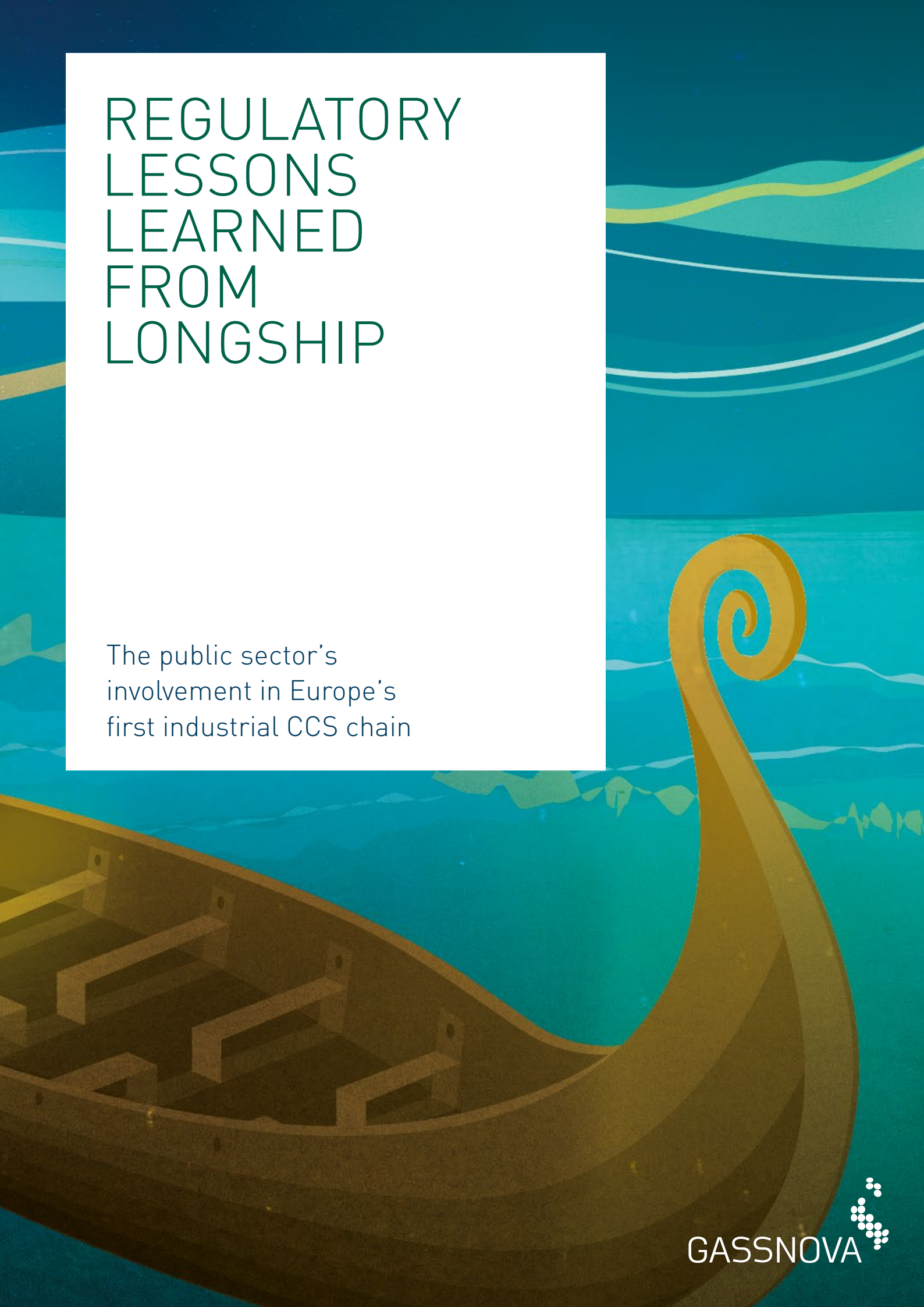
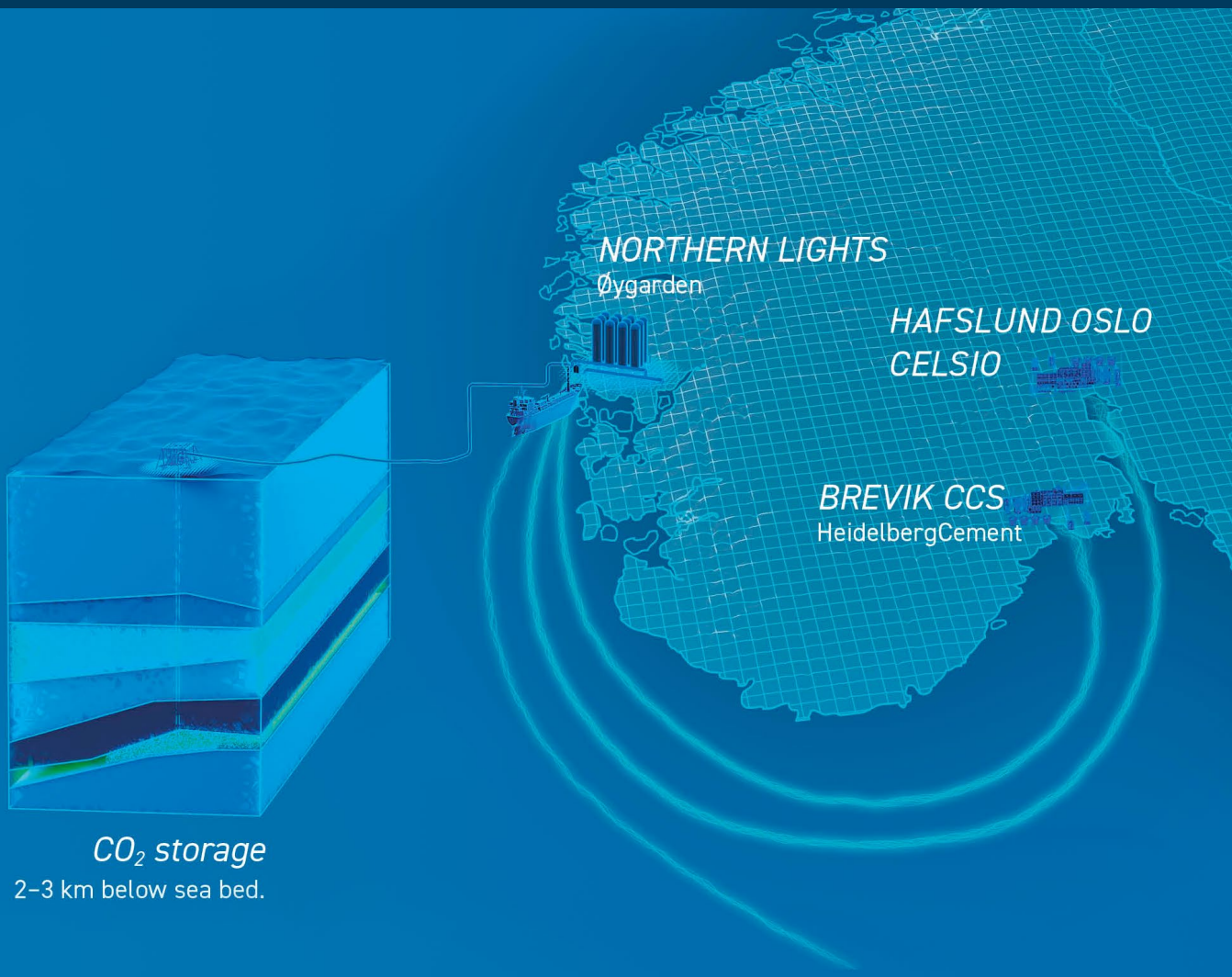
REGULATORY LESSONS LEARNED FROM LONGSHIP

The public sector's involvement in Europe's first industrial CCS chain



GASSNOVA



CO_2 storage
2–3 km below sea bed.

"...Norway showed its leadership in Europe by making a major funding commitment to the Longship project. Longship will connect two different plants capturing CO_2 in Norway with the Northern Lights storage facility deep under the North Sea. Northern Lights will be able to receive CO_2 captured in neighboring European countries, as well, thereby playing an important role in meeting not just Norway's ambitious climate goals but those of the entire region."

CCUS in clean energy transition,
International Energy Agency, 2020

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Gassnova SF
Regulatory Lessons Learned from Longship

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EXECUTIVE SUMMARY

Longship is the first industrial CCS chain in construction under the current European legal framework, and until now, the only CCS chain where investment decisions have been made. Two CO_2 capture projects and one CO_2 transport- and storage project are being established under Longship.

Gassnova's role has been to ensure that the industrial partners are well-coordinated with each other and that the projects are developed in line with the state's objectives. Through this "project integrator role" Gassnova has a thorough overview of the regulatory processes, issues and challenges Longship has encountered, and how these are resolved. With this report, Gassnova aims to provide information to subsequent CCS projects, public sector bodies and others who work to facilitate the use of CCS.

The Norwegian state provides state aid to the industrial partners Celsio (formerly Fortum Oslo Varme), HeidelbergCement and Northern Lights. The state will, according to the initial cost estimates, cover approximately 2/3 of the total costs[01].

The commercial and regulatory framework for Longship is formed by several international conventions, EU and Norwegian legislation and the state aid agreements between the industrial partners and the Norwegian Government. The industrial partners therefore have to comply with many different laws and regulations and engage with a wide range of public sector bodies.

Norwegian public sector bodies are heavily involved in the development of the project and have different roles. Some of these – the regulatory roles – are well defined, though with limited experience in regulating CCS activities. In this report these roles are divided into three sub-categories: **Regulator of HSE, Planning and Building Activities**, **Regulator of Resource Management and Safe Storage** and **Regulator of CO_2 Emissions.** The state has several agencies and directorates handling these regulatory roles in addition to municipalities and county governors. Other public sector roles originate from the fact that Longship is a "first-of-a-kind" project. These are divided into two sub-categories: The **Project Integrator,** described above, and the **State Aid Provider**.

In this report the regulatory issues and challenges facing Longship and how these are resolved are discussed in light of the state's different roles.

A full list of key learning points is summarised over the next pages.

01 Meld. St. 33 (2019–2020) Report to the Storting (white paper) Longship – Carbon capture and storage, Table 6.1 Estimated expected costs and Parliament's cost frame for Northern Lights, Norcem and Fortum Oslo Varme

Key learning points

The role **Project Integrator** targets the chicken and egg situation for CCS: No industry emitter will invest in a capture project without the existence of a storage solution, and no company will develop a storage site without knowing that there is CO_2 to be stored.

Project Integrator

- Dividing the full CCS chain into separate subprojects; a capture and a transport/storage project, was a prerequisite for establishing a whole CCS chain and hence for investment decisions to be made. This allowed the emission source owners to develop their projects without having to establish their own transport and storage solution, and the transport and storage provider could develop its project independent of the capture projects. The state bears risks related to the interface between the projects.
- To coordinate and facilitate the development of the CCS chain, it was important for the state to retain a "project integrator role".
- It has been important to manage interdisciplinary challenges and align different corporate cultures. The Longship CCS chain requires cooperation between different corporate cultures and practices. Different expectations concerning work processes, level of detail in deliverables, resource use, etc. are among these challenges.

Due to a lack of commercial incentives for the industrial partners, risks stemming from commercially immature solutions and immature regulatory frameworks, tailor made **state aid agreements** were needed.

State Aid Provider

- As CCS was not commercially viable it was necessary to provide state aid to the industrial partners.
- The high proportion of state aid makes it necessary for the state to follow up the projects to prevent undue distortive effects on competition and trade etc.
- As the projects in Longship are first-of-a-kind, the project uncertainties are higher than would normally be encountered in well-rehearsed projects. The industrial partners therefore required cost sharing up to an agreed maximum level (related both to capital expenditure and operating expenses).
- Northern Lights has identified a business case for the transport and storage of CO_2: the state aid agreement gives Northern Lights incentives to enter into dialogue with potential customers across Northern Europe. Northern Lights' potential future profits will be based on the tariff paid by potential new customers.
- There are elements in the regulations that have been challenging for the industrial partners, such as lacking incentives for capture and storage of CO_2 from biogenic sources. These are addressed through the state aid agreements.
- The extensive share of state aid means that the industrial partners must comply with the comprehensive procurement procedures set out in the *Act on Public Procurement*. For some of the industrial partners this created a need to acquire new skills.

Key learning points

When regulating **HSE, planning and building activities** for a CCS chain, two main topics can be pinpointed: The **risk associated with handling large volumes of CO_2** and the **risk associated with emissions from amines** used in the capture process.

Regulator of HSE, Planning and Building Activities

- The HSE, planning and building regulation and related processes are generally "business as usual" for industrial partners and regulators. Emissions related to CCS are subject to the same legislation as other emissions.
- Amine-based carbon capture produces small emissions of amines. Both Norcem and Celsio have tested their capture technologies on their own flue gas. They both note that this has been important to reassure themselves that the amine emissions will not exceed certain levels and the degradation products will be below the limit set by the authorities.
- Emissions previously released into air can shift to water as environmental recipient. This could pose some challenges for an updated emission permit. The temperature and volume of the emissions to water (cooling water from the CCS plant) are other issues that need to be taken into consideration.
- A new regulation on safety and working environment for transport and injection of CO_2 on the continental shelf has been developed by the Petroleum Safety Authority.
- The interface between the regulatory agencies, the Norwegian Directorate for Civil Protection (onshore regulator) and the Petroleum Safety Authority (offshore regulator), needed clarification in the case of intermediate onshore CO_2 storage before transport through pipeline to permanent subsurface storage.
- The industrial partners point out that it is important to involve local authorities early in the process due to the complexity and size of the projects.
- The operator needs to secure a zoning plan and building consent for the pipeline from the quay out to one nautical mile offshore the baseline while petroleum pipes are exempt from this requirement. The transport and storage operators point out that this is a lengthy, resource intensive process and could possibly delay planning and execution.

Similarities and differences between the petroleum industry and the new CCS industry are discussed in light of **regulating resource management and safe storage.**

Regulator of Resource Management and Safe Storage

- The licensing system for CO_2 storage is operational and permits have been granted for Longship, being the first industrial CCS chain under the legal framework.
- The licensing system for CO_2 storage is similar to the licensing system for oil and gas exploration and production. The technologies and stakeholders are mainly the same for both industries, and the petroleum industry and the authorities are well acquainted with the licensing system for oil and gas. This is a clear advantage.
- However, there are several important differences between the petroleum industry and the CCS industry. For instance, the business model for CCS (low market maturity, high risk, low return) is very different from the business model in the petroleum sector (high market maturity, high risk, high return). Due to these differences, some of the requirements under the current licensing system (third-party access, liabilities ect) may make it challenging for the storage operator to handle risks and make investment decisions.

Key learning points

A description of lessons learned related to the international **regulation of CO_2 emissions** is given. Weak and lacking incentives for capturing and storing CO_2, and barriers for CO_2 chains across national borders are key words in this section.

Regulator of CO_2 Emissions

- Longship has highlighted the lack of climate regulations incentivising CCS in sectors not subject to EU ETS and for biogenic sources.
- The EU ETS price signal was not sufficient to incentivise the industrial partners in Longship.
- CCS relevant regulations have been applied to a CCS chain for the first time. Norwegian authorities have been in dialogue with the European Commission on their interpretation of the regulations.
- Ship transport of CO_2 is not subject to the EU ETS. A solution for the Longship project has been found through the arrangement between the industrial partners and the state. The regulations are under revision in the EU system, and a proposal for including all types of transport of CO_2 for storage under the EU ETS is under consideration.
- A measurement regime for CO_2 in the CCS chain has been established. This is a prerequisite for transferring the responsibility for the CO_2 between parties in a CCS chain.
- National reporting of CO_2 emissions, including captured and stored CO_2 of biogenic origin, has been clarified in line with new international reporting rules.
- A temporary solution for transporting CO_2 across national borders for the purpose of offshore storage *(the London Protocol[14])* has been established. For Northern Lights to enter into a commercial agreement with an industrial partner outside of Norwegian borders, there must be a bilateral agreement between Norway and the home country of the emission source. The Ministry of Petroleum and Energy is in dialogue with relevant countries with the aim of entering into bilateral agreements with key countries prior to Northern Lights' injection start in 2024.

Applying the legal framework on an industrial CCS chain for the first time, requires practical clarifications and solutions. The requirements in the legal framework must correspond with the existing technical solutions and vice versa. For instance, measuring the amount of CO_2 is a prerequisite for transferring the responsibility of the CO_2 from one partner to another in the CCS chain. Always knowing who is responsible along the CCS chain is also a necessity.

The stakeholders involved in Longship all pinpoint trust between industry and the government as a prerequisite for the success of the project. The project is being realised even though some important regulatory issues are yet to be fully clarified. With a common goal of realising a CCS chain, all the stakeholders involved have, on the basis of this mutual trust, shown openness and flexibility.

