IEAGHG Information Paper 2016-IP56: Feasibility Study for Full Scale CCS in Norway

At the 51st meeting of the IEAGHG Executive Committee held in Switzerland, Members were informed that an English version of the Feasibility Study for full scale CCS in Norway would be published. The English version is now available and can be found at:
http://www.gassnova.no/en/Documents/Feasibilitystudy_fullscale_CCS_Norway_2016.pdf

The summary taken from this report is given in the below for reference.

Summary

1.1 Introduction

This is an unofficial English version of the report "Feasibility study for full-scale CCS in Norway".
In case of deviations between the Norwegian and English versions, the Norwegian version prevails.

In the Sundvolden Political platform, the Government states that it will "invest on a broad front to develop cost-effective technology for carbon capture and storage (CCS) and seek to build at least one full-scale carbon capture demonstration plant by 2020". The Government's CCS strategy was presented in Proposition 1 S to the Storting (2014-2015). The strategy covers a wide range of activities, including the assessment of potential full-scale CCS projects in Norway.

Gassnova's pre-feasibility "Study report on potential full-scale CCS projects in Norway" from May 2015 identified several emission sources and storage sites that may be technically feasible for a CCS project. It also identified industrial players that could be interested in participating in further studies. In the autumn of 2015, the Government decided to continue this work and initiated a feasibility study.

The Ministry of Petroleum and Energy (MPE) has had overall responsibility for the feasibility study. Gassnova SF has been project coordinator and responsible for the CO_2 capture and storage components of the study, while Gassco AS has been responsible for the CO_2 transport component.

Three companies have studied the feasibility of CO_2 capture at their industrial facilities. Norcem AS has assessed the feasibility of capturing CO_2 from the flue gas at its cement factory in Brevik; Yara Norge AS has assessed CO_2 capture from three different emission points at its ammonia plant at Herøya in Porsgrunn; the Waste-to-Energy Agency in Oslo municipality (EGE) has assessed CO_2 capture from the energy recovery plant at Klemetsrud (Klemetsrudanlegget AS). Gassco has carried out a ship transport study with assistance from Larvik Shipping AS and Knutsen OAS Shipping AS.

Statoil ASA has assessed the feasibility CO_2 geological storage at three different sites on the Norwegian Continental Shelf.

The aim of this feasibility study was to identify at least one technically feasible CCS chain (capture, transport and storage) with corresponding cost estimates and this has been achieved.

The results of this study demonstrate that a flexible CCS chain is feasible that makes use of CO_2 transport by ship from multiple sources to a single storage hub. That would mean the initial investment in CO_2 infrastructure can benefit several CO_2 capture projects.

1.2 Technical feasibility and costs

CO_2 capture is technically feasible at all three emission locations. Given the project's objective, both Statoil and Gassnova consider a solution with an onshore facility and a pipeline to "Smeaheia" as the best solution for CO_2 storage. The "Smeaheia" area is located east of the "Troll" field, approximately 50 km from the coast. This solution has the lowest implementation risk, large storage capacity and it is relatively easy to increase the capacity of the infrastructure. Developing a CO_2 storage site is possible in many different ways, but other solutions than with an onshore facility will entail a higher technical risk.

Ship transport of CO_2 between locations for capture and storage has been assessed for three different pressure and temperature conditions. Gassco considers the solutions for all three studied transport conditions (low-pressure, medium-pressure and high-pressure) as technically feasible.

The cost for planning and investment for such a chain is estimated to be between 7.2 and 12.6 billion kroner (excluding VAT). *Note at current exchange rates this equates to a cost of $846m and $1.512 billion).* The planning and investment cost will depend on how much CO_2 will be captured, where it will be captured from, and how many transport ships are needed.

Operational costs vary between approximately 350 and 890 million kroner per annum for the different alternatives. *Note at current exchange rates this equates to a cost of $42m and $106.8m).* The cost estimates are based on the reports from the industrial players and have an uncertainty of +/- 40% or better.

1.3 Assessments of benefit

In order for a full-scale project to gain a socio-economic benefit, it must contribute to the reduction of barriers and costs for the next CCS projects. In parallel with the feasibility study, the Ministry of Petroleum and Energy (MPE) has carried out a Concept Evaluation, which seeks to answer whether full-scale CCS is socio-economically profitable. The Concept Evaluation sets requirements for a project in order to achieve these effects. The following aspects from the Concept Evaluation form the basis for evaluating the benefit from a CCS project:

- Achieve knowledge that can be shared across countries and sectors.
- Provide a storage solution with sufficient capacity for economy of scale.
- Demonstrate that CCS is a safe and effective climate measure.
- Contribute to improvements of the market situation for CCS.

