CCS flow solutions

The pumps and expertise to ensure safe and efficient CCS processes

New Green Solutions

DESMI
Make life flow

We help you keep CCS processes flowing

Successful plant design is never just about the pump

As industries intensify efforts to reduce carbon emissions, carbon capture and storage (CCS) is becoming a key technology in the transition to a low-carbon future.

However, CCS is a complex flow process, and designing efficient solutions requires more than specialized equipment. It requires in-depth technical knowledge and extensive experience.

Our products handle anything from amines and bicarbonates to liquid CO_2, and our decades of supplying pumping solutions for demanding industrial applications have given us a thorough understanding of how flow processes work.

When you work with DESMI, you get much more than pumps: You benefit from our expertise, and from our ability to take a holistic view of objectives, challenges, and stakeholders. We work closely with license holders, EPCs, consultants, and end users to develop a CCS process that is efficient and safe.

CCS OR CCUS?
Carbon capture is also referred to as CCUS (Carbon Capture, Utilization, and Storage). The process is the same in both cases, but CCUS places more emphasis on using the captured CO_2, for example in manufacturing. As utilization is not yet widespread, we use the term “CCS”.

CONTENT

A quick overview of carbon capture and storage basics

Why do we capture CO_2?

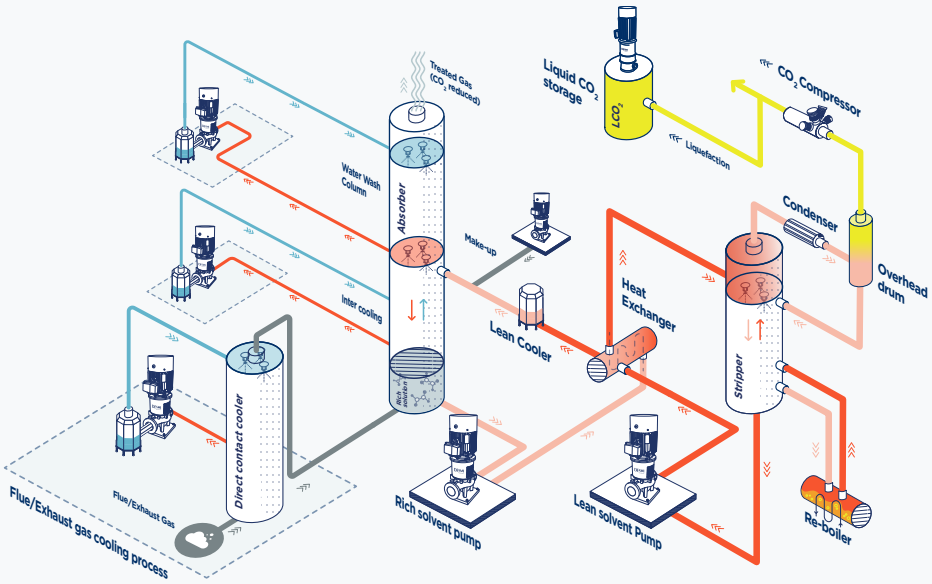
Carbon dioxide (CO_2) occurs naturally and plays an important role in several biological processes. However, CO_2 concentrations are rising, mainly due to human activity, causing global warming and climate change. To counteract this, CO_2 emissions to the atmosphere must be reduced.

What is CCS?

CCS is an important technology for reducing climate impact. It is a set of processes that reduce CO_2 emissions from industrial and power generation sources on land or at sea. Some methods also allow carbon capture directly from air and water, but they are generally less efficient.

What is the potential impact of CCS?

The IEA projects that CCS could capture around 9.7 $GtCO_2$ cumulatively from power generation to 2040, equivalent to more than a decade of emissions from the global aviation industry. And a report from Grandview Research cited by the World Economic Forum projects that the global CCS market will grow at a CAGR of 7.4% from 2025 to 2030, reaching USD 5.61 billion by 2030.



What steps are involved?

1. Capturing gaseous CO_2 from flue gases (post-combustion) and converting it to liquid form
2. Transporting the liquid CO_2 using pipelines, tankers, or trucks
3. Injecting the CO_2 into storage deep underground, or using it

End to end CCS flow solutions

DESMI supports you through the three main steps of CCS

DESMI solutions and expertise help you design and operate your solution. We support you through the three main steps of your CCS process, and our products are equally well suited for land-based and shipboard CCS plants.