Longship can already prove positive effects on the development of CCS in Europe. The existence of a CO_2 transport and storage service provider like Northern Lights has removed an important barrier to CCS. Stronger climate policies and a higher ETS price have also contributed to an increased focus on CCS in key European industries. There has also been a development in the international and European legal framework since Longship was approved, and processes are ongoing.

01

INTRODUCTION

By developing the first industrial CCS chain under the current European legislation the stakeholders have gained experiences that other CCS projects and their stakeholders can learn from.

In this report the regulatory issues and challenges and how these are solved for Longship are discussed and summarized in key learning points.

In the 2014 CCS strategy[02] the Government set an ambition to realise a cost-effective solution for full-scale carbon capture, transport, and storage (CCS) demonstration in Norway, provided that this would result in technological development internationally.

In order to achieve this ambition, the full-scale CCS project "Longship" was launched by the Norwegian Government in 2020 after extensive pre-feasibility, feasibility, concept and FEED studies.

Gassnova is a state enterprise established to promote technological development and build CCS competence, owned by the Ministry of Petroleum and Energy. Gassnova has been closely involved in the planning of the full-scale project since the beginning, producing early phase studies and later acting as a project integrator. Gassnova has administered the public funding to the industrial partners, coordinated the overall project schedule and managed the cross-chain risks and functionality. Gassnova has also established and coordinated a programme that aims to increase the probability of reaching the State's objectives for Longship. Documenting and disseminating the experience and learning from Longship is an important part of this programme.

This report describes the development of Longship under the current Norwegian legislation. The CCS relevant laws and regulations are largely based on international frameworks and EU regulations. Several regulations are being applied for the first time on a full-scale CCS project. Both the industry and the state bodies have navigated unknown waters and needed to find common solutions for specific issues based on first-time interpretations of the regulations. Where relevant, Norwegian authorities have also consulted with the EU Commission on its legislative interpretations.

The commercial framework for the companies is defined by state aid agreements between the companies and the state. In this report, Gassnova will show how these agreements relate to the current laws and regulations.

This document is based on Gassnova's experience as a project integrator and its ongoing engagement with the industrial partners in Longship: Hafslund Oslo Celsio (formerly Fortum Oslo Varme), Norcem and Northern Lights. Gassnova has also incorporated important input from the Norwegian Environmental Agency and the Ministry of Petroleum and Energy.

02 Prop. 1 S (2014–2015) (regjeringen.no)

1.1 About Longship

Longship is a CCS demonstration project. The project "shall provide the necessary development of CCS to ensure that Norway's and the EU's long-term climate targets can be achieved at the lowest possible cost."[03]

Longship covers the capture, transportation and storage of CO_2. The Norwegian state is providing state aid to Norcem for the first capture project in Longship. Northern Lights is a partnership between Equinor, Shell and TotalEnergies, which, with state aid, will implement the CO_2 transportation and storage parts of Longship. Construction of the Northern Lights CO_2 transport and storage infrastructure and the Norcem plant is on schedule to start operation in late 2024 as planned[04].

The Government was also planning to make Hafslund Oslo Celsio (formerly Fortum Oslo Varme) a part of Longship, provided it secured sufficient financing. A new industrial joint venture of Hafslund Eco, Infranode, and HitecVision, named Hafslund Oslo Celsio, entered an agreement to acquire Fortum Oslo Varme in March 2022. In June the Minister of Petroleum and Energy Terje Aasland signed a funding deal securing the realisation of carbon capture operations at Hafslund Oslo Celsio's waste incineration plant at Klemetsrud in Oslo. The plan is for the capture plant to be operational from 2026.

The captured CO_2 from Norcem's cement plant in Brevik, and from Hafslund Oslo Celsio's waste-to-energy plant in Oslo will be transported in liquid form by ships to Northern Lights' CO_2 receiving terminal in Øygarden on the Norwegian west coast. From there, the liquefied CO_2 will be transported by pipeline to an offshore storage location under the North Sea for permanent storage. Norcem's capture project, named Brevik CCS, and the Northern Lights project started construction in late 2020.

Longship is a first-of-its-kind project and will contribute to innovation in several ways[05]:

- Demonstration of a full and flexible CCS chain with carbon capture from cement production (and potentially from waste management), shipping to a receiving terminal, and CO_2 storage beneath the seabed on the Norwegian continental shelf.
- Practical implementation of European and Norwegian regulations in projects involving a complete CCS chain consisting of different stakeholders. The project demonstrates, among other things, the use of the EU ETS and the EU Directive on CO_2 storage.
- A flexible transport and storage solution that will have the capacity to receive CO_2 from many different sources.
- A commercial framework that provides incentives for further development of CCS in Europe.

Although Norcem, Hafslund Oslo Celsio (called Celsio in the following), and Northern Lights have received state aid throughout the project development phase, each industrial partner has been responsible for their own project. In the realisation phase the industrial stakeholders own, construct and operate their own facilities. However, the state continues to provide state aid and assumes some of the risks, including risk related to the interfaces between the industrial partners.

In the first phase, Longship has an annual storage capacity of 1.5 million tonnes of CO_2. This exceeds the 800,000 tonnes of CO_2 allocated to Norcem and Celsio. This means that Northern Lights will have the capacity to receive CO_2 volumes from other sources. The pipeline from the onshore facility to the storage site has been built with an annual capacity of 5–7 million tonnes. Northern Lights intends to expand its storage capacity to 5–7 million tonnes per year. The European Commission has announced that EU countries have agreed to support Northern Lights under the Connecting Europe Facility (CEF) funding scheme, earmarked for Front-End Engineering Design (FEED) studies for the expansion.

03 Meld. St. 33 (2019–2020) Report to the Storting (white paper) Longship – Carbon capture and storage

04 According to the Revised National Budget 2022 an external quality assurance shows that there is a high probability of delays in Norcem's project (start-up is expected to be delayed by four months).

05 Meld. St. 33 (2019–2020) / Storting white paper 2019–2020: Longship – Carbon capture and storage, "Box 2.4 How does Longship contribute to innovation?"

The goals of Longship

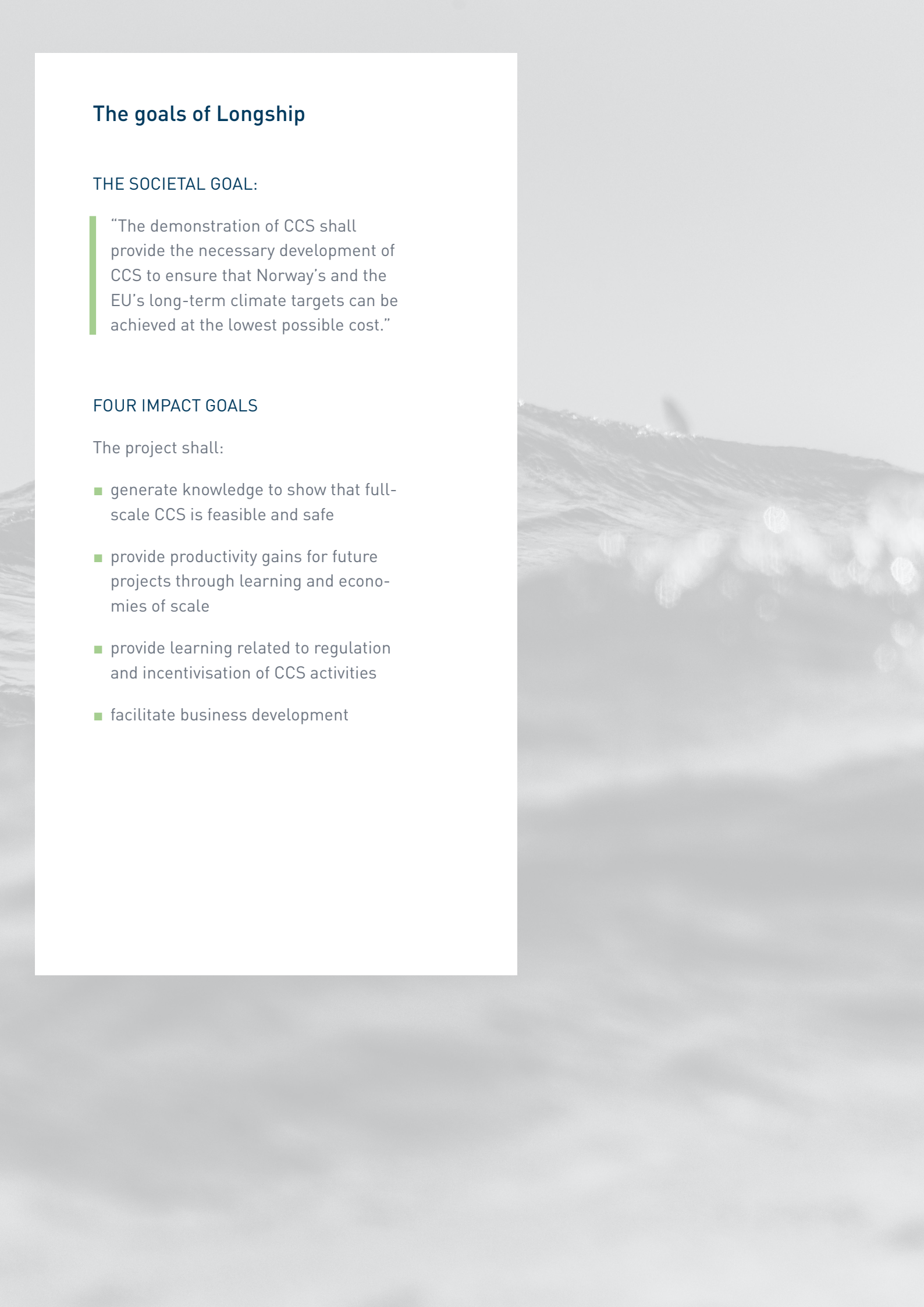
THE SOCIETAL GOAL:

> "The demonstration of CCS shall provide the necessary development of CCS to ensure that Norway's and the EU's long-term climate targets can be achieved at the lowest possible cost."

FOUR IMPACT GOALS

The project shall:

- generate knowledge to show that full-scale CCS is feasible and safe
- provide productivity gains for future projects through learning and economies of scale
- provide learning related to regulation and incentivisation of CCS activities
- facilitate business development



Public sector bodies involved in Longship

The principal responsibility of the **Ministry of Petroleum and Energy** is to achieve a coordinated and integrated energy policy.[06]

Gassnova is a state enterprise established to promote technological development, competence building and cost-effective CCS solutions. Gassnova reports to the Ministry of Petroleum and Energy.[07]

The central tasks and responsibility of the **Norwegian Environmental Agency**[08] are to manage Norwegian nature and prevent pollution. The Norwegian Environmental Agency reports to the Ministry of Climate and Environment.

The **Norwegian Petroleum Directorate**[09] is a specialist governmental directorate and administrative body. The directorate's primary objective is to contribute to the greatest possible values from the oil and gas activities to the Norwegian society, through efficient and responsible resource management The Norwegian Petroleum Directorate reports to the Ministry of Petroleum and Energy.

The overall task of the **Norwegian Directorate for Civil Protection**[10] is to maintain a complete overview of various risks and vulnerability in general. The Norwegian Directorate for Civil Protection's responsibilities cover local, regional and national preparedness and emergency planning, fire safety, electrical safety, handling and transport of hazardous substances, as well as product and consumer safety. The Norwegian Directorate for Civil Protection reports to the Ministry of Justice and Public Security.

The **Petroleum Safety Authority**[11] is a government supervisory and administrative agency with regulatory responsibility for safety, the working environment, emergency preparedness and security in the petroleum sector. The Petroleum Safety Authority reports to the Ministry of Labour and Social Inclusion.

The **EFTA Surveillance Authority (ESA)** monitors compliance with European Economic Area (EEA) rules in Iceland, Liechtenstein and Norway, enabling them to participate in the European Internal Market.

Key documents

Environmental Impact Assessment (EIA)[12] is a tool for integrating environmental concerns and considerations into the decision-making processes of governments at all levels.

Plan for development and operation of a petroleum deposit (PDO) and plan for installation and operation of facilities for transport and utilisation of petroleum (PIO):[13]

A PDO describes the development of a petroleum deposit, or several petroleum deposits taken together, and the consequences the planned development measures will have (impact assessment).

A PIO is a plan for construction, placement, operation and use of facilities for petroleum activity, including shipment facilities, pipelines, cooling facilities, facilities for production and transmission of electricity and other facilities for transport or utilisation of petroleum.

06 https://www.regjeringen.no/en/dep/oed/id750/
07 https://gassnova.no/en/gassnova-en
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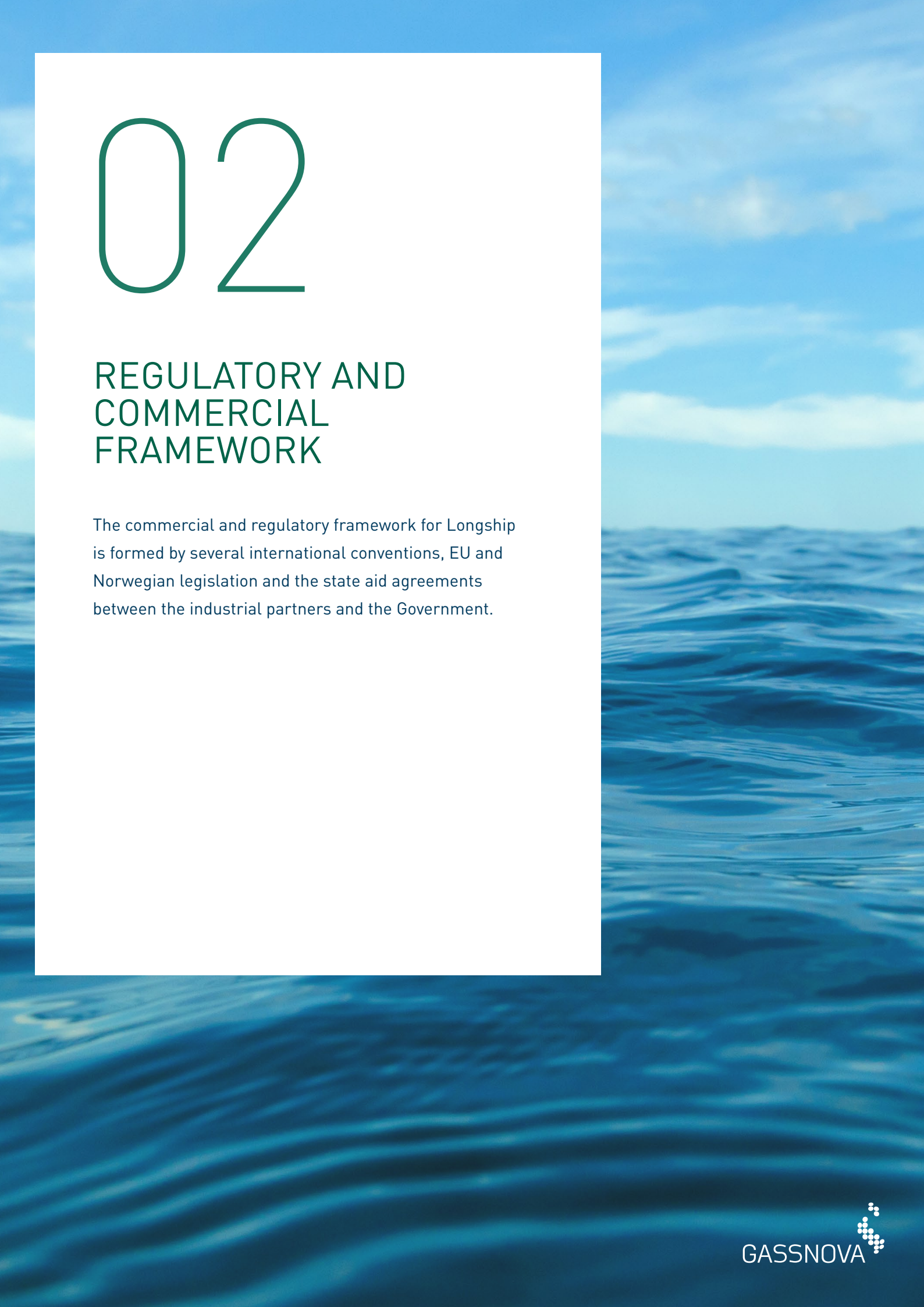
02

REGULATORY AND COMMERCIAL FRAMEWORK

The commercial and regulatory framework for Longship is formed by several international conventions, EU and Norwegian legislation and the state aid agreements between the industrial partners and the Government.



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2.1 Regulatory framework

Norway's regulatory framework and policies on climate change, energy and environment are largely defined, influenced or inspired by international agreements and policies.

International frameworks such as the Kyoto Protocol, the Paris Agreement and the UN Framework Convention on Climate Change (UNFCCC) outline the conditions for mitigating climate change.

