BELLONA

Norway's Longship CCS project

October 2020

A Pioneering Project

In September 2020 the Norwegian Government proposed to the Norwegian Parliament that the go-ahead should be given to the Longship Carbon Capture and Storage (CCS) project. The project is planned to be operational by the end of 2024.

If adopted by the Parliament, the project will be a major step forward for decarbonising industry, as it will be the first time that CCS is applied at sites – in this case a cement factory and a waste incinerator - where there is currently no way other than CCS of largely eliminating emissions. Furthermore, the storage site can receive CO_2 from multiple emitters in Norway and elsewhere in Europe. The project thus has much wider significance as the first of many similar projects likely to be needed if CO_2 emissions reduction goals are to be met.

1. The Longship project

The Longship project will capture CO_2 from Norcem's cement factory in Brevik on the south coast and, subject to additional funding, from Fortum Oslo Varme's (FOV) waste to energy plant in the Oslo area. For these types of emitters there are no available alternatives to CCS for achieving such large reductions in emissions[1].

The captured CO_2 will be shipped to Norway's west coast, from where it will be permanently stored beneath the sea bed (see map).

The project will capture, transport and store 0.8 million tonnes per annum of carbon dioxide, approximately 0.4 million tonnes from each of the two sites[2]. The transport and storage part of the project, known as Northern Lights, is designed to take additional volumes in future from other capture projects in Norway and beyond. There will be potential to expand the amount stored to 1.5mtpa initially, with further expansion to 5.0mtpa possible in future.

The Northern Lights project is classified as a Project of Common Interest (PCI) under the EU's Trans-European Networks for Energy (TENE) programme.

