CARBON CAPTURE & STORAGE

Norway pioneers CO_2 capture projects

Norway aims to develop the world's first storage facility capable of receiving CO_2 from a variety of industrial sources. *Brian Davis* reports

One has only to look at the recent exploits of Extinction Rebellion in London to see that climate change is a big issue. Carbon dioxide (CO_2) emissions continue to rise and there is serious concern among scientists, NGOs and other parties that the 1.5°C target of the Paris Agreement could be exceeded if carbon emissions continue at their current rate. According to the International Energy Agency (IEA), the world must capture and store 6bn t/y of CO_2 from 2050 if we are to achieve UN climate targets... and we are well behind schedule.

Carbon capture and storage (CCS) is an important technology for decarbonising fossil fuels – although not the only one given potential changes in lifestyle, electrification of transport, etc. However, CCS is the only technology that can achieve significant reduction in CO_2 emissions from industrial processes, such as steel and cement production.

Equinor operates some of the largest CCS projects worldwide, capturing and storing over 20mn tonnes of CO_2 at the Sleipner and Snøhvit fields on the Norwegian Continental Shelf (NCS) for over 20 years, to assist enhanced oil recovery. Although CCS technology is proven, developing viable commercial frameworks in order to stimulate the extensive roll-out necessary to reach ambitious climate targets is very challenging.

The Norwegian government is currently evaluating a full CCS value chain that can, through public-private partnerships, seek to demonstrate a commercial framework.

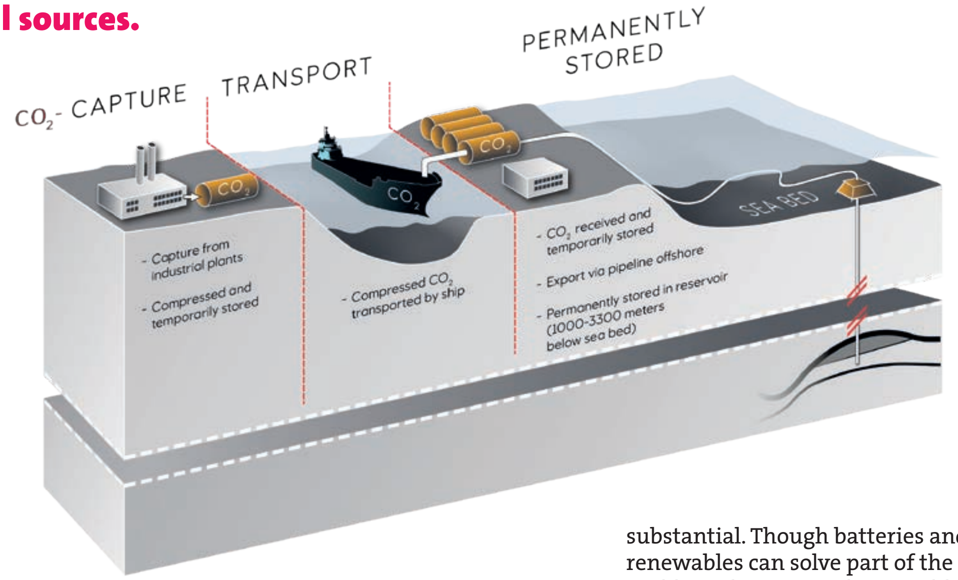
Northern Lights

Equinor, together with Shell and Total, has been awarded development of the world's first CO_2 storage site designed to receive CO_2 from various industrial users. The Northern Lights project will take CO_2 from up to three industrial facilities in eastern Norway and transport it by ship to a receiving terminal located at the Kollsnes premises in Øygarden, outside Bergen on the west coast of Norway. Here, CO_2 will be pumped from ships to tanks onshore, then sent via subsea pipeline to injection wells east of the Troll field on the NCS. The liquefied CO_2 will be stored permanently up to 2,000 metres below the seabed.

Equinor claims the reservoir has sufficient CO_2 capacity to accommodate significant additional volumes and could help other emitters across Europe realise their first CCS projects.