The UN Intergovernmental Panel on Climate Change (IPPC) provides guidelines for how national GHG inventories should be prepared and has decided on how the GHG inventories should be reported under the Convention, the Kyoto Protocol and the Paris Agreement. This sets the framework for national GHG emissions accounting. The GHG emissions and removals are reported to the UNFCCC in a set of common reporting format (CRF) tables.

Another international convention particularly relevant to the Longship project is the *London Protocol*[14] which regulates the prevention of marine pollution and stipulates certain requirements to the export of CO_2 for the purpose of sub-seabed geological storage.

Norway is not a Member State of the European Union (EU). However, it is associated with the Union through its membership of the European Economic Area (EEA) and is therefore an equal partner in the Single Market, on the same terms as the EU Member States. EU regulations and directives are implemented in Norwegian law as committed to in the EEA agreement.

The EU will contribute to achieving the Paris Agreement through three "pillars". Norway is involved in all three pillars[15] of EU climate policy:

- The EU Emissions Trading System (ETS) which regulates emissions from manufacturing industry, power and heat generation, petroleum, and aviation through the *EU ETS Directive*.[16]
- The *Effort Sharing Regulation* for non-ETS emissions[17]: this assigns each country a binding target for reducing emissions from transport, buildings, agriculture, waste, and some emissions from the oil and gas industry and industrial production.
- The *Land-Use, Land-Use Change and Forestry (LULUCF) Regulation*[18]: the Regulation sets out accounting rules for uptake and removals of CO_2 in the LULUCF sector. The legislation lays down an obligation to ensure that overall greenhouse gas emissions from land use and forestry do not exceed removals (this is known as the 'no-debit' rule).

The *CCS Directive*[19], the *ETS Directive*[16] and attaching regulations are particularly relevant to the Longship project. *The CCS Directive*[19] is the legal framework for environmentally safe geological storage of CO_2 underground, aimed at stabilising greenhouse gas concentrations in the atmosphere, and the *ETS Directive*[16] is mentioned above.

The *EU ETS Monitoring and Reporting Regulation*[20] lays down rules for monitoring and reporting GHG emissions and activity data pursuant to the EU ETS Directive[16]. *Article 49* deals with CO_2 that is captured in an ETS installation and transferred out of the installation.

The above-mentioned *CCS Directive*[19] was implemented in Norwegian law in 2014 via the *Storage Regulations*[21], an added chapter in the *Pollution Regulations* (Chapter 35 (7a))[22] and an added chapter in the *Petroleum Regulations*[23] (4a).

Other relevant Norwegian laws and regulations are the *Pollution Control Act*[24], the *Regulations on handling hazardous substances*[25], the *CO_2 Safety Regulations*[26] and the *Planning and Building Act*[27].

14 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (imo.org)

15 The Effort Sharing Regulation is not implemented in Norwegian law but incorporated into Protocol 31 on co-operation in special areas outside the four freedoms

16 The EU ETS Directive, 2003/87/EC, EUR-Lex - 32003L0087 - EN - EUR-Lex (europa.eu)

17 The Effort Sharing Regulation, (EU) 2018/842, EUR-Lex - 32018R0842 - EN - EUR-Lex (europa.eu)

18 The Land Use and Forestry Regulation, (EU) 2018/841, EUR-Lex - 32018R0841 - EN - EUR-Lex (europa.eu)

19 The CCS Directive, 2009/31/EC, EUR-Lex - 32009L0031 - EN - EUR-Lex (europa.eu)

20 The ETS Monitoring and Reporting Regulation (MRR), (EU) 2022/388 , CL2018R2066EN0010010.0001_cp 1..1 (europa.eu)

21 Forskrift om utnyttelse av undersjøiske reservoarer på kontinentalsokkelen til lagring av CO_2 og om transport av CO_2 på kontinentalsokkelen, FOR-2014-12-05-1517 (Regulations relating to exploitation of subsea reservoirs on the continental shelf for storage of CO_2 and relating to transportation of CO_2 on the continental shelf).

22 Forskrift om begrensning av forurensning (forurensningsforskriften), FOR-2021-07-10-2383

23 Forskrift til lov om petroleumsvirksomhet, FOR-1997-06-27-653 (Petroleum Regulation)

24 Lov om vern mot forurensninger og om avfall (forurensningsloven), LOV-2021-05-07-34

25 Forskrift om håndtering av brannfarlig, reaksjonsfarlig og trykksatt stoff samt utstyr og anlegg som benyttes ved håndteringen, FOR-2009-06-08-602

26 Forskrift om sikkerhet og arbeidsmiljø ved transport og injeksjon av CO_2 på kontinentalsokkelen, FOR-2020-02-25-186

27 Lov om planlegging og byggesaksbehandling, LOV-2008-06-27-71

2.1.1 The CCS-specific licensing system in Norway

The Norwegian state's obligation to secure the best possible utilisation of common resources, pollution control and a safe working environment is the logic behind a licensing regime for industrial activities in general, and hence also for a CCS chain. To operate a CCS chain, the industrial partners need several permits.

This Section lists and explains the specific permits, licences and consents (here collectively called permits) needed to establish and operate a CCS chain in Norway, focusing on the storage domain of the whole chain. The reason for this is that the licensing system related to capture of CO_2 is almost the same as for industrial activities in general (refer to Section 3.3), and ship transport of CO_2 is regulated in the same way as ship transport of other liquefied gases.

The laws and regulations governing the different permits are listed in Section 2.1. and a table listing the different storage-related permits[28] are found in Appendix A.

Note that the following applications and permits could be processed/approved simultaneously or in slightly different order than listed, but this gives a general outline. Also note that most applications to the governmental authorities are also subject to consultation rounds, and all planned activities are required to conduct a thorough Environmental Impact Assessment. As a consequence of this it is important to consider the stakeholder engagement in the permit processes and ensure that all steps in the process are followed up thoroughly.

Below the different licences and permits required are described briefly (refer to Appendix A for a status on the different permits in Longship):

Prior to applying for any of the offshore licences related to geological storage, operators are free to screen the Norwegian continental shelf for possible storage sites. Screening does not require a licence from the authorities. Access to existing, publicly available datasets (seismic data, electromagnetic data, well data etc.) can be bought and used as a basis for future applications for the different permits listed below. The Norwegian Petroleum Directorate has compiled CO_2 atlases for the Norwegian offshore regions. These atlases and the available datasets for Norwegian Continental Shelf are comprehensive and of very high quality, ensuring high quality screening processes.

The survey licence (*Storage Regulations*[21], *Chapter 2)* may be granted to several operators at the same time and is valid for one or more geographically defined areas (called blocks or parts of blocks). The licence covers geological, petrophysical, geochemical and geotechnical activity, and shallow drilling may also be permitted. All these activities must be reported to the responsible authorities prior to the activity.

The exploration licence (*Storage Regulations*[21], *Chapter 3*) gives exclusive rights for investigations to the licensee. If there is a consortium, one of the companies will be named as the operator. The investigation licence is valid in one or more blocks or parts of blocks and includes a work commitment. This commitment might include exploration well(s) and seismic surveys with details specified by the Norwegian Petroleum Directorate. Drilling of wells or other activities that might affect the environment must be permitted by the Norwegian Environmental Agency (Pollution Control Act[24], Section 11, and Petroleum Safety Authority gives consent).

The exploitation licence (*Storage Regulations*[21], *Chapter 4*) will be awarded to *one* licensee (which may be an enterprise consisting of more than one body corporate). An applicant holding an exploration licence in the specific area will be preferred if the work commitments are fulfilled. Only one operator will be appointed per storage location. If the licensee consists of multiple bodies corporate operating as a joint venture, one of the participants will be named as the operator. The application for an exploitation licence for a sub-seabed reservoir for injection and storage of CO_2 must be sent to the Ministry of Petroleum and Energy. The exploitation licence allows for the use of the geological resource (reservoir) as a storage site but does not allow for injection and storage of CO_2 into the reservoir.

An injection and storage permit falls within the remit of the Norwegian Environmental Agency and must be applied for separately and closer to the start of injection *(see next paragraph*). If the licensee decides to develop the subsea reservoir for injection and storage of CO_2, they must submit a plan for development and operation (PDO) including a plan to install and operate the facilities related to transport, receival and storage of CO_2 (PIO) and an Environmental Impact Assessment (Storage Regulations[21], Sections 4.5 and 6.1). After the plans and the Environmental Impact Assessment have been approved by the authorities (Ministry of Petroleum and Energy, consent issued by Petroleum Safety Authority) the licensee must make its final investment decision.

28 The English translations of the laws and regulations use both permit and license for the Norwegian term "tillatelse". We have used the term that is used in the corresponding translation.

An injection and storage permit (*Pollution Control Regulations*[22], Section 35-4*)* allows for injection and permanent storage of CO_2 in the stratigraphic layers elaborated in the exploitation permit and is issued by the Norwegian Environmental Agency. A letter of consent must be issued by the Ministry of Petroleum and Energy/ Norwegian Petroleum Directorate, the Ministry of Labour and Social Inclusion and Petroleum Safety Authority. The Petroleum Safety Authority gives consent according to the (*CO_2 Safety Regulations*[26], *Section 12*). These regulations concern safety and the work environment relating to CO_2 storage on the continental shelf.

Along with the injection and storage permit, the transport and storage operator must have a CO_2 emission permit from the Norwegian Environmental Agency *(Pollution Control Act*[24], *Section 11*) for potential emissions of CO_2 from the storage and transportation facilities. A yearly report of emissions (in the event of leakage) is required by law (*Greenhouse Gas Emission Trading Act*[29] *, Section 16)*, and the operator will need to surrender enough allowances to cover its emissions.

The storage operator also needs an emission permit for the deployment of pipelines to the storage complex *(Pollution Control Act*[24], *Section 11).* The Norwegian Environmental Agency also issues this permit. The operator is also required to obtain a zoning plan and building consent for the pipeline from the quay out to sea; this is regulated by the *Planning and Building Act*[27]

The process described above is not fully applied for Longship. The reason for this is among others that CO_2 storage is a new business area with new regulations.

Screenings of areas in the North Sea for storage suitability were done by Gassnova and Equinor (then called Statoil) in connection with the planned (and later abandoned) full scale project at Mongstad. After the screening process, two areas, Aurora and Smeaheia, were chosen as promising prospects. The Aurora and the Smeaheia prospects were then subject to a maturation process, where the Aurora prospect was matured to a high level. Smeaheia was initially selected as CO_2 storage complex, but this was later changed to the Aurora[30] prospect, which was matured to such a level that the Ministry of Petroleum and Energy/Norwegian Petroleum Directorate accepted an application for an exploitation licence directly. Hence, the survey licence and the exploration licence were not applied for in the process. The Northern Lights Joint Venture was founded as a result of three companies being awarded exploitation licences for Aurora. For Longship the injection and storage permit and permits related to CO_2 emissions and emissions from pipeline are yet to be issued.

This Section has focused primarily on the regulations and permits up to the current status of the Longship project (Q2 2022) and a timeline of the storage relevant licences and permit are shown in figure 01. CO_2 storage is a long-term commitment with regulations and permits reaching far into the future. One of these concerns the monitoring of the storage site (refer to Section 4.3).

29 Lov om kvoteplikt og handel med kvoter for utslipp av klimagasser (Klimakvoteloven), LOV-2004-12-17-99

30 "A story about the Johansen Formation" https://ccsnorway.com/a-story-about-the-johansen-formation/

Timeline for storage development in the Longship project
(assessments, permits and concents)

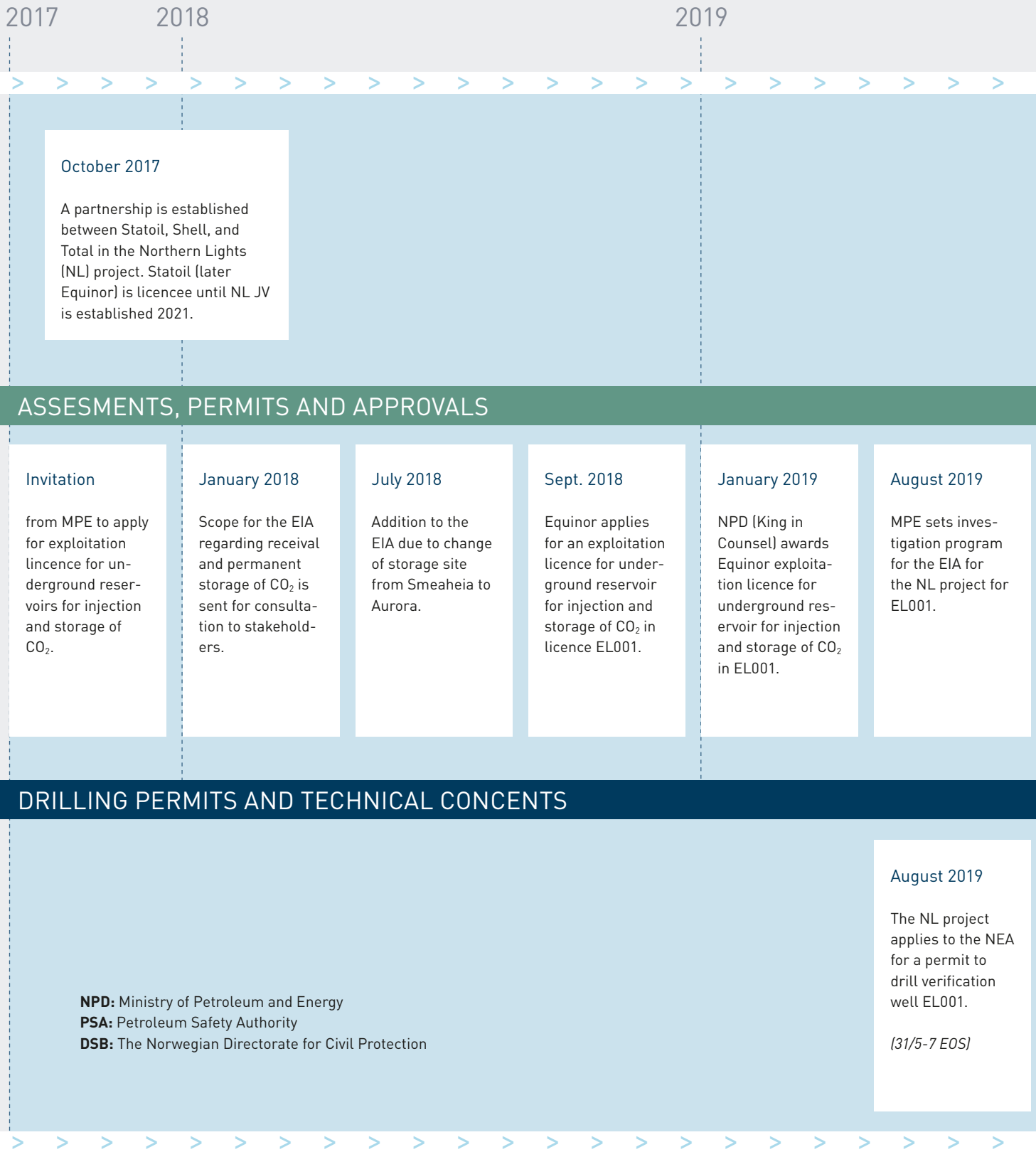


Figure 01: Figure showing the timeline for the storage section of the Longship project. The figure is not meant to be exhaustive, but to give an overview of the processes leading the (Northern Lights) project forwards.

2020 2021 2022

February 2021

Northern Lights Joint Venture (NL JV) is established. NL JV takes over as licencee for the NL project.

ASSESMENTS, PERMITS AND APPROVALS

October 2019

Equinor sends the scope for PDO and POI for receival and permanent storage of CO_2 in EL001 for consultation to stakeholders.

April 2020

Equinor presents the plan for the NL JVs PDO/POI for the NL project.

May 2020

Equinor applies for approval of the NL JVs PDO/ POI for the NL project.

February 2021

MPE approves NL JVs PDO/ POI for the NL project.

DRILLING PERMITS AND TECHNICAL CONCENTS

September 2019

NEA issues a consent to Equinor to drill the EOS well (31/5-7).
The PSA issues a consent to the NL project to drill the EOS well. *(31/5-7)*

November 2019

NPD issues a drilling licence to Equinor for the EOS well. *(31/5-7)*

November 2020

Equinor applies to the DSB for consent to establish and build a receiving terminal for CO_2.

April 2021

DSB issues a consent to Equinor to build a receiving terminal for CO_2.

March 2022

NL NJ JV applies NEA for permit to drill/ complete wells and for usage and emission of chemicals in EL001.

2.2 Commercial framework

Northern Lights, Norcem and Celsio have been incentivised by state aid agreements, supplementing the EU ETS price and a recently implemented national combustion tax. In this section the original state aid agreements, concluded in 2020, is described. Celsio has recently finalized (June 2022) the agreement with the state after securing additional financing. The text in this report may not fully cover the new agreement.

The CCS chain is split commercially, meaning that each industrial partner has its own state aid agreement. Payment of state aid is based on each industrial partner's own successful project, in both the construction and the operation phase.

