipped with advanced sensors and algorithms can detect CO<sub>2</sub> leaks, with sensitivity depending on the type of sensor used.
- They can be designed to detect low to high concentrations of CO<sub>2</sub> .
- It can access hard-to-reach areas, enhancing safety.

Future Perspectives

- CO<sub>2</sub> monitoring technologies hold great value as even a 1% CO<sub>2</sub> leak from a large capture facility could potentially cause a \$2-\$5 million annual loss.
- Advancements in 4D seismic monitoring, fiber optic sensing, and integrated technologies like SCADA, IoT, and AI collect and rectify real-time data from multiple sections in the CCUS value chain, increasing CO<sub>2</sub> monitoring efficiency and reducing repairs, downtime, and associated costs.
- Supportive government policies, 'accurate measurement, reporting and verification' in the CCUS value chain and collaborative efforts would not only help companies save millions of dollars on safety incidents due to undetected CO<sub>2</sub> leak but help mitigate the GHG emission, achieving net-zero carbon emission target set for 2070.

About FutureBridge

FutureBridge is a techno-commercial consulting and advisory company. We track and advise on the future of industries from a 1-to-25-year perspective to keep you ahead of the technology curve, propel your growth, Identify new opportunities, markets and business models, answer your unknowns, and facilitate best-fit solutions and partnerships using our platforms, programs, and access to global ecosystems and players.