A new offshore CO_2 storage site in Norway

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Norway is a leading country for carbon capture and storage (CCS) and the Ministry of Petroleum and Energy has set an ambitious new goal for a further pioneering project to be up and running by 2022.

Two storage sites are already operating off the coast of Norway at the Sleipner and Snøhvit fields, re-injecting 'fossil' CO_2 that comes to the surface mixed with natural gas. Statoil operates these fields in partnership with a number of other oil and gas companies including ExxonMobil (Sleipner) and Total (Snøhvit). The economic incentive for doing so is Norway's offshore CO_2 emissions tax that imposes a penalty of approximately 50 USD per tonne of CO_2 emitted to the atmosphere.

The new Norwegian project is designed to tackle the issue of man-made emissions of greenhouse gases head-on by disposing of CO_2 waste streams generated by industrial sources such as cement manufacturing, ammonia production or the incineration of household waste. In these cases the CO_2 must be separated from a waste gas stream and prevented from entering the atmosphere. The process of separation is often referred to as carbon capture and the new project intends to transport the resulting volumes of CO_2 in a compressed liquid state to offshore injection wells using a combination of ship transport and subsea pipeline from a ship receiving terminal on the west coast. Exactly which industrial sources will eventually be included in the project still remains to be seen.

This technical concept represents the recommendation from a feasibility study that the government commissioned in 2016, and the basis for the conceptual design phase that will begin in 2017. Front End Engineering and Design (FEED) is scheduled to commence in 2018.

The feasibility study was managed by Gassnova, in partnership with a number of companies that expressed an interest in participating in the new CCS project. These companies studied the technical requirements of such a system, how it could be integrated with their existing infrastructure and came up with a +/- 40% cost estimate for the CAPEX and OPEX requirement according to standards laid down by AACE International (Association for the Advancement of Cost Engineering). The following studies were included in the process:

- Capture of CO_2 from cement production by Norcem AS in Brevik;
- Capture of CO_2 from ammonia production by Yara Norge AS in Porsgrunn;
- Capture of CO_2 from household waste incineration by the municipality of Oslo;
- Transport of CO_2 by tanker ship to the west coast by Gassco;
- Storage of CO_2 in offshore geological formations by Statoil ASA.

Gassco is a Norwegian state owned enterprise that operates the natural gas transport network to the rest of Europe and is a sister organization to Gassnova under the jurisdiction of the Ministry of Petroleum and Energy.

The results of the feasibility study are available online in English from the Gassnova website.

Three potential areas for CO_2 storage were examined on the Norwegian continental shelf and the feasibility study made a clear recommendation to proceed with the area they termed Smeaheia, east of the giant Troll field and sharing similar reservoir properties. A depth map for the top of the Sognefjord Formation reservoir interval is shown below with the shaded outline of the Troll field on the left of the figure.

The Alpha and Beta structural closures are within the Smeaheia area of interest, which represents a rotated fault block within the Viking Graben rift system, in the north-eastern part of the Horda Platform. The rift system was initiated during the Permian period and created a number of half-grabens that contain Triassic and Jurassic sedimentary infill.

The Jurassic sequence of sediments consists of a number of predominantly sandstone units including Sognefjord Formation, Fensfjord Formation, and Krossfjord Formation, interbedded with the locally more silty Heather B and Heather C formations. The Sognefjord Formation varies in depth from approximately 900 – 1300m in the area of interest and is a coastal to shallow marine deposit with porosities up to 30% and Darcy level permeability. Additional storage volumes may also be present in the underlying Fensfjord, Krossfjord and Lunde formations.

The reservoir interval in the area of interest is overlain by the Draupne Formation that forms a regional seal consisting of marine, organic rich claystones with its sealing capacity verified at Troll. Porosity ranges from 9% - 18% and vertical permeability is in the order of 6 nano-Darcy. The Lower Cretaceous Cromer Knoll Group and the Nordland Group of sediments form the overburden above Draupne and contain a number of highly effective secondary seals.

