

## Summary - Status on the full-chain CCS demonstration project in Norway

The Norwegian Government wants to contribute to a cost effective technology for CO<sub>2</sub> capture, transport and storage (CCS). The Government's ambition is to realize a cost effective solution for CCS in Norway, provided this results in technology development internationally. Both the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA) point to CCS as a necessary option to reduce global greenhouse gas emissions in line with the climate goals of the Paris agreement at the lowest possible costs.

In the years to come, the climate challenge demands a great effort which will have to be met within a tighter scope in the budgets. Considerable resources are prioritized for climate options in the budgets. A decision to contribute to financing investment in and operation of a full-chain CCS project has to be weighed against other climate measures. The Government has to choose effective measures that maximize the mitigation and minimize the costs.

In the Ministry of Petroleum and Energy's budget proposition for 2018, the Government announced that a comprehensive presentation to the parliament (Stortinget) on the status of the work on realizing the ambition of a full-chain CCS demonstration project was forthcoming. This was followed by an assessment of the economic viability, costs, contributions from the industrial participants and incentives for cost reductions, the State's costs and risks, as well as the co-benefits from a demonstration project, including the potential for cost reductions and technology dissemination to projects internationally.

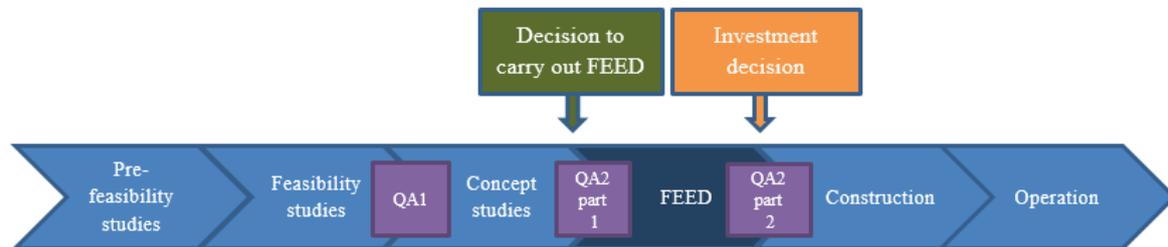
Two external quality assurers<sup>1</sup>, Atkins and Oslo Economics, have considered costs, benefits and the economic viability. The quality assurance of the choice of concept (QA1) report was presented in the autumn 2016. In this report, the external quality assurers refer to the Intergovernmental Panel on Climate Change identifying CCS as one of many necessary mitigation options needed to reach the two degree target. Nevertheless, few facilities are currently planned, as the CO<sub>2</sub> emitters are not faced with a sufficiently high price on their emissions and therefore do not have strong incentives to invest in new technologies for emission reductions. The learning from a demonstration facility can contribute to mitigating future technology costs. However, the extent of other developers following and utilizing the knowledge gained is uncertain. Therefore, proceeding with a full-scale demonstration facility was not recommended until the project could demonstrate probable co-benefits. The quality assurers indicate that more work needed to be done in the following areas: securing sustainable financing for CCS through international mechanisms and cooperation; and how to obtain the intended learning and cost reductions.

The full-chain CCS demonstration project has progressed through pre-feasibility studies, feasibility studies and concept studies. The project has become more mature and the plans more detailed for each phase. The maturation process for the demonstration project is illustrated in the figure below. The Front End Engineering and Design (FEED) phase is usually the last phase giving necessary information for an investment decision. Both the

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<sup>1</sup> More information on the Norwegian scheme for quality assurance of major public investments (the QA scheme) may be found here: <https://www.ntnu.edu/web/concept/qa-scheme1>

Government and the companies involved in the project will make investment decisions based on the results of the FEED phase and the external quality assurance (QA2 part 2). Should the investment be carried out, the project will enter construction and then the operations phase.



The concept studies for CO<sub>2</sub> capture and transport were completed in the autumn 2017 and did not reveal any project showstoppers. The CO<sub>2</sub> storage concept studies will be completed in the fall 2018. The Ministry of Petroleum and Energy, Gassnova SF and the industrial actors have worked on realizing co-benefits from the project as part of the concept studies. This work has accommodated enlarging the co-benefits from the project and safeguarding that possible later projects can make use of knowledge and cost reductions from the demonstration project.