The state aid agreements give certainty for cost coverage, up to a certain level, both for capital expenditure and for operating expenses. They also reduce the project risk for the industrial partners, mainly in the interface between them. However, the industrial financial contribution is significant, about 1/5 to 1/4 of the total cost. The industrial partners also have full ownership of the installations and operations, and they will retain potentially reduced EU ETS quota costs[31]. The state aid agreements secure subsidies for CO_2 captured outside the EU ETS sector (including CO_2 from biogenic sources. In addition, Northern Lights will retain the tariff paid by potential additional, commercial customers.

The initial terms and conditions in the state aid agreements are basically the same for both capture projects. The origin of the CO_2 emitted and the regulatory framework governing the emission source are different for Norcem and Celsio. This is shown in the table below.

The regulatory framework for the emission source (whether or not it falls under the EU ETS) is relevant to the way in which the state aid agreements are designed. The regulatory framework also affects the emission source's incentives for CO_2 capture. The differences in the origin of the CO_2 also affect the capture sites' incentives for emission reduction. For Longship, which is a demonstration project, it was important to provide the same compensation for all the CO_2 captured, regardless of the regulatory framework and origin of the CO_2. The state aid agreements therefore included an additional support scheme that will give a similar incentive for capturing non-ETS CO_2 compared to the incentives for capturing CO_2 under the ETS.

Northern Lights has a different state aid agreement, tailored for transport and storage, and for giving incentives to incorporate new projects. The state aid agreement will cover a large share of the total cost for Northern Lights' capacity up to 1.5 million tonnes CO_2/year. Future revenues will come from the tariff paid by commercial customers for the transport and storage service to be provided. Northern Lights therefore has a strong incentive to develop a commercial market for CO_2 transport and storage.

Table 01: The origin of the CO_2 emitted and the regulatory framework governing the emission source are different for Norcem and Celsio.

Emission source	Regulatory framework	Emissions based on fossil/biological sources
Norcem	EU ETS, new combustion tax[32]	87/13
Celsio	Non ETS/new combustion tax	50/50

31 Only Norcem (not Celsio) is currently covered by the EU ETS

32 The new national combustion tax was introduced January 2022 on waste combustion. As Norcem is combusting waste at their cement plant in Brevik they are currently covered by the EU ETS and the combustion tax for the fossil-based CO_2 from the waste-to-energy process.

03

LESSONS LEARNED

The industrial partners in Longship have to comply with many different laws and regulations and deal with a wide range of public sector bodies. In this section the regulatory issues and challenges and key learning points will be discussed in light of the state's different roles.

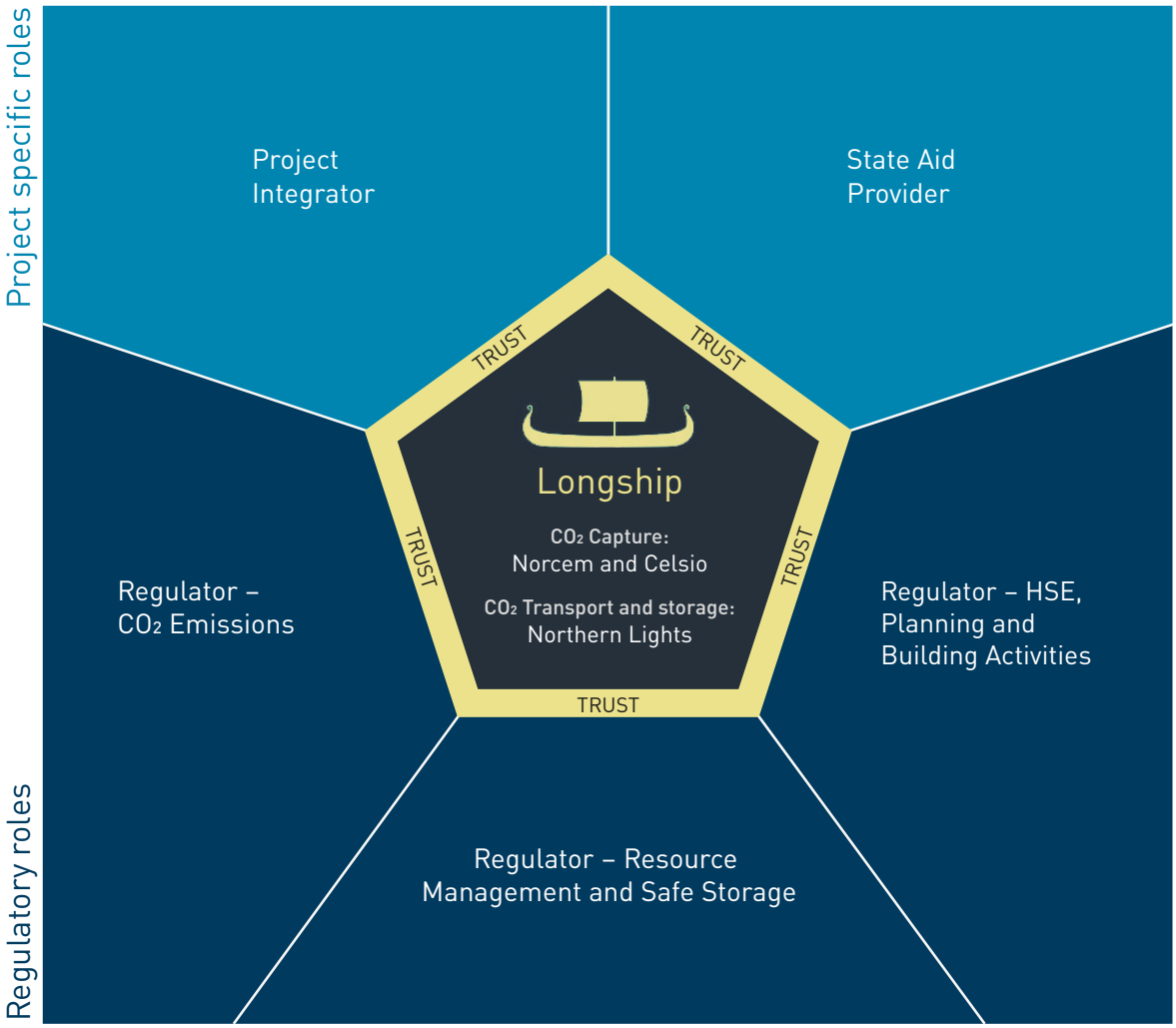


Figure 02: Longship – Public sector's many roles

Norwegian public sector bodies are heavily involved in the project development and have different roles. Some of these – the regulatory roles – are well defined. In this report these roles are divided into three sub-categories: **Regulator of HSE, Planning and Building Activities**, **Regulator of Resource Management and Safe Storage** and **Regulator of CO_2 Emissions**. The state has several agencies and directorates handling these regulatory roles in addition to municipalities and county governors.

Other public sector roles originate from the fact that Longship is a "first-of-a-kind" project. These roles are divided into two sub-categories: the **Project Integrator** and the **State Aid Provider.** The Project Integrator is coordinating the three industrial partners and the Government.

Due to lack of commercial incentives for the industrial partners, risks stemming from commercially immature solutions and immature regulatory frameworks, there was a need for comprehensive state aid agreements. The state has no intention to copy these two roles to following CCS projects even though new CCS projects, in most cases, still will not be fully commercial. These projects have to seek financial support from established or new support mechanisms.

3.1 The Project Integrator

Longship consists of three individual projects: two CO_2 capture projects (Norcem's project and Celsio's project) and one CO_2 transport and storage project (Northern Lights). Each industrial partner is responsible for planning, constructing and operating their own facilities even though the state provides financing and bears the risk related to the interface between the projects.

Norcem and Forum Oslo Varme have both selected amine technologies for their capture projects. Norcem selected Aker Carbon Capture as capture technology provider with ACC solvent S26 at an early stage in the planning process, while Celsio selected Technip FMC as engineering contractor with Shell solvent DC103 before entering the FEED phase.

Northern Lights is owned by Equinor, Shell and TotalEnergies. The three companies have worked as equal partners on the project since 2017, with Equinor as project lead. In 2021 the company Northern Lights JV DA was launched.

The CCS chain was initially split into the individual areas of capture, transport and storage after feedback from the industrial partners in the pre-feasibility phase. In early development the project consisted of three capture projects, one transport project and one storage project. One of the capture projects – Yara Porsgrunn – was discontinued in 2019.

The transport and storage projects were combined into a joint transport and storage project operated by Northern Lights after the concept phase. The CCS chain comprises different sectors and companies with very different corporate cultures. It was a prerequisite for the emission source owners to focus on the capture element alone, and the split of the CCS chain has also allowed the petroleum sector companies to focus on their core competences.

Gassnova has acted as a project integrator. The work done by the partners during the planning phase has been based on study agreements with Gassnova, but the degree of freedom given to the partners has been significant, and the various projects have been developed as the respective partners have seen fit. A technical committee with participants from the industrial projects and Gassnova has met on a regular basis to discuss topics of common interest (e.g. related to CO_2 specification, export rates from the capture plants, use of loading arms between capture export terminal and ship, etc). A committee for cross-chain operational aspects was also established (e.g. principles for developing the ship transport schedule, how to handle off-spec CO_2 during loading of the ship, etc.)

This project integrator role has included responsibilities such as definition and follow-up of the studies throughout the project, including development of the design basis for the CCS chain, evaluation of deliveries from the partners after the concept study phase and the FEED study phase, including technical evaluation and ranking of the capture projects, developing and maintaining an overall project schedule and coordinating the development of the interfaces between these three projects, incl. management of a technical committee and an agreements committee.

For a more in-depth account of lessons learned, refer to Gassnova's report "Developing Longship – Key lessons learned".[33]

Key learning points

- Dividing the CCS chain into capture and transport/storage was a prerequisite for establishing a whole CCS chain and hence for investment decisions to be made. This allowed the emission source owners to develop their projects without having to establish their own transport and storage solution, and the transport and storage provider could develop its project independent of the capture projects. The state bears risks related to the interface between the projects.
- To coordinate and facilitate the development of the CCS chain, it was important for the state to retain a "project integrator role".
- It has been important to manage interdisciplinary challenges and align different corporate cultures. The Longship CCS chain requires cooperation between different corporate cultures and practices. Different expectations concerning work processes, level of detail in deliverables, resource use, etc. are among these challenges.

33 https://gassnova.no/app/uploads/sites/6/2020/11/Gassnova-Developing-Longship-FINAL.pdf

3.2 The State Aid Provider

Based on the Government's ambition to realise an industrial CCS demonstration project, Gassnova, in cooperation with Gassco and the Norwegian Petroleum Directorate, carried out a pre-feasibility study in 2015. This study was carried out in cooperation with the industry. In addition to technical descriptions the study gave recommendations on how to overcome identified investment barriers.

The investment barriers identified for Longship (see table 02) have been overcome through a commercial negotiation process between the Ministry of Energy and Petroleum and each of the industry partners: Celsio, Norcem and Northern Lights. This process has been conducted in parallel with the project maturation process.

In general, companies will make investments that continuously strengthen their competitiveness in relevant markets over time. Covering a part of the project cost is not sufficient to enable a project to be executed. The project also needs to make commercial sense to the industrial partner. It was therefore important for the industrial partners to have a strategic interest in their projects.

As described above, Longship consists of three individual projects: Norcem's capture project, Celsio's capture project and Northern Lights' transport and storage project. Each industrial partner is responsible for its own project, facility and sub-contractors, and the Government has entered into exclusive state aid agreements with each partner.

Table 02: Identified investment barriers for private CCS investments and how they are resolved for Longship.

Investment barriers (2015)	How this is solved in Longship
Low cost of CO_2 emissions and lack of clarity of future climate policy	■ State aid agreements that give certainty for cost coverage, up to a certain level (both OPEX and CAPEX). ■ Equal compensation for capturing CO_2, whether the industry falls under the EU ETS or not, and regardless of the origin of the CO_2 (fossil or biogenic) ■ State aid for phase 1 (capacity up to 1.5 million tonnes of CO_2 per year) of the Northern Lights infrastructure.
Whole chain risk, related to the project development, to technical operation and the financial risk related other parties' operations	■ Pre-feasibility study concluded that the CCS chain should be split commercially, meaning that each industrial partner would have their own state aid agreement. Payment of state aid is based on each industrial partner's own successful project (both in construction and in operation) ■ Gassnova acted as a project integrator: - Setting up a common project maturity process, with synchronised decision gates - Development of a common overarching design basis for the project, including CO_2 specifications
Commercial and regulatory immaturity of the technology – Uncertainty related to cost and operation (yield)	State aid agreements reduce the project risk for industry. However, the state aid agreements require financial contributions from industry and full ownership of the installations and operations by the industrial partners.
CO_2 capture (and CO_2 storage) is not part of the core competence of most energy-intensive industries	Gassnova has for many years supported the development and aggregation of competence relating to CCS in Norway. Gassnova has evaluated the industrial projects at decision gates and given feedback to the industrial projects. However, the industry has taken full ownership and responsibility of its own projects.

The state aid agreements state that the Norwegian authorities will grant aid to Norcem and Celsio to cover an agreed portion of the capture projects' actual operating expenses and capital expenditure. At the same time, Norcem and Celsio will have no costs for transport and storage of the CO_2 captured the first 10 years of Northern Lights operations, according to the state aid agreements. The cost of realising and operating the transport and storage infrastructure is handled in the state aid agreement between the state and Northern Lights. Under this agreement, Northern Lights will cover some of the costs of transport and storage of Celsio's and Norcem's CO_2. In exchange, Northern Lights will get spare capacity in the transport and storage infrastructure for business development and as a basis for further expansions.

Because of the share of state aid granted (above 50 percent), the three projects become subject to the *Act on Public Procurement*[34]. Some of the industrial partners are not very familiar with this legislation.

The state aid agreements are intended to provide incentives for cost awareness to the industrial partners through cost sharing. Northern Lights also has an incentive for business development through the potential for profits if the market evolves. The state aid agreements compensate for differences in incentives for CO_2 capture under different regulatory regimes, and for differences in incentives for bio-based and fossil CO_2 capture. For further information, refer to Section 3.5.

As Norway is a member of the European Free Trade Association (EFTA), the EFTA Surveillance Authority (ESA) has assessed and approved the three state aid agreements between the state and the industrial partners in Longship.[35]

Key learning points

- As CCS was not commercially viable it was necessary to provide state aid to the industrial partners.
- The high proportion of state aid makes it necessary for the state to follow up the projects to prevent undue distortive effects on competition and trade etc.
- As the projects in Longship are first-of-a-kind, the project uncertainties are higher than would normally be encountered in well-rehearsed projects. The industrial partners therefore required cost sharing up to an agreed maximum level (related both to capital expenditure and operating expenses).
- Northern Lights has identified a business case for the transport and storage of CO_2: the state aid agreement gives Northern Lights incentives to enter into dialogue with potential customers across Northern Europe. Northern Lights' potential future profits will be based on the tariff paid by potential new customers.
- There are elements in the regulations that have been challenging for the industrial partners, such as lacking incentives for capture and storage of CO_2 from biogenic sources. These are addressed through the state aid agreements.
- The extensive share of state aid means that the industrial partners must comply with the comprehensive procurement procedures set out in the Act on Public Procurement. For some of the industrial partners this created a need to acquire new skills.

34 Lov om offentlige anskaffelser, LOV-2016-06-17-73

35 https://www.eftasurv.int/newsroom/updates/esa-approves-norwegian-full-scale-carbon-capture-and-storage-eu21bn-aid-meet

3.3 Regulator of HSE, Planning and Building Activities

For the CCS chain, two main risk areas can be pinpointed: The **risks associated with handling large volumes of CO_2** and the **risks associated with emissions from amines** used in the capture process. For Norcem, new process emissions to water (Norcem has no emissions to water today) also needed to be handled. Different governmental agencies have the regulatory responsibility for different parts of the CCS chain.

All industrial activity is subject to the legislation on safeguarding, pollution control and building construction (among others). The permit regimes and processes are generally well known in the industry.

For Longship, the following Norwegian laws and regulations are the most relevant: the *Pollution Control Act*[43], the *Regulations on handling hazardous substances*[25], Regulations on major accident hazards[36], the *CO_2 Safety Regulations*[26] and the *Planning and Building Act*[27].

Celsio and Norcem needed a consent from the Directorate for Civil Protection, the Labour Inspection Authority and the County Governor/Norwegian Environmental Agency. They also needed a building permit, a framework permit and an activity permit from the municipality. They have applied to Norwegian Environmental Agency for a permit under the Pollution Control Act24 and they need to apply for or update the ETS/quota permit.

Celsio holds a licence for the heating plants, boilers, and main pipeline networks to the outer geographical boundary. The expansion and conversion of the facilities requires a new licence. "Expansion and conversion" are defined as construction beyond the specifications given in the existing license. An impact assessment was also needed.

