

Annual Experience Report 2024 – Lessons learned

Northern Lights Joint Venture

Building the world's first dedicated CO2 ships fleet

Shipping is an integral part of the Northern Lights value chain. The first two ships, Northern Pioneer and Northern Pathfinder, are custom designed to safely transport liquefied CO2 from capture sites in Europe to the Northern Lights receiving terminal in Øygarden, Norway. Successfully delivered from the Dalian shipyard in China in 2024, they represent the world's first large-scale CO2 transport ships built specifically for CCS operation.

The transition from conceptual design to full-scale construction introduced challenges inherent to first-of-its-kind shipbuilding. One key learning was the need for design adjustments based on operational testing. Process calculations conducted with customer terminals revealed that modifications to the piping diameter were required to improve efficiency. Additionally, the rotor sails, which enhance fuel efficiency, necessitated additional simulations to understand ship behaviour in the event of blackout. These simulations provided critical insights, as the rotor sails take approximately two minutes to stop spinning, significantly impacting the ship's handling and expected drift path.

The experience gained from constructing the first ship enabled a more streamlined and efficient process for the second. Sea trials for the first ship required two rounds of approximately seven days each, whereas the second ship completed its trials in a single seven-day period. Lessons learned from initial operational challenges on the first ship were immediately rectified on the second, reducing time and improving overall efficiency. As a result, the delivery process for the second ship was significantly smoother than the first.

Building the world's first dedicated CO2 ships underscored the value of iterative learning. Future shipbuilding efforts will benefit from duplicating the first of its kind design while incorporating the insights and learnings gained from the first two ships. This approach will enable a more seamless and cost-efficient process for scaling Northern Lights' shipping capacity, ensuring continued improvements in operational performance and efficiency.

Aligning development pace between emitters and storage providers

While Northern Lights has matured expansion opportunities from a technical perspective, potential customers (emitters) often face challenges in advancing their part of the value chain. These challenges can be both technical and commercial. A key element in the CCS value chain is the development of CO₂ hubs and/or local infrastructure – central facilities that aggregate CO₂ from multiple emitters. However, such hubs typically do not progress unless several emitters can mature their projects simultaneously.

This dependency increases complexity, as projects require substantial upfront investment and must be developed amid significant market uncertainty. Additionally, these projects involve a high degree of technical and stakeholder complexity, requiring coordination across multiple actors. Commercial structures for CCS are still evolving, and negotiating the allocation of risk and rewards across the value chain is often a lengthy and resource-intensive process.

To overcome these challenges, strong policy support and regulatory incentives are essential enablers for CCS development. Furthermore, establishing a deep mutual technical understanding across the value chain from the outset helps create a shared foundation for negotiations. This enables all parties to better grasp each other's perspective and risk assessment, ultimately streamlining the decision-making process.

A final investment decision (FID) on a carbon capture or storage project is a major milestone that requires alignment among multiple stakeholders. Setting a clear and detailed timeline for negotiations – including milestones leading up to the respective FIDs – can help maintain alignment, highlight potential points of misalignment early, and allow for timely interventions to keep projects on track.

Standards in the CCS sector

As the CCS value chain evolves and attracts a growing number of stakeholders from a wide range of industries, new research has identified a risk of corrosion in CO₂ transport and storage infrastructure. Studies have shown that even low levels of specific impurities, when combined with other components, can pose challenges to the safety, integrity, and lifespan of key infrastructure, including intermediate storage facilities, ships, receiving terminals, pipelines, and wells.

The growing body of knowledge highlights that updates to CO₂ quality standards are necessary to ensure safe and reliable operations. Lessons from recent studies emphasise that new insights will continue to emerge as more industries join the CCS value chain. Additionally, CO₂ standards and specifications have direct commercial implications, as they impact infrastructure design, operational costs, and long-term asset integrity.

Moving forward, Northern Lights will maintain a proactive approach to continuously monitoring and evaluating CO₂ quality and corrosion risks throughout the operational phase. Sharing insights and operational experiences with industry stakeholders will remain a priority, ensuring that the broader CCS sector benefits from collective learnings and best practices.

Streamlining multiple government processes and regulations

Obtaining the necessary consents and permits for CCS projects requires engagement with multiple regulatory bodies. Our experience has shown that different authorities often require similar information, however, approvals are processed independently.

As CCS is a relatively new industry, some lack of clarity remains among regulatory bodies regarding the interfaces and areas of responsibility on CCS. While this is expected in an emerging sector, avoiding parallel processes and setting clear expectations early can lead to more effective and predictable processes. Despite these challenges, there has been strong support and willingness from authorities to help establish the first CCS project.

To optimise the regulatory process, greater alignment and coordination among authorities handling various consents and permits will be essential. Streamlining processes and improving collaboration between different authorities will optimise the delivery from storage operators. Additionally, simplifying and standardising regulatory frameworks will help pave the way for broader CCS industry development.