The assessment of benefits shows that all alternatives will contribute to significantly reducing barriers and costs for subsequent CCS projects. This is in particular valid for alternatives which establish and qualify storage sites and other infrastructure with capacity to store excess amounts of CO_2.

Important learning will be achieved through realisation of one of the alternatives; construction and operation of CO_2 capture facilities integrated with existing industry facilities, regulation of CCS chains, the establishment of a business model for capture, transport and storage, updated cost estimates and the further development of capture technology.

For CO_2 storage, an onshore facility will be well suited to provide economy of scale in the sense that it has capacity to receive volumes that are higher than are needed from an initial demonstration plant. If investing in more than one capture project, CCS will prove even to a greater extent that it is a safe

and effective climate measure. This is because of lower risk of lack of CO_2 for the chain, and because cost per unit CO_2 reduced will be lowered with increasing CO_2 volumes in the chain.

All alternatives can contribute to improvements of the CCS market situation, and reinforced if capture from several CO_2 sources is realised. Stimulation of the market for CCS is important to achieve further technology development and cost reductions for other future projects.

1.4 Framework conditions and incentive structure

The State's (Norwegian) starting point is a split of costs and risk between the Norwegian State and the industry players that participate in the project. During the feasibility study phase, the State has informally explored possible incentives and principles for sharing costs and risk in the development and operating phase.

Norwegian State support for a first CCS project will be a combination of several elements. State support rules prohibit covering more than the cost related to CCS. A combination of support for investment and operations could be a solution. Important parameters such as required rate of return, discount period, and length of state support period will also have to be determined before making an investment decision. An overarching objective of the State's effort to establish framework conditions and incentives for an initial CCS project is directed at the State and the industry players achieving maximum concurrence in the incentives for building and operating a cost effective CCS chain.

1.5 Next phase – the concept and FEED phase

The next phase will be used to optimise concepts for the identification of the best-suited solution for a CCS chain, clarify technical requirements in the chain, and develop a technical and commercial basis for an investment decision. Preparing for the construction phase is also part of the task. This work is necessary to provide a sufficient basis for an investment decision for both the State and the industry players.

According to the feasibility study report, the next step in the project should be a combined concept and Front End Engineering and Design (FEED) phase, which could be announced in the autumn of 2016 as a competitive tender process. Signed contracts for the concept and FEED phase could be obtained in the first quarter 2017 and the work finished early in the autumn of 2018. This work will form the basis for the State's quality assurance and decision processes for an investment decision (Decision Gate 3), a decision that can be taken, according to this plan, in the spring of 2019. If so, a full-scale CCS project can have its start-up in 2022. The industry players will have to make their own investment decisions, therefore they should carry out these studies according to their own project execution models and procedures.

Based on the result from the feasibility study, Gassnova recommends that several of the industry players should get the opportunity to continue to study CO_2 capture in the next phase. More participants will enhance competition and thereby contribute to assuring cost effective solutions in the project. Further assessment of multiple emission sources also reduces the risk of no completed project should one or more of the CO_2 emission sources failing to provide CO_2.

Gassnova will be responsible for managing the project through the concept and FEED phase. Gassco will be responsible for work related to transport. The Ministry of Petroleum and Energy will have overall responsibility for the development of framework conditions and incentives.

Before announcing the concept and FEED phase, a decision must be made as to how many players will receive support for the concept and FEED phase and, if relevant, at what point this selection should be made. Before commencing the concept and FEED phase, the overall design basis for the CCS chain, pressure and temperature conditions for ship transport and development solution for the CO_2 storage site must be clarified. These issues will have to be thoroughly discussed with the industry players, and decisions should be based on what is optimal and will give the best balance of cost and benefit for the total chain.

The CCS-project is subject to external quality assurance under the Norwegian state's quality assurance process for large public investments (the "KS scheme"). The quality assurance process includes two stages, KS1 and KS2, where KS1 is currently ongoing and expected to be complete by 31 August 2016. KS2 will need to be completed before any final investment decision by the Storting - the Norwegian parliament.

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