Norcem, Celsio and Northern Lights have all conducted Environmental Impact Assessments (EIA). An EIA[37] was not required for Norcem's CO_2 capture project, but Norcem wished to be transparent about its project with the authorities and their local community.

In order to establish a carbon capture and storage plant, Celsio needed a new zoning plan according to the *Planning and Building Act*[27]. As a part of this, an EIA[38] was required.

For Northern Lights the EIA[39] was required under the several regulations, among others: the *Storage Regulations*[21], *the Planning and Building Act*[27], *and the Pollution Control Act*[24].

CO_2 differs from hydrocarbons in many ways, and it is important to note that it does not ignite like hydrocarbons. There is therefore no risk of explosion due to ignition. CO_2 is not harmful to living organisms in low concentrations. HSE risks are linked to overpressure and leakage of large volumes. Leakage of large volumes with high concentrations of CO_2 is harmful to most living organisms, humans included, and should be avoided or, in the worst case, mitigated without delay.

The Norwegian Directorate for Civil Protection regulates facilities handling of hazardous substances, including pressurised CO_2, and has provided necessary consents to the industrial partners in the Longship project. The Petroleum Safety Authority has the regulatory responsibility for safety, the working environment, emergency preparedness and security in the petroleum sector. The Petroleum Safety Authority has developed new regulations on safety and working environment for transport and injection of CO_2 on the continental shelf (*the CO_2 Safety Regulations* [26]*).*

During the planning of the transport and storage infrastructure it became apparent that it was not clear where the responsibility of the Directorate for Civil Protection stopped and that of the Petroleum Safety Authority started. With regard to intermediate storage of CO_2 onshore before transport in a pipeline for permanent storage in a reservoir under the seabed, the Directorate for Civil Protection and the Petroleum Safety Authority have generally agreed on the following:

The Directorate for Civil Protection is the authority responsible for the handling of CO_2 on land, both at the capture facilities and in the intermediate storage before transport in a pipeline. The Petroleum Safety Authority is responsible for transport in the pipeline from upstream of the export pump, which includes the necessary equipment and piping systems for operation and maintenance of the pipeline, as well as equipment and systems for well monitoring and control and associated emergency and safety systems in connection with pipeline and injection well. However, this is an interface that can be complicated for the reception facilities. There may therefore be a need for case-by-case assessments of where the interface should go[40].

36 Directive 2012/18/EU (Seveso-III-Directive)

37 Multiconsult, Karbonfangstanlegg Norcem Brevik – konsekvensutredning, 2019

38 Fortum Oslo Varme, Reguleringsplan med konsekvensutredning for utvikling av energigjenvinningsanlegget på Klemetsrud – Konsekvensutredning, 2019

39 Equinor, EL001 Northern Lights Plan for utbygging, anlegg og drift Del II – Konsekvensutredning, 2020

40 Letter from DBS to Gassnova: "Kartlegging av ansvarlige myndigheter for CCS - grense mellom sjø og land"

An amine-based CO_2 capture plant will produce small amounts of amine emissions to air. Amines can react with other substances in the atmosphere and form nitrosamines and nitramines. Some nitrosamines and nitramines have shown carcinogenic effects in animal studies, so any spread in the environment is not acceptable and should be limited. The Norwegian Institute of Public Health has given recommendations for how much nitrosamine and nitramine can be allowed in the air and in drinking water. This has given the Norwegian environmental authorities a method for setting emission limits for CO_2 capture plants. The method for documenting emissions is based on a specific model developed for the emitting sites. This is due to the complex atmospheric chemistry, dispersion patterns and emission components of each site. The selected CO_2 capture technologies at the two capture sites have provided documentation on specific performance related to CO_2 capture, solvent degradation and potential solvent emissions to air from previous test sites. Documentation on these parameters for specific flue gases from a cement plant and a waste-to-energy plant were not available. Both of the capture sites therefore ran a pilot test campaign on the selected technology on site to document that the technology was fit for purpose and would meet the stringent emission requirements when exposed to the specific flue gas.

An added chapter (35, 7a) in *the Pollution Regulations*[22] is intended to ensure that all storage of CO_2 is done in an environmentally safe way. All companies that inject and store CO_2 need a permit from the Norwegian Environmental Agency. For further information refer to Section 2.1.1.

According to the *Planning and Building Act*[27], the operator needs to obtain a zoning plan and building consent for the pipeline from quay out to one nautical mile offshore (the baseline - Norwegian "grunnlinje"). For the Longship project this involves applications to two municipalities and agreement with many stakeholders (e.g. crossing pipelines and infrastructures). This is a lengthy process which ties up resources and could possibly delay planning and execution.

Petroleum pipes are exempt from these requirements in the *Planning and Building Act*[27], *Chapter 2, Section 1-3*. This exemption applies from the quay and further offshore, not on the land facilities. Figure 03 indicates the difference in zoning plan area for petroleum and CO_2 pipelines. Norther Lights have initiated contact with relevant Ministries to address the difference in requirements for CO_2 pipelines vs petroleum pipelines.

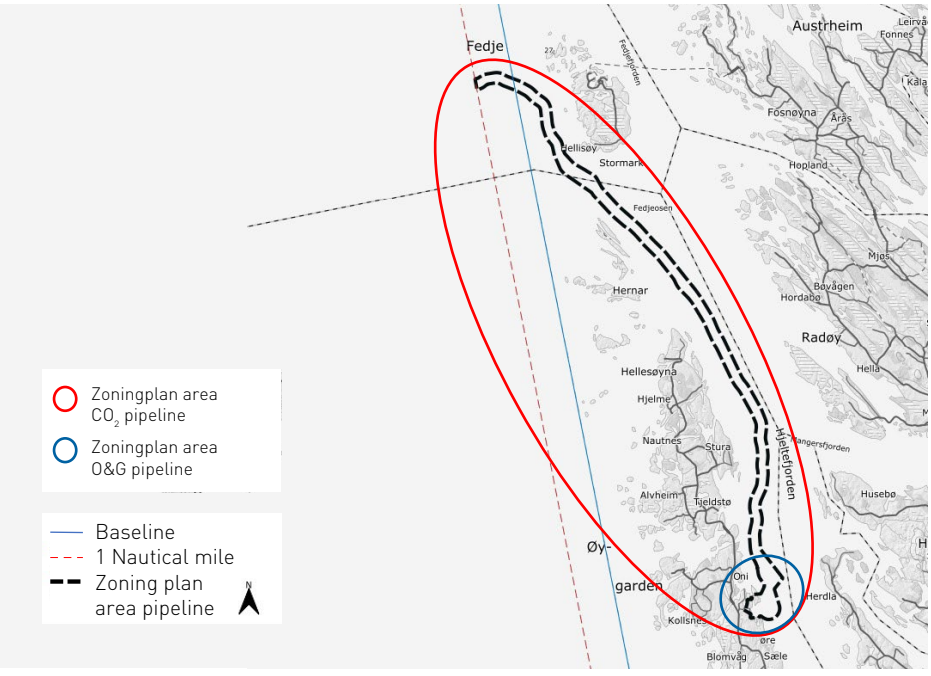


Figure 03: Difference in zoning plan area for CO_2 pipelines (red ring in the figure) compared to petroleum pipelines (violet ring in the figure) as per the Plan and Building act. The example is from the Northern Lights project zoning plan in Øygarden and Fedje municipalities. Comprehensive zoning plan work had to be carried out by the project out in sea including Øygarden and Fedje Municipalities with subsequent building applications. This is not required for petroleum pipelines cf. § 1-3 in the Plan and Building act. (figure curtesy of P.G. Stavland; Northern Lights, background map curtesy of Geonorge and ABO Plan og Arkitektur as requested by Northern Lights).

Key learning points

- For the CCS chain, two main risk areas can be pinpointed: The **risk associated with handling large volumes of CO_2** and the **risk associated with emissions from amines** used in the capture process. The HSE, planning and building regulation and related processes are generally "business as usual" for industrial partners and regulators. Emissions related to CCS are subject to the same legislation as other emissions.
- Amine-based carbon capture produces small emissions of amines. Both Norcem and Celsio have tested their capture technologies on their own flue gas. They both note that this has been important to reassure themselves that the amine emissions will not exceed certain levels and the degradation products will be below the limit set by the authorities.
- Emissions previously released into the to air can shift to water as the environmental recipient. This could pose some challenges for an updated emission permit. The temperature and volume of the emissions to water (cooling water from the CCS plant) are another issue that one needs to be taken into consideration.
- A new regulation on safety and working environment for transport and injection of CO_2 on the continental shelf has been developed by the Petroleum Safety Authority.
- The interface between the regulatory agencies the Norwegian Directorate for Civil Protection (onshore regulator) and the Petroleum Safety Authority (offshore regulator) needed clarification in the case of intermediate onshore CO_2 storage of before transport through pipeline to permanent storage in a reservoir under the seabed.
- The industrial partners point out that it is important to involve local authorities early in the process due to the complexity and size of the projects.
- The operator needs to secure a zoning plan and building consent for the pipeline from the quay out to one nautical mile offshore the baseline while petroleum pipes are exempt from this requirement. The transport and storage operators point out that this is a lengthy process binding resources and could possibly delay planning and execution.

3.4 Regulator of Resource Management and Safe Storage

A CCS-specific regulatory framework, to ensure safe long-term storage for CO_2, was implemented in Norway in 2014, through the implementation of the *EU CCS Directive*[19]. For the Norwegian implementation of the *EU CCS Directive*[19], a two-track system was chosen.[41] The system separates industrial CCS from CCS related to petroleum activities. The two sets of CCS activities are regulated under different acts and regulations, as the objectives of the parallel systems are different. The main objective of the petroleum activities is to ensure that resource management is "carried out in a long-term perspective for the benefit of the Norwegian society as a whole", i.e. value creation for the whole of society. The objective of CO_2 storage as formulated in the regime for industrial CCS is related to mitigating climate change and it must "contribute to sustainable energy generation and industrial production, by facilitating exploitation of subsea reservoirs on the continental shelf for environmentally secure storage of CO_2 as a measure to counteract climate change".

Industrial CCS is regulated in the *Storage Regulations*[21] (Section 2.1). The *Storage Regulations*[21] are subject to the *Act on other underwater natural resources*[42]. The Longship project is defined as an industrial CCS project subject to the *Storage Regulations*[21].

The *Storage Regulations*[21] govern issues related to safe geological storage of CO_2. The climate and environmental aspects of storage are regulated by the environmental authorities through a new chapter in the *Pollution Regulations*[22] (Sections 2.1 and 3.4).

The system for obtaining permits for subsurface geological storage of industrial CO_2 is similar to the petroleum licensing system. The permit system consists of a set of permits and obligations which the operator is subject to and needs to obtain and fulfil during the time frame of the project: pre-operation, operation, cessation of operation (decommissioning), and transfer of liability to the Norwegian state. For more information on the permit system refer to Section 2.1.1.

The companies involved in CO_2 storage are energy companies with extensive oil and gas experience. The technologies used for CO_2 storage and the competences involved are generally the same as for oil and gas activities. The permit regime for oil and gas is of course familiar to these industries and the authorities, which is an advantage.

The authorities have to safeguard the companies' legal rights and also safeguard the interests of society by preventing monopoly situations, protecting the environment etc.

The transport and storage component of Longship, Northern Lights, is a joint venture partnership between Equinor, Shell and Total Energies. Northern Lights JV DA was established and incorporated in February 2021, but the partnership was formed back in 2017.

In 2019 the authorities granted Equinor, on behalf of the Northern Lights consortium, a permit to exploit an area for CO_2 storage on the Norwegian continental shelf (EL001). The permit was later transferred to Northern Lights. Northern Lights' plan for development, installation and operation (PDO/PIO), including an Environmental Impact Assessment, was approved by the authorities in 2021. Before the start of operation Northern Lights will need a permit for injection and storage of CO_2. Northern Lights plans to send the application for this permit to the Norwegian Environmental Agency during the autumn of 2022. To obtain the injection permit, a full monitoring plan must be submitted beforehand. This will also need approval from the EFTA Surveillance Agency. For more information refer to Section 2.1.1.

In April 2022 the Ministry of Petroleum and Energy awarded two new licences in accordance with the *Storage Regulations*[21] on the Norwegian continental shelf (NCS), one in the North Sea and one in the Barents Sea. The licence in the North Sea has been awarded to Equinor ASA, while the licence in the Barents Sea has been awarded to Equinor ASA, Horisont Energy AS and Vår Energi AS.[43]

The Ministry of Petroleum and Energy (MPE) has also proposed changes[44] to the *Company Act*[45] and the *Storage Regulation*[21]. If approved, the MPE argues that these changes will contribute to simplification for the concerned companies. In its consultation response Northern Lights pinpoint the differences between the petroleum industry and the CCS industry and argue for a comprehensive review of the legal framework for CCS as a new and upcoming business area.

41 "CCS policies and regulatory framework for CCS" by Svein Mofossbakke, Gassnova SF; Ingvild Ombudstvedt, IOM Law and Maria Ellingsen Gran, IOM Law

42 Lov om vitenskapelig utforskning og undersøkelse etter og utnyttelse av andre undersjøiske naturforekomster enn petroleumsforekomster og mineralforekomster, LOV-1963-06-21-12

43 Two licenses under the carbon Storage Regulations awarded on the NCS - regjeringen.no

44 Høring – forslag til endring i selskapsloven – transport og lagring av CO_2 i undersjøiske reservoarer på kontinentalsokkelen - regjeringen.no

45 Lov om ansvarlige selskaper og kommandittselskaper (Selskapsloven)

Making Longship investable for the storage operator:

Before the transport and storage operator Northern Lights decided to invest in the transport and storage infrastructure, they expressed some concerns about the perceived uncertainty relating to future permits and how the state would enforce the legal framework.

In general, there are provisions in the *Storage Regulations*[21] that imposes uncertain future liabilities and other obligations on the storage operator. The uncertainty is related to different parts of the *Storage Regulations*[21], including: *Monitoring (Section 5-4), Transfer of responsibility to the state (Section 5-8), Financial security (Section 5-9), Financial mechanism (Section 5-10)* and *Third-party access to facilities for storage of CO_2 and storage sites (Section 5-12)*.

The perceived uncertainty was related to a lack of experience of how the CCS-specific regulations would be enforced, especially related to when, and the conditions for, transfer of the responsibilities under the *Storage Regulations*[21] to the state, demands for monitoring, the amount and form of the financial security that would have to be provided before injection could start, the amount to be provided through the financial mechanism before transfer of responsibility at the end of the license, and the requirements for obtaining an injection permit in general.

The business model for CCS (low market maturity, high risk, low return) is very different from the business model in the petroleum sector (high market maturity, high risk, high return). In short, the storage operator was of the opinion that the *Storage Regulations*[21] gave too much uncertainty in their business model.

An example of how a provision in the *Storage Regulations*[21], seen from the transport and storage partner's perspective, places risk on the transport and storage partner, is the requirement for third-party access to the storage infrastructure and the lack of control of the conditions for this. The state argues, however, that requirement for third-party access only will come into play if the storage operator do not need the infrastructure itself, and if third party access is required, the operator will be financially compensated.

For a financial investment decision to be made by Northern Lights, the state needed to bear a substantial part of the risk, as well as granting investment and operating aid to cover a portion of Northern Lights' costs (for more information about the state aid agreement, refer to Section 2.2). The State's liability also covers part of the risk for a potential but unlikely leakage from the subsurface storage complex once the CO_2 from Norcem and Celsio is stored. Northern Lights' liability for any leakage of CO_2 received from Norcem and Celsio during the operating period, is limited to a maximum ETS price of EUR 40 per tonne (index adjusted).

This was agreed at a time when the EU ETS price was approximately EUR 20 per tonne. The Norwegian authorities will, subject to certain conditions, also grant closure support for eligible removal costs. Closure support is only relevant for CO_2 storage given the legal requirements pertaining to the administration of such sites. A minimum monitoring period of 20 years applies[46] before the responsibility is transferred to the state.

As well as providing risk relief to Northern Lights through the state aid agreement, the Ministry of Petroleum and Energy in 2020 (prior to the Northern Lights' final investment decision) sent a "comfort letter"[47] to the transport and storage operator (Equinor ASA) confirming the state's common goals with the industry, and the intention to find and implement appropriate solutions to the above, raised concerns.

Key learning points

- The licensing system for CO_2 storage is operational and permits have been granted for Longship, being the first industrial CCS chain under the legal framework.
- The licensing system for CO_2 storage is similar to the licensing system for oil and gas exploration and production. The technologies and stakeholders are mainly the same for both industries, and the petroleum industry and the authorities are well acquainted with the licensing system for oil and gas. This is a clear advantage.
- However, there are several important differences between the petroleum industry and the CCS industry. For instance, the business model for CCS (low market maturity, high risk, low return) is very different from the business model in the petroleum sector (high market maturity, high risk, high return). Due to these differences, some of the requirements under the current licensing system (third-party access, liabilities ect) may make it challenging for the storage operator to handle risks and make investment decisions.