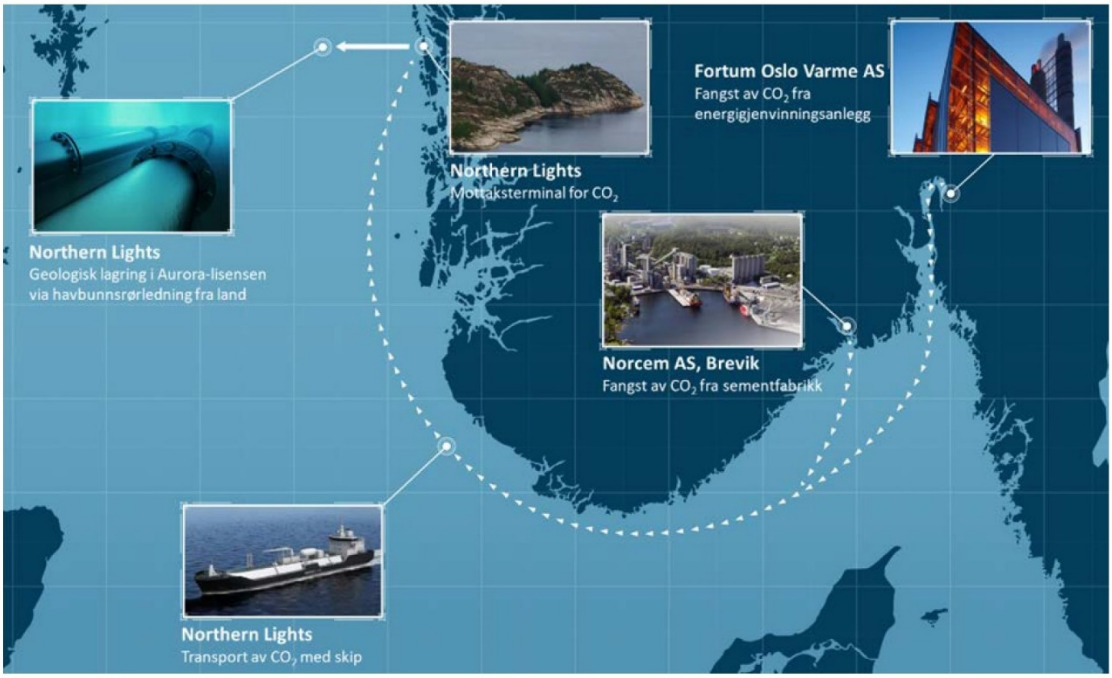

Figure 1: The Longship CCS project *(Source: Gassnova)*

[1] In addition to emissions from energy use, CO_2 emissions from Portland cement manufacture are produced by the basic chemical process of making cement. CCS is the only option for largely eliminating these emissions, although other measures such as improved energy efficiency can provide incremental emissions reductions. Waste incineration also lacks alternatives for eliminating CO_2. CCS leaves a small amount of residual emissions uncaptured – expected to be around 5% of the total going into the capture plant – but no other available approach can secure such deep cuts in emissions. In this case Norcem only seeks to put around half its total emissions through the capture process. This decision reflects project specific factors.

[2] Total CO_2 emissions from Norcem were approximately 0.8 mtpa in 2019 but only half of these are part of the capture project. See Norcem Brevik plant emissions data: https://www.norcem.no/no/materialregnskap_brevik.

2. Stages of the Longship CCS chain

Emissions at both sites are captured by absorbing the CO_2 from the exhaust gas into a solvent. The capture processes use amine-based technology. The absorbed CO_2 is then recovered from the solution in preparation for transport. The recovery process is made more energy efficient at both sites by the use of waste heat already available on site. Capture efficiency for the plants is expected to be around 95%.

The CO_2 is then cooled and pressurised and piped to ships. It is then transferred to the storage site from where it is injected into deep saline aquifers two or more kilometres under the bed of the North Sea. Storage in saline aquifers has been used successfully in the Norwegian North Sea and Barents Sea for many years for CO_2 captured from the Sleipner and Snohvit[3] natural gas projects.

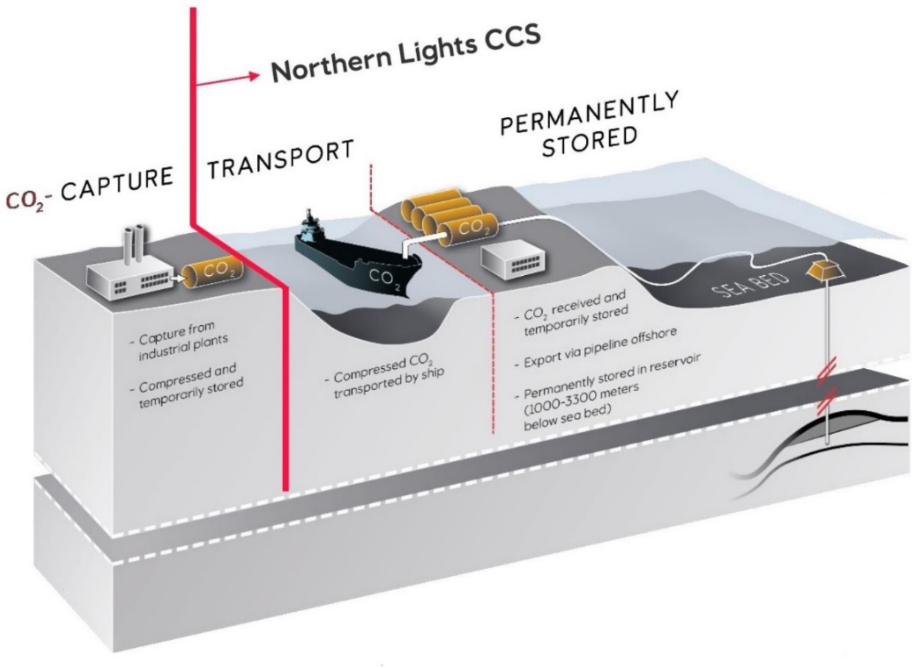

Figure 2: Longship Project Stages *(Source: Northern Lights)*

3. Project Commercial Structure

Different parts of the Longship project have different ownership and commercial structures. Among other things this allows flexibility for future developments. In particular it makes it easier for the Northern Lights part of the project to transport and store CO_2 from additional capture sites.

The Northern Lights part of the project is a joint venture between Equinor (formerly Statoil and StatoilHydro), Shell and Total. The joint venture will own and operate transport and storage.

[3] Sleipner began storing CO_2 in 1996, Snohvit in 2008.