In June 2017, state-owned Gassnova awarded Statoil (now Equinor) the contract for the first phase of the CCS project on the NCS with partners Shell and Total. The first phase could reach a capacity of 1.5mn t/y CO_2 storage.

In a Masterclass at the recent energy:connected conference near Oslo, Norway, Equinor Project Director Sverre Overå explained the opportunities and challenges of the Northern Lights project. 'CCS needs to start now and escalate quickly into something that is substantial. Though batteries and renewables can solve part of the problem, there are industries, like steel and cement, that don't have the luxury of going down the renewables path. Nevertheless, CCS can do things that reduce their emissions,' he said.



The first phase of the Northern Lights CCS project could store up to 1.5mn t/y of CO_2

Photo: Equinor

He also cited the opportunity for hydrogen as a future zero emission fuel, when CO_2 is extracted from natural gas. In fact, Equinor, Vattenfall and Gasunie are currently evaluating possible conversion of Vattenfall's gas power plant at Magnum, in the Netherlands, into a hydrogen-powered facility.

As mentioned, CCS is not new – CO_2 has been extracted from the gas stream at Sleipner since 1996, liquefied and stored in a depleted natural gas reservoir 2,600 metres below the seabed. Subsequently, CO_2 has been extracted using amine technology and stored at Snøhvit since 2008, motivated by the Norwegian government's CO_2 tax exemption. The Norwegian CO_2 tax applies to about 80% of greenhouse gas emissions (GHG) in the country.

Plans to build a full-scale CCS plant at Mongstad were abandoned in 2013, because it was too complex and costly. But the Technology Centre Mongstad (TCM) has become the world's largest CCS test centre, undertaking research for major companies globally, like Fluor.

Overå admitted there have been some concerns about the safety of CO_2 storage projects. Some landlocked countries like Germany are negative about CO_2 injection and storage. Meanwhile, others such as Canada have no such reservations about storing liquefied CO_2 below ground, confident that it binds itself to the rock formations over time.

Norway holds approximately half the potential offshore storage for CO_2 in Europe. The Norwegian Petroleum Directorate has mapped the storage opportunities on the NCS. However, with the exception of Sleipner and Snøhvit, these opportunities have yet to be proven.

Political will

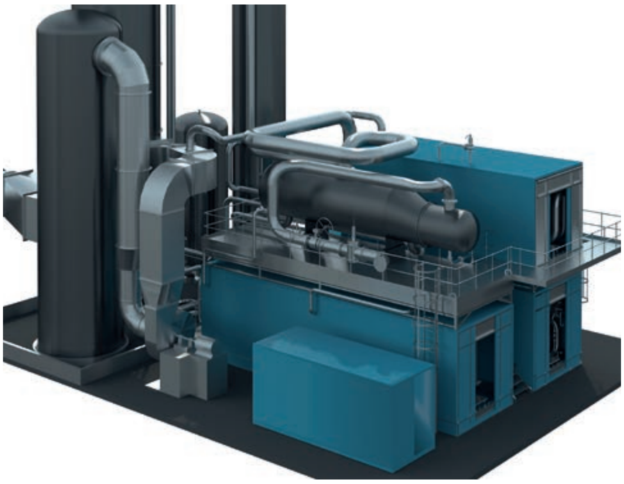
Despite the Mongstad CCS cancellation, the Norwegian government still has the political will to encourage use of CCS as a climate mitigation tool. Gassnova, a state enterprise, is cooperating closely with industry players to develop CCS projects. Concept studies have been completed at the Norcem cement plant in Brevik and Fortum Oslo Varme waste-to-energy plant in Oslo, and front-end engineering design (FEED) is underway.

A final investment decision (FID) by the Norwegian government is anticipated this year. Total cost of capture, transport and storage over a five-year period is estimated to be NKr11.8bn (£1.06bn). A third option for carbon capture at Yara's ammonia plant in Porsgrunn was considered uncommercial for the time being.

The Norwegian government aims to have either the Norcem CCS plant or Oslo waste-to-management CCS plant operational by 2022. The Norcem plant will have a capacity of about 400,000 t/y of CO_2.