46 Unless the Ministry or the entity it authorises, upon application from the operator, is convinced that the requirement of "*that the stored CO_2 will remain entirely and permanently enclosed*" has been met before the expiry of the said, minimum 20 year period.

47 Letter from the Ministry of Petroleum and Energy to Equinor ASA, 7 April 2020: "Prinsipper for regulering av transport og lagring av CO_2 på norsk kontinentalsokkel"

3.5 Regulator of CO_2 Emissions

There are several laws and regulations (international and national) that form the basis for the climate regulations in Norway (Section 2.1).

Norcem's CO_2 emissions are covered by EU ETS, but Celsio's CO_2 emissions are not. As from 01.01.2022, both Norcem and Celsio are subject to a new national combustion tax. Both emission sources have CO_2 stemming from both fossil and biogenic sources. CO_2 emissions based on sustainable biogenic sources do not need to be compensated by EU ETS allowances.

Longship has highlighted the lack of regulation for CCS in sectors not subject to EU ETS and for biogenic sources. Also, for Norcem the ETS price signal was not sufficient to incentivise the company to make an investment decision without financial support. The ETS price was somewhere between 20 and 30 euros when the state aid agreements were negotiated in 2019-2020. At the time Celsio had no economic incentive to cut its emissions.

The industrial partners in Longship have to report their CO_2 emissions to the Government. For the industrial partners subject to the EU ETS the *ETS Directive*[16] and the *EU Monitoring and Reporting Regulation*[20] is relevant.

The fact that ship transport is not subject to EU ETS had implications for the possibility of transferring responsibility for the CO_2 in the CCS chain. For Longship this has been solved through the state aid agreements.

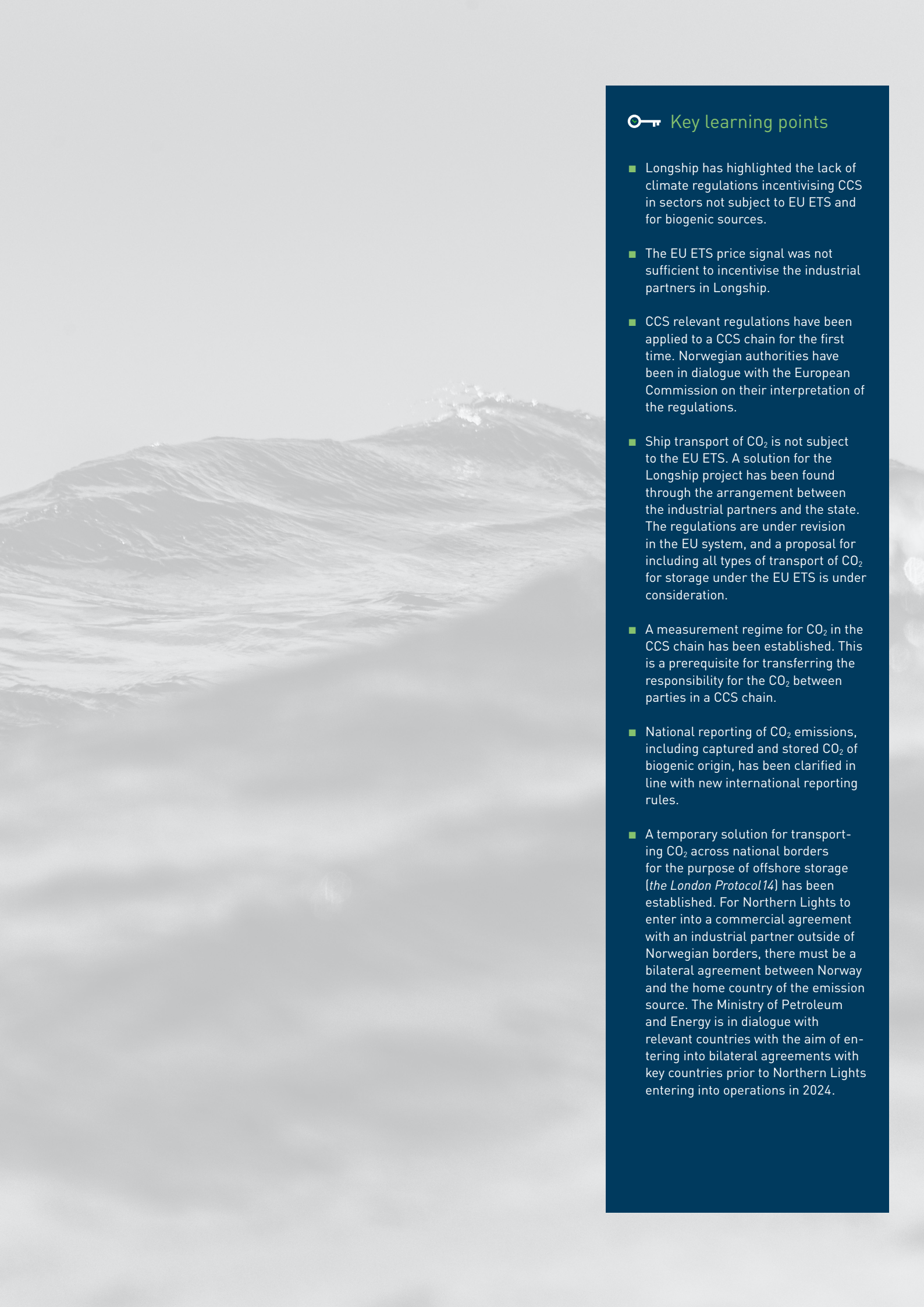
Norway, as a country, is required to monitor its emissions under the EU's Climate Monitoring Mechanism, which sets the EU's own internal reporting rules based on internationally agreed obligations. In Longship CCS relevant regulations have been applied on a CCS chain for the first time. Norwegian authorities have been in dialogue with the EU Commission on their interpretation of the regulations. For more information refer to Section 4.1.

In addition to the EU, Norway has to report GHG emissions and removals to the UN Framework Convention on Climate Change. GHG emissions are reported to the UN in a set of common reporting format (CRF) tables. A shortcoming of the CRF tables has been that it is difficult to transparently report carbon capture and storage (CCS) of biogenic CO_2 and have this reflected in the national totals. At the COP26 in Glasgow the CRF tables were improved. CCS of biogenic CO_2 can now be reported in line with CCS of fossil CO_2, both to EU and to the UN.

The London Protocol[14] also poses some challenges for cross-border CCS. *The London Protocol*[14] contains a prohibition on export of all waste and other matter to other states for dumping or incineration at sea. In 2009, the parties to the Protocol adopted an amendment that allows for the export of CO_2 to other states for storage purposes under certain conditions. This amendment will enter into force when ratified by two-thirds of the 53 parties. This is a legal obstacle to cross-border cooperation on CCS. As of February 2022, only nine of the 53 Contracting Parties – Norway, the United Kingdom, the Netherlands, the Islamic Republic of Iran, Finland, Estonia, Sweden, Denmark and South Korea have formally accepted the amendment.

In 2019, the parties to the *London Protocol*[14] supported a Norwegian–Dutch proposition to allow provisional application of this amendment while awaiting ratification by two-thirds of the 53 parties. Countries that so wish can make arrangements for the transport of CO_2 across national borders by submitting a declaration to the International Maritime Organization (IMO).

This has implications for Northern Lights' business development. Bilateral agreements between Norway and the relevant countries need to be in place for cross-border transport of CO_2 to take place. This activity is led by the Ministry of Petroleum and Energy. Informal consultations have started with a number of European countries. Memorandums of understanding on CCS collaboration have been signed with Belgium and the Netherlands.



Key learning points

- Longship has highlighted the lack of climate regulations incentivising CCS in sectors not subject to EU ETS and for biogenic sources.
- The EU ETS price signal was not sufficient to incentivise the industrial partners in Longship.
- CCS relevant regulations have been applied to a CCS chain for the first time. Norwegian authorities have been in dialogue with the European Commission on their interpretation of the regulations.
- Ship transport of CO_2 is not subject to the EU ETS. A solution for the Longship project has been found through the arrangement between the industrial partners and the state. The regulations are under revision in the EU system, and a proposal for including all types of transport of CO_2 for storage under the EU ETS is under consideration.
- A measurement regime for CO_2 in the CCS chain has been established. This is a prerequisite for transferring the responsibility for the CO_2 between parties in a CCS chain.
- National reporting of CO_2 emissions, including captured and stored CO_2 of biogenic origin, has been clarified in line with new international reporting rules.
- A temporary solution for transporting CO_2 across national borders for the purpose of offshore storage (*the London Protocol14*) has been established. For Northern Lights to enter into a commercial agreement with an industrial partner outside of Norwegian borders, there must be a bilateral agreement between Norway and the home country of the emission source. The Ministry of Petroleum and Energy is in dialogue with relevant countries with the aim of entering into bilateral agreements with key countries prior to Northern Lights entering into operations in 2024.

3.6 The value of trust between private companies and the authorities

The Nordic region is regarded as a world leader when it comes to trust among its population.[48] A high level of trust is an important resource for a society.

The stakeholders involved in Longship all pinpoint trust as a prerequisite for succeeding with the project. The project is being realised even though important regulatory issues have yet to be clarified and it is unclear how the authorities will enforce the regulations. For more information, refer to Section 3.4.

The project has been developed through a phased project development process, with several decision gates for both industry and the state. Gassnova believes that this approach has been instrumental in gradually building trust between the public and private sector before final investment decisions were made. During the project development process both the industrial projects and the state aid agreements has been matured.

In view of the state's and industry's common goal of realising a CCS chain, all the parties have shown an openness and flexibility that is not common for other projects.

> "What we set out to achieve, well over a decade ago, is now turning into reality. It is a strong result of a fruitful collaboration between [all stakeholders] across the CCS value chain in Norway."
>
> (Giv K. Brantenberg, General Manager HeidelbergCement Northern Europe, from the Northern Lights summit 2022)

48 TRUST – THE NORDIC GOLD (diva-portal.org)

04

REGULATIONS APPLIED AND SOLUTIONS UNDER DEVELOPMENT

Applying the legal framework on an industrial CCS chain for the first time, requires practical clarifications and solutions. The requirements in the legal framework must correspond with the existing technical solutions and vice versa. For instance, measuring the amount of CO_2 is a pre-condition for transferring the responsibility of the CO_2 from one partner to another in the CCS chain. Always knowing who is responsible is also a necessity. Likewise, making sure that CO_2 is safely stored, requires monitoring of the storage site for decades. In the Sections below a description of how this is sorted out for Longship is given.

4.1 Transfer of responsibility for CO_2 in the Longship CCS chain

The purpose of CCS is to eliminate CO_2 emissions to the atmosphere for climate purposes. It is therefore important to monitor the amount of CO_2 captured, transported and stored and any potential leakage of CO_2 in the CCS chain.

In this section "responsibility for CO_2" means that the industrial partner is responsible for monitoring and reporting any leakage of CO_2 in the CCS chain and for submitting allowances under the ETS. Measuring the amount of CO_2 transferred from one partner to another is a prerequisite for transferring the responsibility. For measurement methods refer to Section 4.2

Prior to and in parallel with the planning of the Longship project the Norwegian Government has been working to clarify how the EU legislation, which has never been applied to a CCS project like Longship before, should be interpreted.

Longship is complicated in a regulatory sense because it includes CO_2 from both fossil and biogenic sources, CO_2 from the EU ETS and non-EU ETS sectors, and transport of CO_2 by ship and trucks.

The Norwegian Government sent a letter[49] to the EU Commission in July 2019, requesting legal clarifications related to the *ETS Directive*[18] and the *Monitoring and Reporting Regulation*[20]. The EU Commission replied in a letter of 27. July 2020[50].

Ship transport of CO_2 is not subject to the EU ETS, and during the planning phase it was unclear how CO_2 transport by ship should be regulated. This issue was addressed in the letters cited above. According to a Norwegian interpretation of the *Monitoring and Reporting Regulations*[20] the capture facilities will be able to subtract CO_2 from their emissions accounting when CO_2 is transferred from the ship to the reception terminal.

The European Commission endorsed this interpretation, and the following was stated in its reply letter:

> "Transfer of captured CO_2 to a ship or a truck does not prevent the right to subtract the CO_2 when it is later on transferred from the ship or the truck to a pipeline transport network or directly to a storage site. When that later transfer from the ship or truck to the network or storage site is completed, the capturing installation can subtract the CO_2 according to *Monitoring and Reporting Regulation*[20] Article 49 (a) (ii) or (iii)."

This means that Norcem (subject to EU ETS) will be able to subtract allowances when the CO_2 has entered the receiving terminal in Øygarden and when Norcem has received a certificate for the amount of CO_2 delivered, issued by Northern Lights. Norcem will not be able to subtract allowances for leaked CO_2 during transport.

During the negotiations with the state, Norcem made it clear that it was unacceptable to risk a financial loss due to leakage of CO_2 from a ship Norcem did not operate itself. Northern Lights and the State will therefore cover the costs related to leakage of CO_2 from the ship, according to an agreed cost sharing ratio. Another issue addressed in the above-mentioned letters was subtraction of CO_2 from biological origin.

In the letter from the Norwegian Ministry the following approach was proposed:

> "The captured CO_2 may – regardless of its origin (fossil or bio) – be subtracted as long as it does not exceed the operator's total amount of produced fossil CO_2 from the relevant installation. If the operator captures more CO_2 than the total production of fossil CO_2, the captured CO_2 exceeding this number cannot be subtracted."

49 Letter "The Norwegian CCS demonstration project - request for legal clarifications related to the ETS Directive and the MR-regulation" from the Norwegian Ministry of Climate and Environment to the EU Commission dated 1 July 2019

50 Letter "Subject: Legal issues regarding Carbon Capture and Storage" from the EU Commission to the Norwegian Ministry of Climate and Environment dated 27 July 2020

The EU Commission replied with the following statement:

> "...the Commission does not agree that captured CO_2 from biological origin may be subtracted from the emissions of the installation. Indeed, there is no legal ground in the ETS Directive that could support this, and Article 49(1) of the *Monitoring and Reporting Regulation*[20] makes it clear that this is not possible ("The operator shall subtract from the emissions of the installation any amount of CO_2 originating from fossil carbon [...]"). However, it seems that other instruments could address the issue of and create incentives for bio-energy with carbon capture and storage in a more efficient way."

Norcem's (subject to the EU ETS) emissions stem from both fossil and biogenic sources. For Norcem this ratio is 87/13. Norcem will capture approx. 50 per cent of its emissions. When the CO_2 is captured, it is assumed that the proportion of fossil/bio is the same as for the total emissions from the factory. However, although it is possible to estimate the amount of biogenic CO_2 captured and stored from Norcem, they will neither be able to subtract bio-CCS within the EU ETS nor to receive emission allowances for such storage.

This illustrates that the EU ETS is not designed to create incentives for bio-CCS. To our knowledge, this issue related to bio-CCS is still being discussed within the EU.

Apart from the ship transport, all the Northern Lights (NL) activities (receiving terminal, pipeline, injection well and storage site) are subject to the EU ETS. When the CO_2 enters the Northern Lights storage network in Øygarden, the CO_2 – both the fossil and biogenic part – is regulated. Northern Lights is responsible for any leakage. The costs related to potential leakage is covered by Northern Lights and the State according to an agreed cost sharing ratio. It is unclear whether a leakage of sustainable biogenic CO_2 can be counted as zero or not within the EU ETS if a leakage should occur from the storage site. For potential revenue from voluntary markets separate reporting rules may apply for relevant CO_2 volumes.

Table 03: Norcem - responsibility for leakage in the CCS chain and the financial compensation in the state aid agreement

	CO_2 origin*	Capture	Ship transport	Storage network
Current regulation	**Fossil CO_2**	Norcem (EU ETS / new combustion tax)	Norcem (EU ETS)	NL (EU ETS)
	Biogenic CO_2 (sustainable)	Norcem (EU ETS, counted as zero)	Norcem (EU ETS, counted as zero)	NL (EU ETS, counted as zero?)
State aid agreement	**Fossil CO_2**	Compensation from the state for captured CO_2	NL and the state cover the costs related to leakage	NL and the state cover the costs related to leakage
	Biogenic CO_2	Compensation from the state for captured CO_2	N/A	NL and the state cover potential costs related to leakage

Celsio is not subject to the EU ETS. Its emissions stem from combustion of both fossil and biogenic sources. For Celsio this ratio is 50/50. Celsio will capture approx. 90 per cent of its emissions.

As for Norcem when CO_2 is captured, it is assumed that the proportion of fossil/bio is the same as for the total emissions from the factory. A carbon tax on waste incineration was introduced in 2022. The tax is only relevant to the part of the emissions produced by combustion of fossil sources. Celsio will not have to pay the tax for emissions that are captured and stored.