We supply the products you need as skid based, containerized, or modular solutions. We engineer your solution to suit your requirements, and we contribute expertise, support, and cooperation from the very start of the project.

We design our CCS flow solutions to be scalable so they can be upgraded to match future requirements. And when you do business with DESMI, you can count on expert support from our strong international supply chain and logistics network.

DESMI solutions used in groundbreaking full-scale onboard CCS

One of the world's first ships with a full-scale CCS plant on board uses DESMI pumps to ensure efficient and reliable CCS operation. The plant can cut vessel emissions by around two-thirds, demonstrating that it is a viable solution for reducing carbon emissions from global shipping.

Land-based applications

CCS helps lower the climate footprint of carbon-intensive facilities such as power plants, concrete manufacturing, steel plants, and refineries.

Shipboard applications

CCS significantly reduces your fleet's carbon footprint, helping ensure compliance with standards such as EEDI, EEXI, and CII.

Step 1: Capture and Conversion

Design a reliable system that handles solvents safely and efficiently

Post-combustion carbon absorption using a liquid solvent as a sorbent is handled as follows:

1. The flue gas is cleaned, cooled, and moisture is removed.

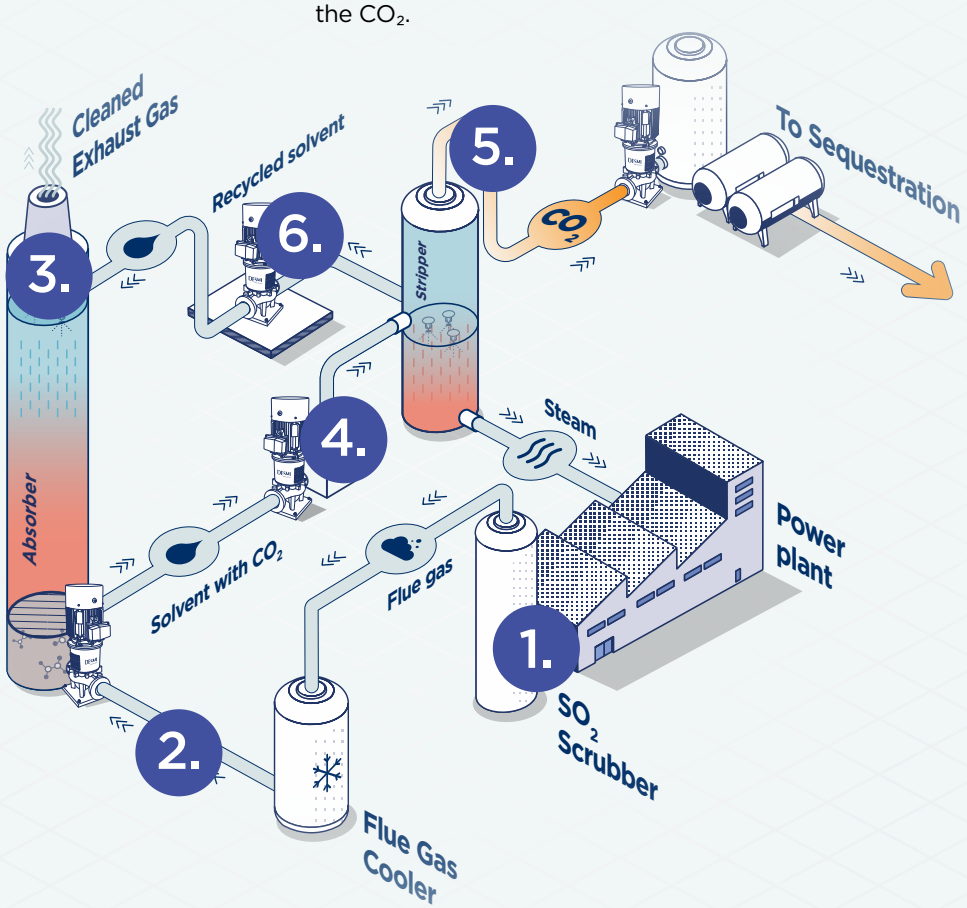
2. The cleaned flue gas is sent to an absorber where a solvent is flushed over the gas to absorb CO_2.