On a smaller scale, Aker Solutions is to deliver a low cost, modular carbon capture and liquefaction system, called Just Catch, to capture emissions at Twence's waste-to-energy plant in Hengelo, in the Netherlands. The Just Catch system and liquefaction plant has a capacity of 100,000 t/y and is planned to be in operation by 2021. The company claims there are 20 European prospects for Just Catch in 50,000t/y and 100,000t/y versions.

Aker Solutions was recently awarded a contract for subsea infrastructure for the early CO_2 injection well for the Northern Lights Norwegian Demo Project. According to Oscar Graff, Head of Aker Solutions' CCS initiatives: 'We are the only company that covers the whole CCS value chain, from carbon capture technology and CO_2 liquefaction to pipeline transport and offshore installations.'



Aker Solutions' Just Catch low cost, modular carbon capture and liquefaction system at Twence's waste-to-energy plant in Hengelo, in the Netherlands, will have a capacity of 100,000 t/y and is planned to be in operation by 2021

Photo: Aker Solutions

No comparison – oil and gas development vs CCS

'In the normal oil and gas project, the resources are known and we have a well-established framework and market for hydrocarbons,' said Overå. 'But carbon capture is a different matter altogether, that requires optimising unknown components and incremental technology development.'

Overå maintained that carbon capture projects don't have a business case – if there was, somebody would have done it long ago. There is little or no market for CO_2. The few that exist are variable and not driving CCS development. However, CO_2 is plentiful – there's too much of it. The storage potential is massive, but it's not being utilised.'

He reiterated: 'It's very difficult to suggest a business case for CCS and the regulatory framework is untested. We don't have a market or customers for the product. So it's a bit different from the normal oil and gas project.'

Equinor has been awarded an exploitation permit (EL001) for CO_2 storage, covering a huge area. It's empty as far as hydrocarbons are concerned. 'In order to drill, it needs serious investment – and money only comes with potential for future revenue,' remarked Overå. What's more, liquefied CO_2 pipelines require stringent planning and building permits, as it has never been done before.

The Norwegian carbon tax is encouraging CCS development, but the lack of a business case is a serious barrier. 'Fortunately, the Northern Lights proposal is scaleable and could become a reality with significant state assistance. At scale, unit costs could be driven down. But the abundance of CO_2 means you need large capacity to get unit costs down. The infrastructure will also be costly, but given sufficient customers Europe-wide, the cost could be spread over time and become more manageable. We are looking at point sources of CO_2 in Europe and the Baltic, as a way for them to stay in business in a low carbon future,' said Overå.

> ***'Carbon capture projects don't have a business case – if there was, somebody would have done it long ago.'***
>
> **Sverre Overå, Project Director, Equinor**

Facility perspective

The CO_2 capture sites will vary, depending on the industry. As a newbuild, with liquefaction and intermediate storage, plants could be industrialised and mass produced. The ships could also be standardised over time. The concept phase of Northern Lights is complete. But transport of CO_2 could be tricky as it must remain in the liquid phase and avoid becoming dry ice, which requires cold transport at carefully managed pressure.

The location of the receiving terminal at Kollsnes was selected because it offered a safe harbour year round and a feasible pipeline route offshore. The terminal will be highly automated. The CO_2 pipeline will be equipped with a subsea injection point at the end of the line. However, 'nobody has yet determined how to commission it,' remarked Overå.

He emphasised: 'There is no pot of gold at the end of this project. So, there is no reason to spend more money than we need to. A first well is being planned to determine the state of the ground below, and will also serve as an injection well. For this to be a permanent well, it will also need a subsea structure. But there are no plans for a full subsea template because of the cost… and the possibility it couldn't be used. If successful, the well also needs to be extendable, in order to create a daisy chain [of wells] from this single flow template. We need a robust sandstone formation with good injectivity, well-sealed to avoid CO_2 migration upwards and closely monitored.'

Control is also an expensive item, as it would be prohibitively costly to run a control umbilical from onshore. Therefore, control is likely to come via power and fibreoptic lines from the Øsberg platform.

Despite the challenges, the Norwegian parliament is expected to make a positive investment decision this year. ●