Celsio's CO_2 will be transported by truck to intermediate storage at the Port of Oslo. From there the CO_2 will be loaded onto the ship, operated by Northern Lights. Neither the CO_2 truck transport nor the CO_2 ship transport are currently regulated under the EU ETS.

As explained above, all the Northern Lights (NL) activities except ship transport are subject to the EU ETS. When the CO_2 from Celsio enters the Northern Lights storage network in Øygarden, all the CO_2 is regulated under the ETS in the same way as described for Norcem above.

Table 04: Celsio - responsibility for leakage in the CCS chain and the financial compensation in the state aid agreement

	CO_2 origin	Capture and truck transport	Ship transport	Storage network
Current regulation	**Fossil CO_2**	Celsio (new combustion tax)	Not regulated	NL (EU ETS)
	Biogenic CO_2 (sustainable)	Not regulated	Not regulated	NL (EU ETS, counted as zero?)
State aid agreement	**Fossil CO_2**	Compensation from the state for captured CO_2	NL and the state cover the costs related to leakage	NL and the state cover potential costs related to leakage
	Biogenic CO_2	Compensation from the state for captured CO_2	N/A	NL and the state cover potential costs related to leakage

Additional issues related to potential new CO_2 volumes to Northern Lights:

The only potential revenue stream for Northern Lights during the 10-year operating period is the tariff paid by new customers, the so-called "third-party volumes". Northern Lights will manage the surplus capacity in the storage network and keep the revenue (limited upwards in the state aid agreement).

The responsibility for the CO_2 delivered to Northern Lights' (NL) ships from new customers in Norway and abroad will in principle be regulated in the same way as the responsibility for the CO_2 from Norcem and Celsio. The fact that ship transport is not included in the EU ETS means that the capture operator is responsible for leakage of CO_2 during ship transport even though the ships are operated by another company.

However, the financial loss that results from a potential leakage during transport, can be regulated in private legal contracts between the operators. Despite this possibility, not including ship transport under the EU ETS is seen as an important barrier to cross-border transport of CO_2. Revision of the *EU ETS Directive*[14], including a proposal of including all forms of transport of CO_2 for permanent storage in the ETS, is however ongoing.[51]

It is a complicating factor when CO_2 is transported across borders. In addition to define the responsibility at a commercial level, there is a need to define the responsibility at a country level. At what point is the responsibility for leakage of CO_2 during transport transferred from one country to another? This must be defined in the bilateral agreement between the states. This needs to be in place before a commercial agreement between a new customer and Northern Lights can be concluded (read more about the *London Protocol*[14] in Section 3.5).

Table 05: Third-party-volumes – responsibility for leakage under current and proposed regulation under the EU ETS

	CO_2 origin	Capture	Ship transport	Storage network
Current regulation	**Fossil CO_2 from ETS**	Capture operator	Capture operator	NL (EU ETS)
	Biogenic CO_2 (sustainable) from ETS	Capture operator (counted as zero)	Capture operator (counted as zero)	NL (EU ETS, counted as zero?)
	Fossil CO_2 from non-ETS	Not regulated	Not regulated	NL (EU ETS)
	Biogenic CO_2 from non-ETS	Not regulated	Not regulated	NL (EU ETS, counted as zero?)
Proposed regulation	**Fossil CO_2 from ETS**	Capture operator	NL	NL (EU ETS)
	Biogenic CO_2 (sustainable) from ETS	Capture operator (counted as zero)	NL	NL (EU ETS, counted as zero?)
	Fossil CO_2 from non-ETS	Not regulated	NL	NL (EU ETS)
	Biogenic CO_2 from non-ETS	Not regulated	NL	NL (EU ETS, counted as zero?)

51 https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)698890

4.2 CO_2 measurement in the CO_2 transport chain

The measurement and inventory of the transported CO_2 is set up to meet the necessary commercial and regulatory requirements. The *Monitoring and Reporting Regulation*[20] requires a maximum uncertainty in the measurement system when CO_2 is transferred between installations.

Both CO_2 quality and quantity are measured several places along the chain in the Longship project. The purpose of most measurements is process control. However, the total volume of CO_2 inventory on the ship is defined for transfer between parties. This is measured twice: first when the CO_2 is transferred from the capture site to the ship, and then before the CO_2 is transferred from the ship to the receiving terminal in Øygarden (ref. point 3 and 4 in figure 04). For responsibility for potential leakage, refer to Section 4.1.

The state aid agreement between the capture sites and the Norwegian State specifies that capture sites will be compensated for the volume of CO_2 received by the ship and corrected to -26°C (ref. point 3 in figure 4). This is done by the ship's Custody Transfer Measurement System (CTMS) which measures the change in CO_2 liquid level in the ship's CO_2 tanks, compensated for CO_2 composition, pressure, temperature, trim and list. The state aid agreement requires the capture sites to measure the density of liquid CO_2, which can be used to calculate the mass of liquid CO_2 loaded onto the ship. The total accuracy of the agreed quantity measurement system (the CTMS) has been estimated to be well below 2,5% accuracy, which lays within the requirement in the *Monitoring and Reporting Regulation*[20]. This principle of quantity measurement is similar to the system used for trading of other liquified gases as e.g. LPG. The Longship partners will follow the same regime for 3rd party verification at 36-month intervals.

CO_2 quantity measurements

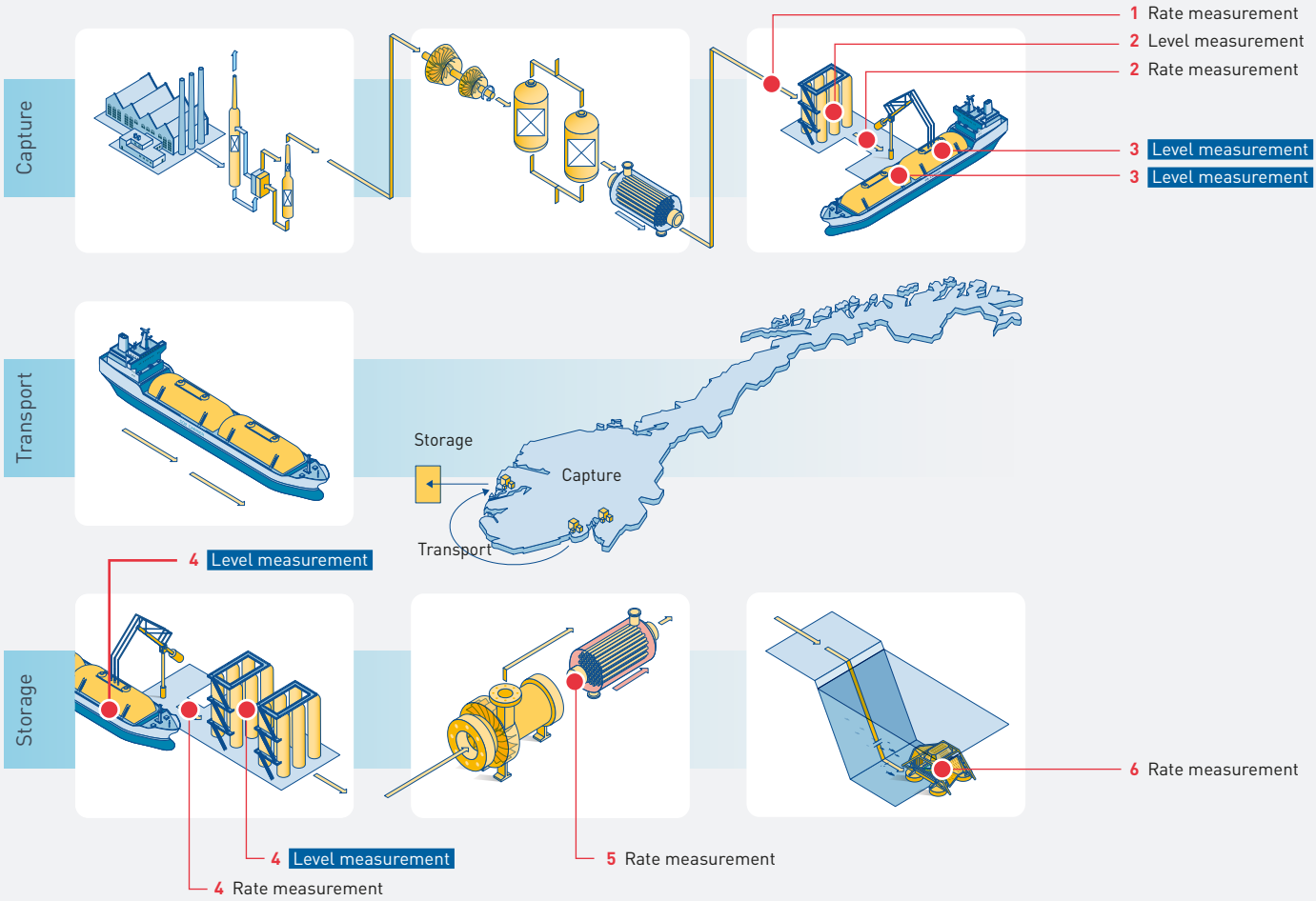


Figure 04: Outline diagram of the main process steps in Longship project. Carbon capture, liquefaction and interim storage at the capture site, ship transport and interim storage, pumping and injection into well. The figure shows where the CO_2 is measured in the chain. The inventory transfer of CO_2 is based on tank level measurement (blue boxes).

Table 06: The table gives a brief description of the main quantity measurements in the Longship chain

	Description
1	Amount (in cubic metres) of CO_2 liquefied and transported in the pipe to storage tanks to be measured continuously with flow meter (ultrasonic).
2	Amount (in cubic metres) of CO_2 exported from Norcem to be calculated from measurements of storage tank levels at start and end of ship loading operation. Measurement of flow rate will most likely enter into the calculation, if deemed accurate enough.
3	Amount (in cubic metres) of CO_2 loaded onto the ship (docked at Norcem) to be calculated from measurements of ship tank levels at start and end of ship loading operation. This is the formal determination of the volume of CO_2 transferred from Norcem to Northern Lights in the state aid agreements.
4	Amount (in cubic metres) of CO_2 discharged from the ship (docked at the receiving terminal) to be calculated from measurements of tank levels (both ship cargo tanks and interim storage tanks) at start and end of discharge operation. Northern Lights will evaluate use of operational flow meters, but not for accounting/custody transfer (in Longship).
5	Amount of CO_2 injected to be measured continuously with a flow meter. This measurement, together with the subsea measurement, will be important for verifying the integrity of the pipeline.
6	Amount of CO_2 entering the reservoir to be measured continuously with a subsea flow meter.

Gas return

CO_2 storage/transport tanks cannot be drained to full vacuum and introducing other gases to displace the CO_2 would pollute the next CO_2 batch. The tanks will therefore contain gaseous CO_2 at approximately equal pressure and temperature when emptied. As liquid is drained from one tank and filled into another tank, gaseous CO_2 will flow the opposite way (in a dedicated pipe/pipeline). The mass of gaseous CO_2 flowing is approximately 4% of the mass of the liquid CO_2, due to the difference in density.

As the gaseous CO_2 is liquefied together with the CO_2 that has just been captured, the rate of liquid CO_2 will therefore be increased by 4%, as shown in the outline diagram in Figure 05. If e.g., 100 tonnes/day is captured from flue gas, liquefied and transferred to interim storage vessels, the volume of the 100 tonnes will displace an equal volume of gaseous CO_2, which is approximately 4 tonnes. These 4 tonnes of gas return will also have to be liquefied, so the liquefaction must be designed for 104 tonnes/day. The effect applies to every tank the liquid CO_2 is transferred to, and the ship will also have to transport 104 tonnes.

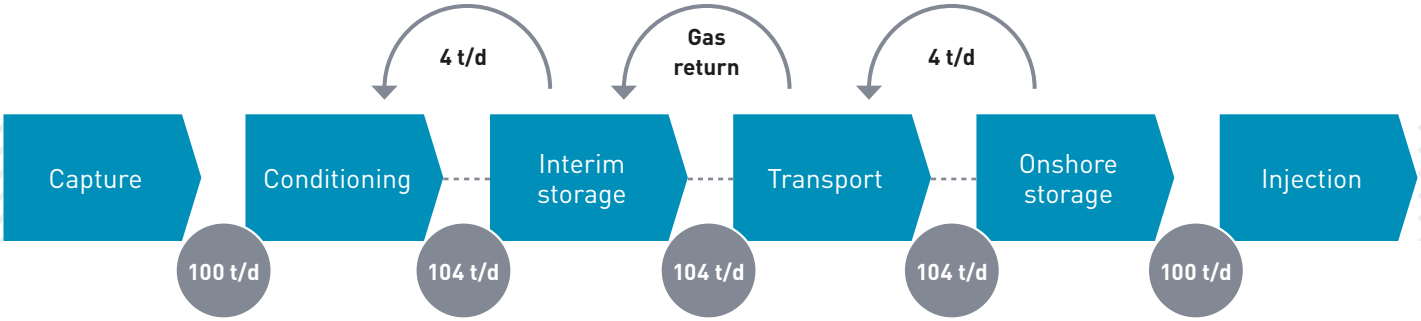


Figure 05: Outline diagram of the effect of gas return.

CO_2 specification

The CO_2 specification in the Longship project has been agreed between the parties and is considered to be quite strict. For the transport and storage operator, it will reduce the risk for corrosion etc. to have the CO_2 stream as pure and dry as possible. For the capture operator, purifying the CO_2 may be costly. However, in the Longship project the CO_2 is liquefied and therefore meets the CO_2 specification set.

The CO_2 volume is almost 100% pure CO_2. The following specification governs the CO_2 in the Longship project.[52] Design Basis for the CCS Chain' rev. 5.2, 12.03.19.

Table 07: CO_2 specification

Component	Concentration, ppm (mol)
Water, H_2O	⩽ 30
Oxygen, O_2	⩽ 10
Sulphur oxides, SOx	⩽ 10
Nitric oxide/Nitrogen dioxide, NOx	⩽ 10
Hydrogen sulphide, H_2S	⩽ 9
Carbon monoxide, CO	⩽ 100
Amine	⩽ 10
Ammonia, NH_3	⩽ 10
Hydrogen, H_2	⩽ 50
Formaldehyde	⩽ 20
Acetaldehyde	⩽ 20
Mercury, Hg	⩽ 0.03
Cadmium, Cd Thallium, Tl	⩽ 0.03 (sum)

Note: Non-condensable gases are components that, when pure, will be in gaseous form under the given thermodynamic conditions. The content of non-condensable gases will be limited by the actual solubility in the liquid CO_2 in the interim storage tanks at the capture plants.

52 Northern-Lights-FEED-report-public-version.pdf (gassnova.no)

4.3 Monitoring

In Section 2.1 the regulatory framework for CCS was addressed, and in Section 2.1.1 the licencing system and regulations used this far in the Longship project was described. Monitoring requirements involves long-term commitments. The need, requirements and time for monitoring can change in the course of a storage project's life-time; so although a monitoring plan needs to be submitted to obtain a permit for storage, this can later change (especially with regards to the timeframe of when CO_2 can be considered safely stored). This represents potential uncertainties for the storage operator (Section 3.4). Northern Lights submitted a monitoring plan according to requirement of the legal framework, and this Section addresses the demand to a monitoring plan according to the *CCS Directive*[19] and *Storage Regulations*[21] and highlights the future obligations.

CCS is a climate mitigation tool, and the aim of CO_2 storage is consequently to prevent the CO_2 from entering the atmosphere. Monitoring the behaviour of the CO_2 beneath the seabed and confirming that the CO_2 stays underground for the foreseeable future is therefore important. However, the long timespan of the monitoring may impose a financial uncertainty on the storage operator.

A monitoring plan is a prerequisite for obtaining the necessary permits for underground injection. Generally speaking, all requirements to measuring and monitoring are covered by the *CCS Directive*[19], transposed into Norwegian law through *the Storage Regulations*[21], except the quantification of emissions, which is covered by the EU ETS alone.

The legal requirement for monitoring in Norway is based on Section 5.4 of the *Storage Regulations*[21], which adheres directly to the guidance set out in the *CCS Directive*[19], Article 13 and Annex II, which describe the requirement for monitoring of the injection facilities, storage complex and surrounding environment, and the details required in the monitoring plan. Section 5.4 of the *Storage Regulations*[21] are referred to in figure 06.

The monitoring should be based on a monitoring plan produced by the operator in accordance with the requirements in Annex II to these Regulations, which the Ministry of Petroleum and Energy has approved pursuant to Section 5-2.

5-4 Monitoring

The operator must monitor the injection facilities and the storage complex, including the spread of CO_2, to:

a)	Compare the actual and modelled behaviour of CO_2 and formation water at the storage location,
b)	Identify significant irregularities,
c)	Track the migration of CO_2,
d)	Detect any leakage of CO_2 from the storage complex,
e)	Update the assessment of the short and long-term safety and integrity of the storage complex, Including whether the stored CO_2 remains securely contained.

Figure 06: Section 5.4 of the *Storage Regulations*.