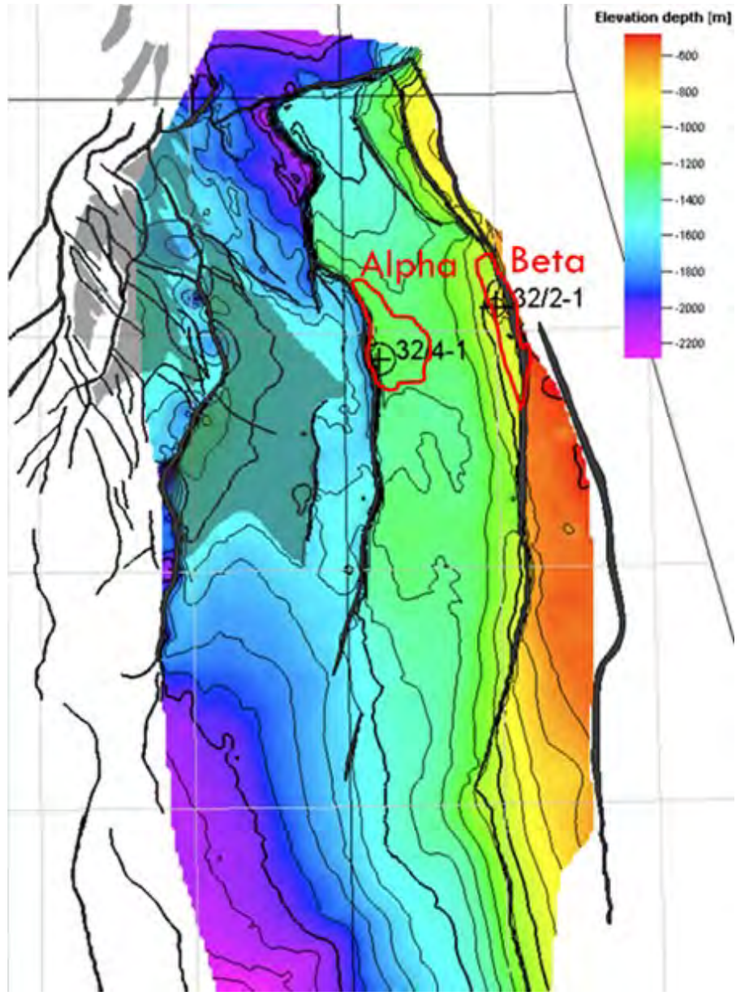
The Smeaheia fault block has been the subject of historical oil and gas exploration and enjoys extensive seismic coverage and good well control. No hydrocarbon reserves exist in the area however, as evidenced by the dry exploration wells in the Alpha and Beta structural highs. Despite this lack of hyrdrocarbons, the Smeaheia area is affected by the regional pressure drop caused by reservoir draw-down at Troll and neighboring fields. The Norwegian Petroleum Directorate monitors this pressure effect and anticipates that it is sufficiently large to more than offset any potential pressure increase caused by large scale CO_2 injection.

The conceptual design phase that will begin in 2017 will examine the Alpha and Beta structural traps in more detail and may expand the area of investigation to include other topographic high points in the Sognefjord Formation. This work will be carried out in a manner that is consistent with the new international standard for CO_2 storage sites, ISO 27914, as well as being compliant with Norwegian CCS legislation. This legislation was introduced in 2014 by way of implementing the EU Storage Directive and represents a modified form of Norway's petroleum legislation..

How much CO_2 can be stored in the current area of interest? Almost certainly more than the volumes discussed in the feasibility study, and potentially enough to be able to accept significant volumes from other emission sources in Norway and elsewhere in Europe. The total storage capacity will depend on the number and size of structural traps that can be exploited, the magnitude of regional pressure depletion from hydrocarbon production and the number of injection wells that one is prepared to invest in.

What will the storage site be called? Smeaheia was a working title that was used during the feasibility study and the Norwegian Petroleum Directorate will assign an official field name during 2017. Watch this space.

What happens next? The conceptual design phase is scheduled to begin in 2017 in order to meet the government's ambition of starting CO_2 injection in 2022. The government however has made it clear that it is private industry that will build, own and operate the project – with incentives and investment provided from public funds. That investment will be significant and will require a commitment from the Norwegian parliament before construction can begin. Fortunately, CCS in Norway does attract support from across the political spectrum.



The area of interest for geological storage of CO_2, including structural closures Alpha and Beta. The colours represent depth (m) to Top Sognefjord Formation, which is the main reservoir unit. The outline of Troll field is shown on the left and the horizontal distance between the wells in the Alpha and Beta structures is 15 km.