Norcem, a subsidiary of Heidelberg Cement, owns the cement capture plant. Fortum and Oslo Municipality own 50% each of FOV.

There are no direct commercial contracts between the capture projects and Northern Lights. The Government acts as an intermediary between capture and transport and storage.

3.1 - The role of Norwegian Government funding

The Norwegian Government will pay around three quarters of the costs of the Northern Lights and Norcem parts of the project for the first 10 years.

The Norwegian Government is willing to provide this support because the project serves strategic objectives, contributing to the development of CCS in order to reach long term climate goals in Norway and EU cost effectively. As part of this, specific objectives are understood to include:

- Demonstrating CCS is feasible and safe
- Demonstrating CCS in industry
- Demonstrating the regulatory regime for CCS
- Reducing the costs and risks of subsequent projects
- Generating new industrial opportunities

Other than the indirect holding via Equinor the state has no share-holding in the project.

The project received State Aid clearance under European Economic Area (EEA) rules in July 2020.

3.2 - Allocation of financial risks[4]

The Norwegian State absorbs many of the financial risks of the project. The details are complex, and the description here is simplified seeking to capture the main principles.

- The State takes **risks of delay**. If either the capture or transport and storage parts of the project are delayed it will compensate the other party.
- The State also takes a large proportion of the **risk of cost over-run**. In broad terms, for capital costs it takes 80% of overrun costs for Northern Lights, and 83% for the capture plants. For operating costs over the first 10 years it takes 75% of the costs of any overrun at Northern Lights and also 75% for the capture plants. These payments are limited to the level at which there is estimated to be an 85 per cent probability that the costs will be below.
- If Northern Lights is profitable after future expansion then State will take a **share of the profits**, from 50% rising to 75% at defined thresholds, and sees reduced costs for volumes above 1.5 million tonnes per annum. Similar types of arrangement apply to the capture projects, with a reduction in operating cost grant over a certain rate of return. If the rate of return is above a higher threshold the state gets a 75% share of further net cash flow.
- The State also absorbs most of the **risk of leakage from storage**, but this is considered to be a low risk, based on experience from other projects.

[4] This is a summary only. Further details are given in the Government Proposal document.

- It also absorbs some **other risks**, for example for CO_2 not meeting the technical specifications required for storage.

When the project was announced, financing was fully in place for capture from Norcem and Northern Lights but not for capture from the FOV waste incinerator. The two first parts of the project will proceed in any case[5] . FOV has applied for co-funding from the EU's Innovation Fund.

3.3 - Longship Project Costs[6]

Total expected (P50) capital costs for the project (including both capture plants) are NOK 17 billion (£1.4 billion, €1.5 billion[7]). Over half of this is for Northern Lights. However the costs of Northern Lights reflect the transport and storage infrastructure being sized to accommodate additional volumes up to a total of 1.5 million tonnes p.a., with the pipeline to the storage reservoir able to transport up to 5 million tonnes p.a.. If these additional volumes are achieved, capital costs will be less for Northern Lights than for the capture projects per tonne of CO_2.

Total operating costs are NOK 820 million p.a. (£68 million p.a., €75 million p.a.) Again, the majority of this, NOK 479 million (£40 million p.a., €44 million p.a.), is in the Northern Lights part of the project. However, as with capital costs, operating costs for transport and storage will be lower than capture costs per tonne of CO_2 if Northern Lights succeeds in storing CO_2 from additional capture projects.

Total capex plus opex over the first 10 years of the project operation (including both capture plants) is estimated at NOK 25.1 billion (£2.1 billion, €2.3 billion).

3.4 – Estimated costs per tonne of CO_2

Estimated levelised costs per tonne of avoided CO_2 emissions over 25 years are shown in the chart at illustrative discount rates of 3.5% and 7%.[8] Costs are estimated as £150/tCO_2 (€165/tCO_2) at a 3.5% discount rate, and £190/tCO_2 (€208/tCO_2) at a 7% discount rate.

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[5] The waste incinerator will have to raise additional funding, but has received a government guarantee for a substantial share of the investment and operating costs.