3. The flue gas with significantly reduced CO_2 content is released to the atmosphere.

4. The CO_2-rich solvent is sent to a stripper and heated to around 150° C (302° F) to release the CO_2.

5. The gaseous CO_2 is converted to liquid by compressing it to 20-30 bar (290-435 psi) and cooling it to -20 to -50° C (-4 to -58° F)

6. The lean (CO_2-free) solvent is cooled down in a heat exchanger and reused.



Challenges

This type of carbon capture is typically handled using highly abrasive amin-based solvents such as MEA and MDEA, or bicarbonates. To ensure system efficiency, safety, and reliability, it is important to select **pump materials and seals** that can handle the solvent (especially with amines).

Unless the flow process is designed and handled carefully to ensure optimal transport conditions for the solvent, foaming and cavitation can occur which can reduce the efficiency of the CCS plant. One way to mitigate these issues is by using **frequency converters** for stepless pump speed control, enabling more precise process regulation and stable operationl. By doing so, you get better control of the process and can keep it running with no issues.

To maximize efficiency and balance-of-plant (BOP), it is very important to achieve the right process **temperatures**, for example when cooling flue gas or heating the rich solvent. Pumps are a key part of this. We recommend that plant designers and pump suppliers work closely together to ensure maximum efficiency.

OptiSave™

- ✓ Energy saving system with frequency converter
- ✓ Handles multiple pumps and complex, interconnected systems
- ✓ Compatible with any pump brand
- ✓ Minimal changes to existing electrical installations
- ✓ Integrates seamlessly with plant SCADA systems for full process visibility
- ✓ Field proven from 700+ installations

Pump types

NSL/NSLH

In-line centrifugal pump

Up to 1800 m^3/h (7900 US GPM)

Up to 25 bar (360 psi)

Vertical or horizontal configuration

ESL/ESLH

High-efficiency in-line centrifugal pump

Up to 225 m^3/h (990 US GPM)

Up to 30 bar (435 psi)

