2020-IP24

Lessons from "Longship"
Norway's Full-Scale, Full-Chain CCS Project

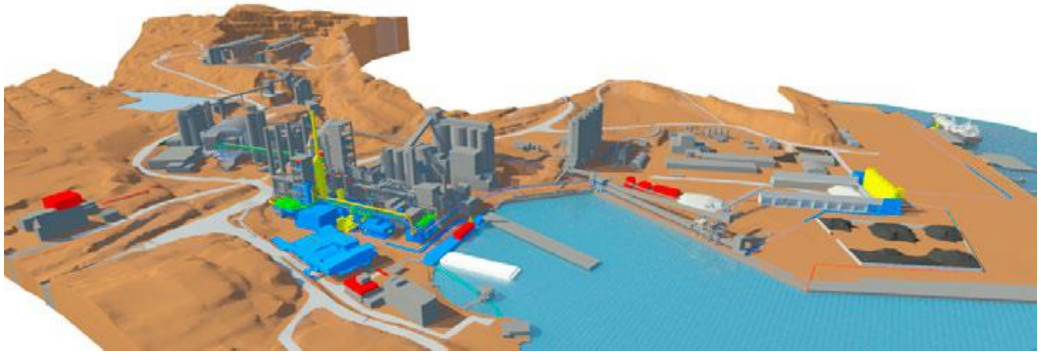
On 25 November, Gassnova[1] published its report, "Developing Longship: Key Lessons Learned". Presenting key learnings from the development of Norway's 'Longship' CCS project, it covers the six-year development period, from the pre-feasibility study in 2014 to the completed FEED studies and the industrial partners' final investment decisions (FID's) in 2020. Publication of the report followed submission on 21 September of a White Paper to the Norwegian Parliament proposing the project's launch, with Parliament approving the FID on 14 December 2020. Learnings presented in the report are primarily related to CCS-specific aspects of the project. With the intention of assisting those interested in developing CCS, the report focuses on central lessons learned rather than making firm recommendations.

With the Sleipner and Snøhvit projects, and the large-scale testing at Technology Centre Mongstad, Norway has long been the lead country in Europe for the development and demonstration of CCS. While the learnings presented in the report draw largely upon the FEED studies undertaken, they also draw upon experience from these initiatives and from experience built up by Gassnova in the development of CO_2 capture technology expertise.

Longship's CCS chain covers the capture of CO_2 from Norcem's[2] cement factory in Brevik and from Fortum Oslo Varme's waste-to-energy plant in Oslo. The captured CO_2 from these facilities will be shipped in liquid form to a CO_2 receiving terminal on the Norwegian west coast and, from there, transported by pipeline to an offshore storage location under the North Sea for permanent storage. The transport and storage part of the project is a collaboration between Equinor, Shell and Total called the "Northern Lights Project".

Norcem's Cement Factory

The Norcem Cement factory is located in Porsgrunn, in south-east Norway, producing 1.2 million tonnes of cement annually. It is located adjacent to a deep harbour that enables vessels up to 40,000 tonnes to load and unload.



Norcem's existing plant (shown in grey) and the planned capture facility (in other colours).
Source: Norcem AS

[1] Gassnova was established by the Norwegian authorities in 2005 to further the development of technologies and knowledge related to CCS and to serve as the adviser to the government on this issue. On behalf of the Norwegian government, Gassnova has coordinated the development of the Longship project.
[2] Since 1999, Norcem has been part of the HeidelbergCement Group.

Fortum Oslo Varme's waste-to-energy plant

The waste-to-energy plant is located in Klemetsrud and incinerates more than 400,000 tonnes of waste per year. The waste heat from the incineration is used to produce electricity, district heating and cooling to the city of Oslo. Fortum Oslo Varme received a conditional offer of funding from the Norwegian government provided that the project secures sufficient own funding as well as funding from the EU or other sources.