[6] Cost data in this section is based on data in the project risk review by Atkins and Oslo Economics in June 2020. See table on page 8 of: https://www.regjeringen.no/contentassets/9f8d6e401b4e4f2e9d48645323aa26c0/kvalitetssikring-ks2-av-tiltak-for-demonstrasjon-av-fullskala-co2-handtering.pdf

[7] All costs are converted at rates of 12 Kroner/£ and €1.1/£.

[8] 3.5% may be appropriate for assessing a project with state funding. It is the figure recommended in the UK Government's Green Book on project appraisal. See https://www.gov.uk/government/publications/green-book-supplementary-guidance-discounting . Higher discount rates may be more in line with the returns a commercial company would seek for a project with a similar set of risks.

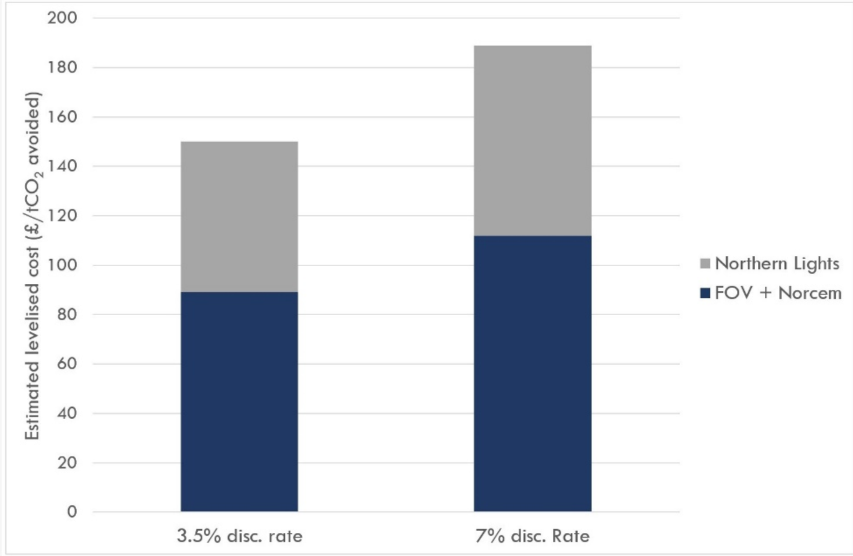

Figure 3: Costs per tonne of avoided emissions (£/tonne CO_2) *Source: Bellona estimates. Assumptions: 25 year cashflows based on plant design life. Northern Lights assumed to achieve full economies of scale from storing 1.5 million tonnes p.a.. In practice build-up of volumes is likely to be phased, and full economies of scale will only be achieved if there is an exactly counterbalancing phasing of expenditure, which may prove challenging.*

These estimates assume the full benefits of economies of scale as volumes stored by Northern Lights increase to 1.5 million tonnes p.a., including through phasing of expenditure. The economies of scale substantially reduce costs per tonne of CO_2 for Northern Lights. If these economies of scale cannot be realised costs per tonne of CO_2 will be higher. Conversely, if the storage is scaled up to 5 million tonnes p.a., costs per tonne of CO_2 will be lower.

The costs are per tonne of emissions avoided, taking into account the emissions from operation of the CCS chain. 0.04 tCO_2 are emitted from operations across the chain per tonne captured and stored, so 0.96 tCO_2 are avoided for every tonne captured and stored. This is a lower CO_2 footprint than most CCS projects. This is mainly due to the capture projects using waste heat or steam, and the Norwegian electricity mix being very low CO_2 intensity[9].

Costs per tonne of CO_2 are split between capture and transport and storage approximately 60:40, even allowing for economies of scale in storage. This is a larger proportion for transport and storage than is typically found in CCS projects. It may reflect a number of factors, including the use of ships rather than pipelines for transport, the depth at which CO_2 is being stored offshore, no use of existing pipelines or other infrastructure, and options for future expansion being built in.

The project is more expensive in total than other realised CCS projects, and other project estimates. There appear to be several reasons for this.

- The project is a first of a kind (FOAK). Future projects will benefit from learnings on this project.