High configuration flexibility

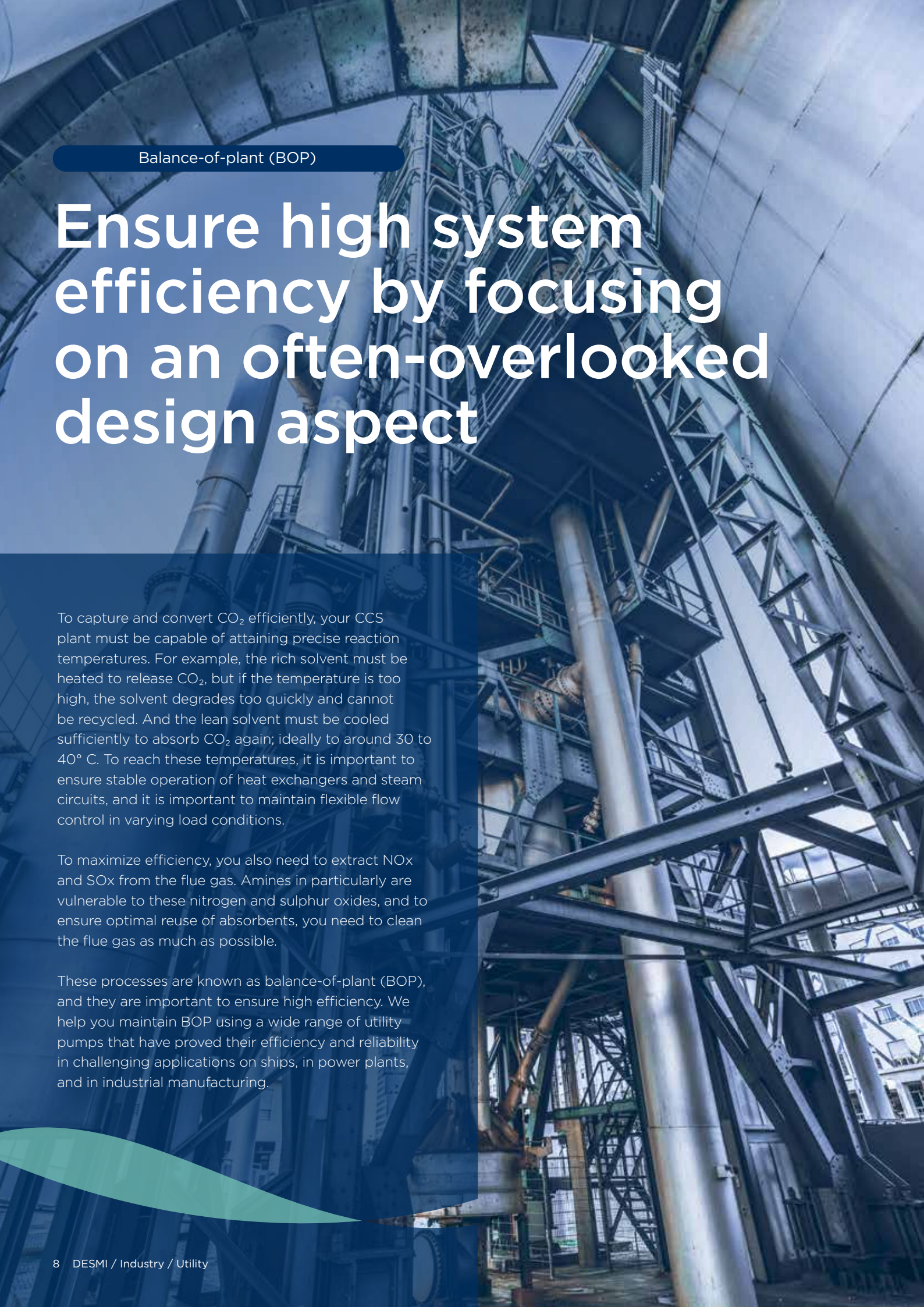
TSL/TSLH

Two-stage vertical centrifugal pump

Up to 40 m^3/h (180 US GPM)

Up to 16 bar (230 psi)

Inline or angular suction/ discharge port arrangement



Balance-of-plant (BOP)

Ensure high system efficiency by focusing on an often-overlooked design aspect

To capture and convert CO_2 efficiently, your CCS plant must be capable of attaining precise reaction temperatures. For example, the rich solvent must be heated to release CO_2, but if the temperature is too high, the solvent degrades too quickly and cannot be recycled. And the lean solvent must be cooled sufficiently to absorb CO_2 again; ideally to around 30 to 40° C. To reach these temperatures, it is important to ensure stable operation of heat exchangers and steam circuits, and it is important to maintain flexible flow control in varying load conditions.

To maximize efficiency, you also need to extract NOx and SOx from the flue gas. Amines in particularly are vulnerable to these nitrogen and sulphur oxides, and to ensure optimal reuse of absorbents, you need to clean the flue gas as much as possible.

These processes are known as balance-of-plant (BOP), and they are important to ensure high efficiency. We help you maintain BOP using a wide range of utility pumps that have proved their efficiency and reliability in challenging applications on ships, in power plants, and in industrial manufacturing.

Other capture methods

Alternative liquid-based methods of capturing CO_2

There are alternatives to post-combustion carbon absorption using a liquid solvent. Some of these are liquid-based, and DESMI can supply the pumps and expertise to design a CCS plant based on them.

Cryogenic capture

With this method, the flue gas is cleaned using the same method as for liquid solvents. The gas is then compressed and cooled down until the CO_2 crystallizes (around -40 to -50° C / -4 to -58° F). Other gases are now released, and the solid CO_2 is heated to liquid form and stored. The technology can be a good solution for concrete plants, steelworks, and other industrial applications where the flue gas has a high CO_2 content.

DWC (Direct Water Capture)

Direct Water Capture is a technology that removes CO_2 directly from seawater, where CO_2 is present at higher concentrations than in atmospheric air. The method typically relies on electrochemical or thermal processes to extract dissolved CO_2, which is then collected for storage or utilization. Since the ocean acts as a vast global CO_2 reservoir, DWC can serve as a complementary solution to Direct Air Capture (DAC). The technology is still in the early stages of development (TRL 3–5) and requires significant energy input and large volumes of water. Its efficiency depends not directly on CO_2 concentration, but rather on operating parameters and system design.