Fortum Oslo Varme's existing plant (shown in grey) and the planned capture facility (in other colours). Source: Fortum Oslo Varme AS

Northern Lights Project

The Northern Lights project comprises the transport and storage component of the Longship project. Liquified and pressurised CO_2 will be loaded from the capture sites to ships for transportation to the Northern Lights onshore receiving terminal located at the premises of CCB Kollsnes AS in the Naturgassparken industrial area near Bergen. At the terminal, CO_2 will be offloaded from the ships into onshore intermediate storage tanks. Buffering the CO_2 in onshore intermediate storage tanks allows for continuous transport of CO_2 by pipeline to the subsea well(s) for injection into a subsurface, geological storage complex. The project is governed by a collaboration agreement between Equinor, Shell and Total.

Northern Lights' planned CO_2 receiving terminal.
Source: Equinor ASA

More detail on the each of the facilities comprising the Longship project are presented in the FEED study reports from Gassnova and the industrial partners.

- Norcem's FEED report
- Fortum Oslo Varme's FEED report
- Northern Lights Project

While many of the technical solutions applied in Longship are in operation elsewhere, they are put together in this project for the first time as a complete CCS chain. When underway, the project will deliver:

- First-of-a-kind capture of CO_2 at scale from cement and waste-to-energy plants;
- A scalable transport and storage infrastructure, ready for use by other emission sources;
- The application of European and Norwegian CCS regulations, with the potential for cross-border transport and storage of CO_2 of particular note.

Although the project has been developed under circumstances that are unique for Norway, many of the experiences gained are universal, relevant to the setup and development of CCS projects wherever the location. Gassnova summarises the key learnings as:

1. Developing a CCS chain with CO_2 capture, transport by ship and geological storage is technically feasible and safe, but commercially challenging;
2. Until recently, the London Protocol had presented a barrier to cross-border transport and storage of CO_2 offshore. However, in 2019 the parties to the London Protocol[3] agreed on a resolution allowing export of CO_2 for the purpose of storage offshore (see IEAGHG Information Paper 2020-IP22)Aside from this, no regulatory showstoppers had been identified to date;
3. It has been possible to develop the CCS chain with limited use of new technology. Amine technologies are used to capture the CO_2.
4. Although there are few comparable CCS chains worldwide, experienced and competent contractors and suppliers can be mobilised and the technical know-how is readily and widely available.
5. As expected for a first-of-its-kind CCS project, the net cost per tonne for capture, transport and storage is high. To capture 800,000 tonnes CO_2 per year, the cost has been estimated at around NOK 1,280/tonne ($145/tonne); this is expected to decrease substantially with full utilisation of the transport and storage facilities.
6. To perform the detailed engineering and to construct the transport and storage facilities based on ships and a greenfield CO_2 receiving terminal takes around 36 months. A capture plant retrofitted onto an existing industrial plant will take up to 42 months.
7. Upon approval by the Parliament, Norcem and Northern Lights will each enter an agreement with the government, which will provide state aid towards the construction and the first ten years of operation of the CCS-facilities. Reflecting the balance between risks and opportunities in these agreements, the state will bear approximately 84% and 73% of the expected cost of Norcem's and Northern Lights' projects, respectively. The government is ready to cover 40% of Fortum Oslo Varme's cost provided they are able to secure supplementary funding from third parties.

The Longship project provides a notable example of successful planning and cooperation between the many stakeholders in this complex undertaking. Apart from the principals and partners in the component capture, transport and storage projects, the roles of the Norwegian government and

[3] IEAGHG has long been involved in the London Protocol and was involved in the negotiations for this export resolution. See also IEAGHG Information Papers 2013-IP26, 2014-IP19, 2019-IP11.

Gassnova were pivotal. Gassnova administered the public funds to the industrial partners, coordinated the overall project schedule and managed the cross-chain risks and functionality. The Ministry of Petroleum and Energy has led negotiations with each industrial partner on the terms for the state aid for the construction and operation of the CCS-facilities.

That this project enables and encourages more CO_2 capture plant to be built across Northern Europe, interest in which has been clearly demonstrated by the number of MoUs already agreed (see IEAGHG blog of 6 September 2019), is warmly welcomed by IEAGHG. IEAGHG is also proud to count Norway (represented on its Executive Committee by Gassnova and the Research Council of Norway), Equinor, Shell and Total in its membership. Their constructive engagement in IEAGHG actively benefits all members in gaining continued learning from the Longship project throughout its lifespan.

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