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[9] An average value for the carbon efficiency for a number of projects in Europe is estimated to be around 85%. The two Norwegian value chains studied here have a higher carbon efficiency of approximately 95% and 90% for Norcem and FOV respectively. (Source: CCS Norway carbon footprint report https://ccsnorway.com/carbon-footprint/ .) Carbon efficiency is the inverse of CO2 footprint. These estimates include embodied emissions from construction. The cost calculations presented here include only emissions from operation for more direct comparability with a carbon price.

- Norway is a high cost location for construction and operation.

- In particular, storage costs are high as offshore Norway is an intrinsically high cost environment. This is especially so in this case as the top of the injection reservoir is 2850m below sea level. Water depth at the site is about 300m. It is much more expensive to drill and construct wells at these depths. Storage costs elsewhere, including the UK part of the North Sea, should be much lower.

- The transport and storage part of the project is all new build, rather than using or repurposing existing infrastructure.

- Storage costs include some costs to create the option of possible future expansion to 5mtpa.

Bellona recognises the importance of this project to CCS development in Europe, and will continue to monitor the project as it develops.

Note: This briefing paper has been produced by Bellona based on available information. It is not intended to represent the views of any of the parties to the project.

About Bellona

The Bellona Foundation is a multidisciplinary international environmental NGO based in Oslo, Norway since 1986. Our team consists of about 65 employees with diverse professional backgrounds in communication, engineering, ecology, economics, geosciences, law, physics, and political and social sciences.

Our solution-oriented approach to climate issues follows the evaluation of existing options, assessment of associated challenges and promotion of identified solutions. Supported by the breadth of knowledge and skills of our experts, Bellona follows a holistic, trans-sectoral approach to assess the economics, climate impacts and technical feasibility of possible climate options

We believe that the process of finding solutions to pollution from industries that are currently essential to our economy and the standard of living needs to involve them. Bellona has worked with CO_2 capture and storage since the early 1990s. Today, the organisation is most active at European Union level, in Norway, and in the United Kingdom. The activities include policy development, publications, and other forms of advocacy for industry decarbonisation.

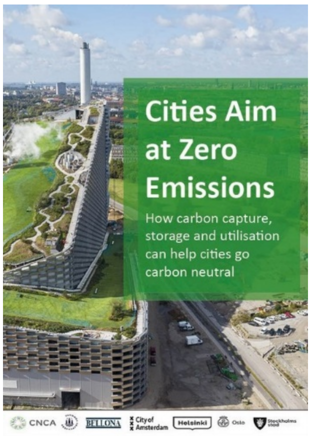
Bellona is engaged on several platforms where we aim to initiate discussion and fuel debate to identify the climate solutions we need. We work jointly with scientific institutions on several European research projects, and have close relationships with fellow climate NGOs across the globe.

Related Publications

Laying the Foundation for a Net Zero Society (June 2020)

In partnership with: Centre of Energy Policy at the University of Strathclyde (CEP)

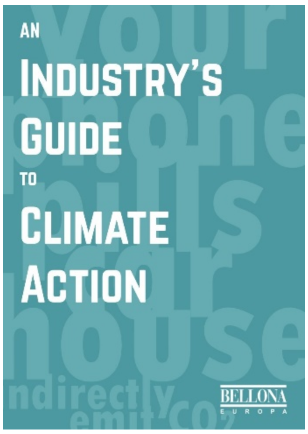
The paper conducts an analytical economic review of three net zero actions: enabling and progressing the realisation of residential energy efficiency gains the electric vehicles rollout, investing in carbon capture and storage capacity.



Cities Aim at Zero Emissions (January 2020)

In Partnership with Carbon Neutral Cities Alliance (CNCA), NIRAS and 5 Northern European capitals.

The report overviews the latest CCS and CCU technologies, the current progress made by the five cities, business models and viability analytics. The report shares recommendations for cities that want to engage with carbon capture technologies.



Industry Guide to Climate Action (November 2018)

The guide outlines how heavy industry and the regions that host them must take up their fair share of responsibilities in moving towards a low-carbon economy. The report highlights technologies, which already exist and are in development, possible to be deployed for industries to cut down on emissions whilst keeping their competitive advantage.

Further information

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