Membranes and Solid Sorbents

Membrane and solid sorbent technologies separate CO_2 from flue gas without using liquid solvents. Membranes work by allowing CO_2 molecules to pass through a semi-permeable barrier, while other gases are retained. Solid sorbents - such as metal-organic frameworks (MOFs) or amine-based materials - capture CO_2 molecules on their surface at low temperature and pressure, after which the CO_2 is released through heating or pressure swing. These technologies are particularly suited for industrial processes with high CO_2 concentrations, such as cement production and steel manufacturing. They have low energy requirements and do not rely on water, making them attractive for deployment in water-stressed regions.

Step 2: Transportation

Design solutions that transport liquid CO_2 safely over land or sea

The liquid carbon dioxide resulting from step 1 must be transported either to underground storage sites or for further utilization. This step typically involves the following approaches:

Seaborne transportation:
Liquid CO_2, typically stored at 15–25 bar (217-362 psi) and –20 to –50°C (-4 to -58° F), is transferred from onshore storage tanks to the cargo tanks of a CO_2 carrier vessel. Transfer is achieved using deepwell pumps, which are installed both in the onshore tanks and on the vessel to ensure stable flow and pressure control during loading and unloading operations.

Overland transportation:
Two main methods are used for transporting liquid CO_2 overland:

- **Pipeline transport:** Liquid CO_2 is pumped from storage using deepwell pumps and transported through insulated pipelines, often above ground. Along the pipeline route, intermediate booster stations equipped with additional pumps (sometimes housed in so-called “cans”) may be installed to maintain pressure and flow over long distances. Pipelines can also be routed subsea for offshore storage.
- **Truck transport:** Alternatively, liquid CO_2 can be loaded into pressurized cryogenic tanker trucks. This method is primarily used for small-scale facilities or pilot projects due to the limited volume capacity and higher per-tonne transport costs compared to pipelines or ships.

Pump types

NDW

Deepwell cargo pumps

Up to 1200 m^3/h / 5283 US GPM

Shaft can rotate in both directions to break ice blocking

Maintenance access without gas freeing the tank

Challenges

To ensure efficient and safe handling and transporting of liquid CO_2, liquid phase stability must be maintained at all times. This requires pump hydraulics designed for CO_2 and cryogenic high-pressure applications. In addition, transportation systems must be designed to prevent cavitation, corrosion, and dry ice formation.