The plan should be updated in accordance with the requirements in Annex II to these Regulations, and in any case every five years. This is to make any changes to the risk assessment concerned with leakage and in the interests of the environment and human health, in light of new scientific knowledge or technological improvements. Updated plans are conditional on approval from the Ministry of Petroleum and Energy pursuant to Section 5-2.

The demands for monitoring will vary in the different stages of a CCS project (ref. figure 07), from the baseline measurements in the initial phases of a storage project, over the comparative and control measurements during the operative phase to constant observatory monitoring after end of the project and will therefore require the use of different methodologies. It is important to understand that there is no single methodology that allows a complete quantitative analysis of potential CO_2 leakage from an underground storage site.

The operator is responsible for monitoring the storage site during the operational phase on the basis of the monitoring plan, but also in the period following closure until the storage site has been transferred to the state. In the event of leakages of CO_2 or significant irregularities, the operator must notify the state and take the necessary corrective measures. The state may also take corrective measures itself and recover the costs from the operator, and it has a duty to do so if the operator fails to fulfil its obligations.

Further, it is a requirement that the monitoring technologies put in place should be based on "best practice available at the time of design". How a technical monitoring, measuring and verification framework should be put in place and structured, and which technologies are available, are dependent on the geological setting of the specific storage site. The elements of any monitoring plan, its objectives and the technologies used, are therefore site-specific and risk-based.

In practice, this means that the monitoring technology employed may change during the operational phase of the site and that the competent authority might, at a later stage, make use of other specific technologies or measurement methods that were not in the original monitoring plan (for example, at Sleipner the monitoring methods were changed and adapted over time). The requirement for how often the methods are to be performed and reported is not set out in the directives.

The regulatory framework *(some highlighted issues)*

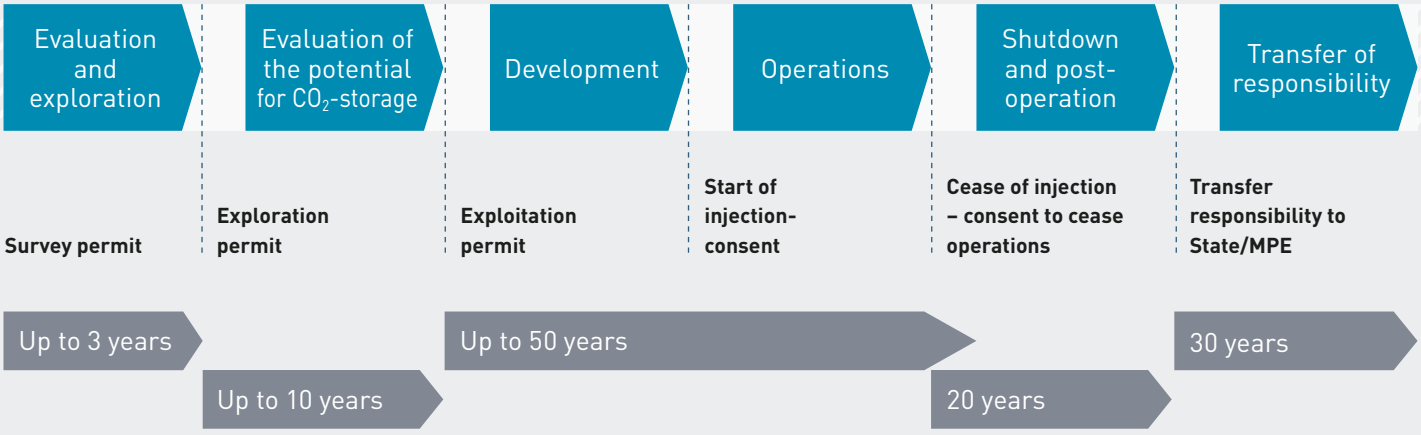


Figure 07: Timeline for CO_2 storage

The overall requirements can be loosely subdivided into three monitoring categories: containment assurance, conformance assurance and contingency monitoring in the event that the former two categories are not met. The risks of potential leakage points will be identified, and a number of elements are evaluated with regards to the three subcategories in a risk assessment. A general (but not exhaustive) table of elements are highlighted in Figure 08.

The Northern Lights – Storage Complex Monitoring Plan[53] describes the scope of Northern Lights monitoring for the Aurora CO_2 storage site to prevent and mitigate leakage risk exposures, and to ensure regulatory compliance with respect to storage of CO_2 in the subsurface strata according to the *Storage Regulations*[21] and the *Pollution Regulations*[22]. The plan was accepted by the Norwegian Environmental Agency and the Ministry of Petroleum and Energy as part of the process of obtaining the permit for injection and storage of CO_2 (Section 2.1.1).

The planned subsurface monitoring consists of in-well monitoring of pore pressure and temperature, and 3D seismic (active and passive) monitoring of the subsurface. The planned monitoring is tailored around conformant behaviour, with a second monitoring being triggered in case of non-conformance with a contemporaneous change in injection. The plan is based on an extensive risk analysis based on the site's unique geological characteristics and the best technological methods to meet the need for monitoring.

The monitoring plan will be updated based on data collected from the monitoring plan activities, and in any case every five years to take account of changes in the assessed risk of leakages, changes in the assessed risks to the environment, new scientific knowledge and improvements in the best available technology. If significant non-conformance between observed and predicted behaviour is detected, the 3D model will be calibrated/updated, and an updated plan will be re-submitted for approval.

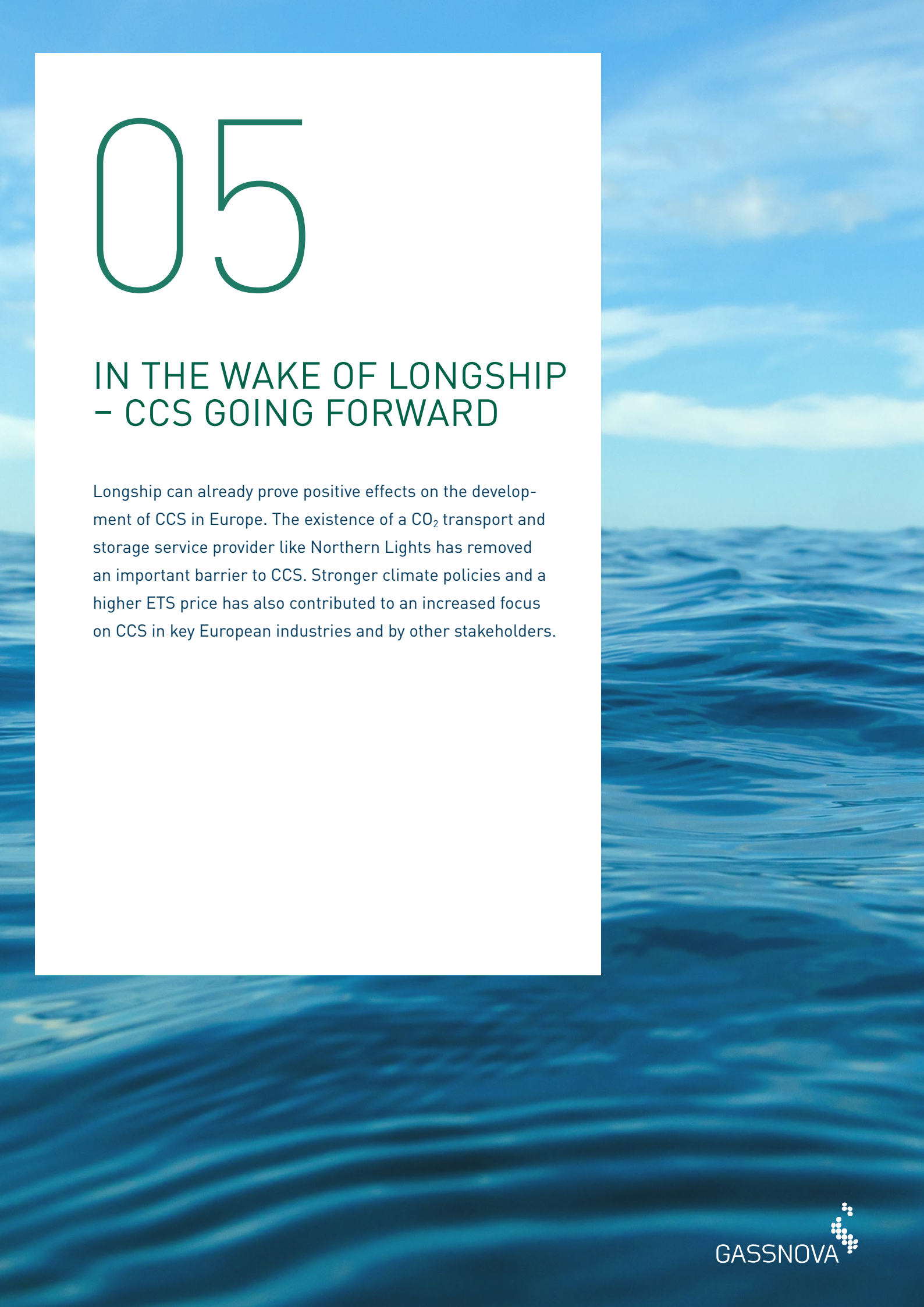
Figure 08: Key elements of a monitoring plan. (EU Commission Report, 2011)

53 Northern Lights – Storage Complex Monitoring Plan, 40 pp., 2020

05

IN THE WAKE OF LONGSHIP – CCS GOING FORWARD

Longship can already prove positive effects on the development of CCS in Europe. The existence of a CO_2 transport and storage service provider like Northern Lights has removed an important barrier to CCS. Stronger climate policies and a higher ETS price has also contributed to an increased focus on CCS in key European industries and by other stakeholders.



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Northern Lights has decided to conduct a study regarding expanding its capacity (phase 2) from 1.5 million tonnes of CO_2 per year to 5–7 million tonnes due to the strong demand experienced for CO_2 transport and storage services across Northern Europe. Phase 2 of Northern Lights is not governed by the state aid agreements but has the status of a Project of Common Interest[54] for Europe, and is described by the European Commission as "a commercial CO_2 cross-border transport connection project between several European capture initiatives (United Kingdom, Ireland, Belgium, the Netherlands, France, Sweden) and the transport of the captured CO_2 by ship to a storage site on the Norwegian continental shelf". Northern Lights has received CEF support for the FEED study of phase 2. Four of the potential customers of Northern Lights have received support from the Innovation Fund. There are other CO_2 transport and storage projects under development in Europe, but Northern Lights is a few years ahead of these other projects.

A prerequisite for Northern Lights closing agreements with customers abroad is bilateral agreements between the Norwegian Government and the government of the country of the emission sources. The Norwegian authorities have started informal consultations with a number of European countries. Memorandums of understanding on CCS collaboration have been signed with Belgium and the Netherlands.

HeidelbergCement has 10 CCS projects in the pipeline with a capture project at Slite, a factory on Gotland in Sweden, being one of the most mature. HeidelbergCement has said that they have built on and benefited from the experiences from Norcem and the Longship project while developing their CO_2 capture project on Gotland.

Interest in CCS in the waste to energy sector in Europe is also increasing.

A major driver for the increased focus on CCS in key European industries is the higher ETS price. The ETS price has risen to about 80 euros per tonne (June 2022) from about 20 euros per tonne when the investment decisions for Longship were made in 2020. The ETS price peaked at 97 euros before the invasion of Ukraine in February 2022. Stronger European climate policies are behind the rise in the ETS price. The large fluctuation in the EU ETS price over the last few months shows, however, the political risk related to the future price development of CO_2 emissions in the EU.

There has also been a development in the legal framework since Longship was approved and processes are ongoing. Revision of the *ETS Directive*, including a proposal of including all forms of transport of CO_2 for permanent storage in the ETS, is ongoing. At COP26 in Glasgow there was a change in the UN reporting regime making it possible to report CCS of sustainable biogenic CO_2 in line with CCS of CO_2 from fossil sources both to the EU and to the UN. The Norwegian Government has been working to clarify how the EU legislation, which has never been applied to a CCS project like Longship before, should be interpreted and this work will continue. More countries are ratifying the 2009 amendment to the *London Protocol*[14]. Norway is in the process of opening up more storage areas and will gain further experience with the *Storage Regulation*[21]. A change in regulations is proposed and processes are ongoing.

54 https://ec.europa.eu/energy/maps/pci_fiches/PciFiche_12.4.pdf

APPENDIX A

Table of permits and licences relevant to the storage development.

The table lists the different storage-related applications, consents, licences and permits[01]. The table is not exhaustive, but covers the major steps in the "permit-regime". The laws and regulations governing the different permits are listed in Section 2.1. Note that the listed applications and permits could be processed/approved simultaneously or in slightly different order than listed.

Permit	Regulation/law	Regulation holder	Responsible authority	Status permits in Longship project
Survey licence	Storage Regulations, Chapter 2	Storage operator	Ministry of Petroleum and Energy	Not applied in the Longship project
Exploration licence	Storage Regulations, Chapter 3	Storage operator	The King in Council	Not applied in the Longship project
Permit to drill exploration wells	Regulations relating to materials and documentation in connection with surveys for and utilisation of subsea reservoirs on the continental shelf to store CO_2, Section 15	Storage operator	Norwegian Petroleum Directorate	Drilling permit[02] (boreløyve) (29.11.2019)
Permit to drill investigation and injection well(s)	Pollution Control Act, Section 11 Management Regulations, Sections 25 and 26 CO_2 Safety Regulations, Section 12	Storage operator	Norwegian Environmental Agency, with consent from Petroleum Safety Authority	Drilling, Aurora field: Verification well (31/5-7, EOS): Permit, Norwegian Environmental Agency (25.09.2019) Consent from Petroleum Safety Authority [03] (12.09.2019) Well 31/5-A-7 AH and 31/5-C-1 H: Application from NL[04] (09.03.2022)
Exploitation licence for underground reservoirs for injection and storage of CO_2*	Storage Regulations, Chapter 4	Storage operator	The King in Council (Ministry of Petroleum and Energy)	Exploitation licence, EL001[05] (11.01.2019)
Consent to establish a CO_2 receiving facility	Regulations on the handling of flammable, reactive and pressurised substances and equipment used for this purpose, Section 17	Storage operator	Norwegian Directorate for Civil Protection (based on Environmental Impact Assessment)	Consent from Norwegian Directorate for Civil Protection[06] (15.04.2021)

01 The English translations of the laws and regulations use both permit and license for the Norwegian term "tillatelse". We have used the term that is used in the corresponding translation.

02 Boreløyve for brønn 31/5-7 i utnyttelsesløyve 001 - Oljedirektoratet (npd.no)

03 2019_1049-brv-equinor---samtykke-til-leteboring-av-co2-verifiseringsbronn.pdf (ptil.no)

04 Equinor søker om utslipp fra boring av CO_2-injeksjonsbrønner på Aurora i Nordsjøen og fra legging av kontrollkabel. - Miljødirektoratet (miljodirektoratet.no)

05 utnyttelsestillatelse-el-nr-1.pdf (npd.no)

06 samtykke-til-etablering-og-bygging-av-mottaksanlegg-for-karbondioksid-i-oygarden-kommune..pdf (dsb.no)

Permit	Regulation/law	Regulation holder	Responsible authority	Status permits in Longship project
Permit for CO_2 emissions	Greenhouse Gas Emission Trading Act, Section 5 (subject to the Pollution Control Act, Section 11)	Storage operator	Norwegian Environmental Agency	To be issued
Permit to discharge (chemicals) when preparing the pipeline to the storage site	Pollution Control Act, Section 11	Storage operator	Norwegian Environmental Agency	To be issued
Permit for injection and storage of CO_2	Pollution Control Regulations, Section 35-4 Storage Regulations, Section 5-2 Management Regulations, Sections 25 and 26 CO_2 Safety Regulations, Section 12	Storage operator	Norwegian Environmental Agency (consent from Ministry of Petroleum and Energy, (Norwegian Petroleum Directorate), Ministry of Labour and Social Affairs, and Petroleum Safety Authority), ESA	Storage operator will apply closer to the start of injection (end of 2022 according to plan)
Licence to install and operate facilities	Storage Regulations, Sections 4-5, 4-6, 6-1 and 6.2 CO_2 Safety Regulations, Section 11	Storage operator	Ministry of Petroleum and Energy, Petroleum Safety Authority	Plan to install and operate the transport, receiving- and storage facilities approved (PDO/PIO) by Ministry of Petroleum and Energy[07] (25.02.2021)
* This is not for the injection and storage, only for the right to exploit the reservoir, see Permit for injection and storage of CO_2,				

07 Northern Lights – godkjennelse av plan for utbygging, anlegg og drift (regjeringen.no)

Gassnova is a state-owned enterprise under the Norwegian Ministry of Petroleum and Energy.

Gassnova is established to promote technological development, competence building and cost-effective CCS solutions.

Gassnova SF
Dokkvegen 11
NO-3920 Porsgrunn
Norway

postmottak@gassnova.no
+47 400 05 908

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ccsnorway.com