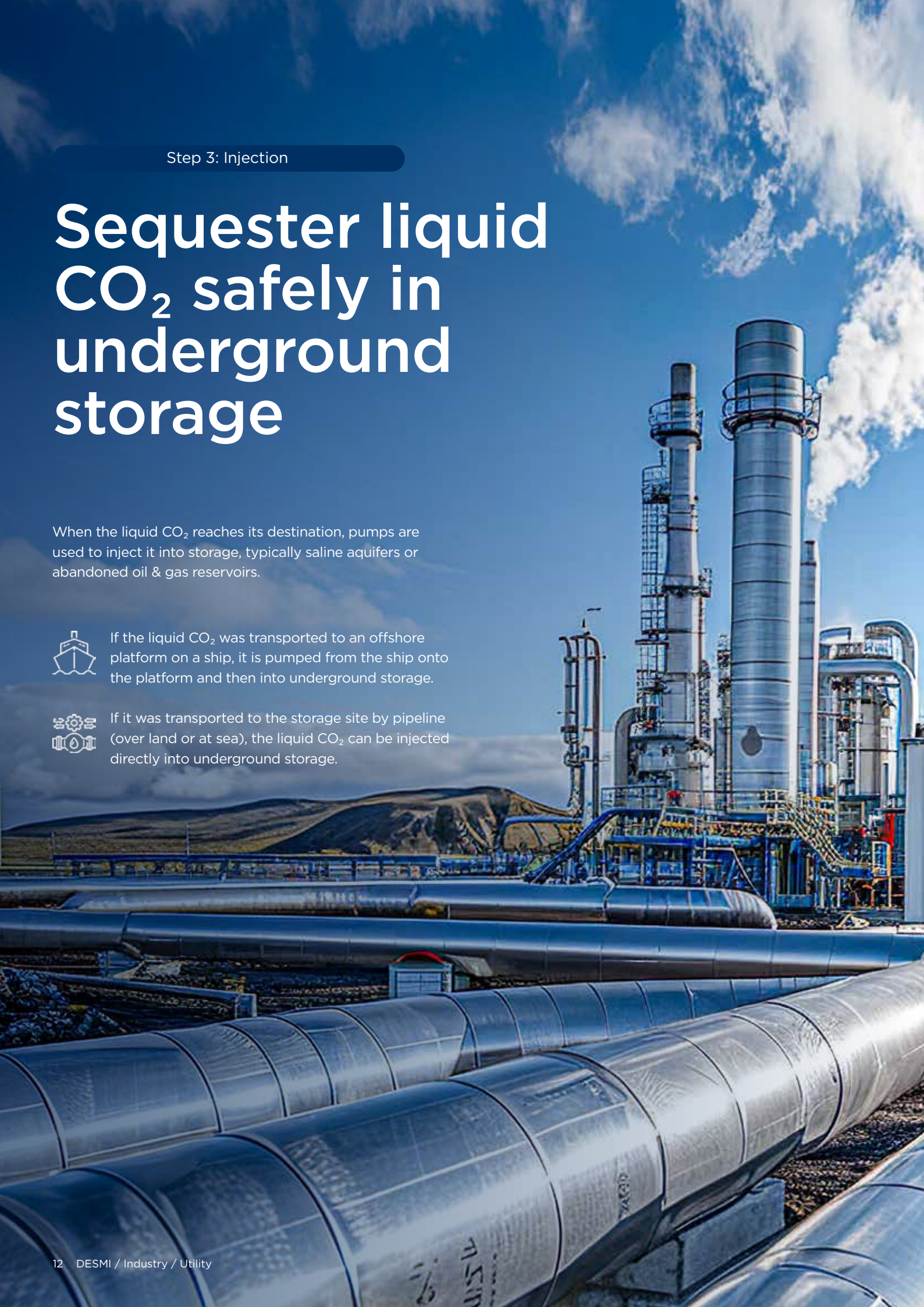
Step 3: Injection

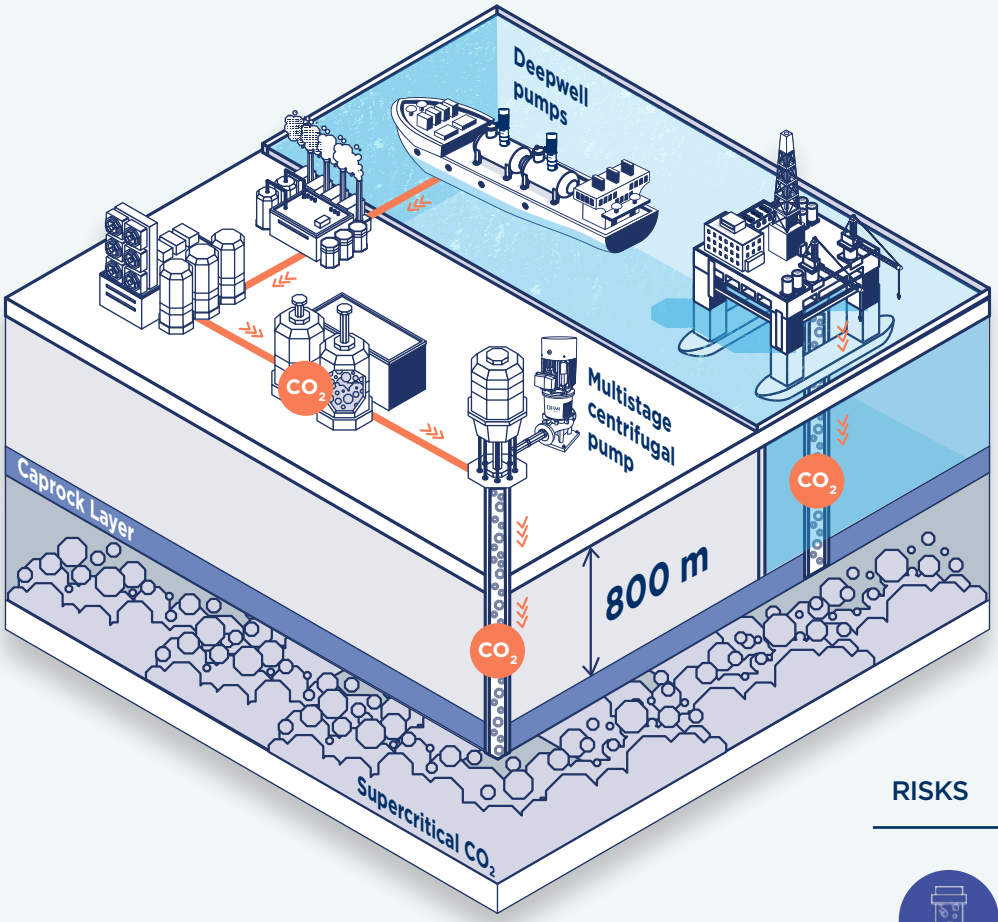
Sequester liquid CO_2 safely in underground storage

When the liquid CO_2 reaches its destination, pumps are used to inject it into storage, typically saline aquifers or abandoned oil & gas reservoirs.

If the liquid CO_2 was transported to an offshore platform on a ship, it is pumped from the ship onto the platform and then into underground storage.

If it was transported to the storage site by pipeline (over land or at sea), the liquid CO_2 can be injected directly into underground storage.





RISKS

- Cavitation
- Corrosion
- Dry ice formation

The injection is typically handled using a multistage centrifugal pump that can build pressure to at least 80 bar (1160 psi). Transfer from a tanker is handled using deepwell pumps on the ship.

CO_2 should be stored at depths of at least 800 meters underground, where the pressure is high enough for the CO_2 to exist in a **supercritical state** - a dense phase that behaves like both a liquid and a gas. In this state, CO_2 is denser than the surrounding formation fluids and tends to stay trapped beneath impermeable caprock layers. If CO_2 were to migrate outside its intended storage zone, geological structures and physical properties (e.g. caprock, gravity segregation, and solubility trapping) help to contain it.

In offshore settings, if liquid or supercritical CO_2 were to leak into the seawater, it would dissolve and lower the pH of the surrounding water, contributing to **ocean acidification**, which can harm marine ecosystems. Therefore, robust monitoring and risk management are essential to ensure **safe and permanent CO_2 storage**.

Captured CO_2 can also be used for various processes, for example in manufacturing or industrial cooling. However, utilization of captured carbon is still in its infancy because captured CO_2 is comparatively expensive. As supply grows and prices drop, demand may grow.

Challenges

As in the transportation step, maintaining CO_2 in its liquid or supercritical phase is critical. This requires pump systems specifically designed for CO_2 and cryogenic high-pressure conditions. Additionally, the injection systems must be engineered to prevent cavitation, corrosion, and dry ice (solid CO_2) formation, all of which can compromise system integrity and performance.

Global after-sales service

Keep all systems running with DESMI global service

Call the DESMI Service Hotline round the clock at +45 96 32 81 10

When your job involves important and potentially hazardous flow processes, it's a good idea to keep your process equipment in top condition, and to work with a supplier you can rely on when you urgently need spare parts, maintenance, or replacement products.

The DESMI Service after-sales organization offers tailor-made, global services to ensure optimization and long-term performance of your DESMI products. We focus on ensuring uptime and availability, and on high efficiency and safety. No matter where you and your CCS plant are located, we will be ready at a moment's notice with the expertise, spares, and know-how to keep your processes running.

And for gas and cargo systems, our specialists at Nordan Marine A/S (a DESMI company) are on hand to provide dedicated support.

Our service team can provide a long list of services on your CCS plant, on land or on a ship, for example inspection and maintenance, commissioning, or service work on pumps and related equipment. Our teams are highly experienced, factory trained, and fully capable of meeting your demands.

Overhaul Videos

We exist to keep your business flowing

With decades of proven expertise in handling challenging fluids, DESMI delivers trusted high-performance solutions for CCS projects worldwide. Our pumping technologies and extensive experience ensure safe and efficient carbon capture and storage, helping industries accelerate their transition to a low-carbon future.

At DESMI, our focus has never been on discovering what we can do – it's about pushing the boundaries of what we can do for you. Our class-leading equipment, solutions, and services are designed specifically for your applications and help you achieve your objectives, even in very complex applications.

Founded in Denmark in 1834, we have provided the expertise, solutions, and aftermarket support our customers need for nearly two centuries. We help you reduce climate impact and contribute to a decarbonized future whilst realizing your ambitions for reliable performance, compliance, and growth.

Together, we can make a difference, whatever the future holds. Because we, like you, are here to **make life flow**.

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