In the spring 2018, in connection with this comprehensive presentation, the external quality assurer has updated the cost estimates and uncertainties, and assessed the plans for the realization of co-benefits in the project. This is part 1 of QA2 for the project. According to the external quality assurer the economic viability has decreased since QA1, mainly because of increased cost estimate. The external quality assurer holds that the recommendations from the previous report have been handled well and the plan for realizing co-benefits from the project is on the right level for the project phase. In order for the project to become economically viable, the demonstrational effect has to contribute substantially to accelerating CCS. As a result of the work carried out so far, the probability for this has increased somewhat but there is still considerable uncertainty if this project will lead to the realization of subsequent projects. According to the external quality assurer substantial state aid is expected to be necessary for coming projects for a long time. Whether FEED will be carried out for the whole chain will now have to be considered. During FEED, uncertainties still unsettled in the concept phase will be clarified, the cost estimates will have a lower uncertainty range, and the project will be able to find solutions for different technical challenges revealed during the concept studies and their quality assurance.

Of the three evaluated CO<sub>2</sub> capture projects, Norcem has the best features for a successful implementation. The external quality assurance concludes that Norcem's project also has the best potential for realizing co-benefits. Norcem has demonstrated executions abilities and low costs per ton CO<sub>2</sub> captured compared to the other two capture projects. Norcem is committed to sharing knowledge gained in the project, and can do so both within the Heidelberg group and in the cement industry. This is an important aspect, as the cement industry is a significant contributor to global greenhouse gas emissions. The Government

suggests providing funds to Norcem for continued planning of their CO<sub>2</sub> capture project, entering into FEED.

The Government does not recommend continued studies on CO<sub>2</sub> capture at Yara's ammonia plant at Herøya in Porsgrunn. Yara does not have as strong a commercial motivation as the other participants to prioritize CO<sub>2</sub> capture at its facility. The processed gas alternative has the lowest total cost and would have a high likelihood for success if realized. Nevertheless, it has a low learning potential in terms of optimization and upscaling and is therefore considered weaker than Norcem. Yara has informed the Ministry of Petroleum and Energy of uncertainties regarding the production at the ammonia plant. Yara is also considering changing the feed gas to LNG. This will reduce Yara's CO<sub>2</sub> emissions, as well as the volumes available for CO<sub>2</sub> capture. A decision of whether to change the feed gas to LNG, will be taken by the end of 2018. This timeline is incompatible with the timeline in the demonstration project.

Fortum Oslo Varme has greater implementation risks compared to the other two capture projects. These are related to, inter alia, the length of the pipeline, public perception of having amine emissions close to a city and the project management experience in the organisation. Further, cost estimates are considerably higher, compared to the other two. This was revealed in the concept studies and the external quality assurance process. Taking this into account, Fortum Oslo Varme's original proposal would not be competitive with the other alternatives. High costs and high implementation risks increase the risk of undermining the demonstrational effect, and could deter potential subsequent projects. These are factors weighing against proposing further studies at their plant. However, after the QA2 part 1 was finalised, Fortum Oslo Varme has provided updated information concerning costs and risks to the Ministry of Petroleum and Energy. Before the Government can consider further support to Fortum Oslo Varme's project, this updated information must be evaluated by the external quality assurer. This process has been initiated. Based on the external quality assurance, the Government will decide if it will offer further support to Fortum Oslo Varme's project.

FEED studies are a necessary step towards a potential investment decision. The Government is now proposing funds for FEED studies of CO<sub>2</sub> transport and storage, as well as up to two CO<sub>2</sub> capture projects in 2018.

There is still uncertainty regarding some elements in the project that are essential for an investment decision. Further maturation of the project is therefore necessary. Throughout the FEED-phase, project risk will be reduced and the possibilities for realisation of co-benefits will be further clarified. In parallel with the FEED-studies, the Government's risks and funding will be clarified.

When FEED and the external quality assurance process (QA2, part 2) is completed, the Government will consider whether the demonstration project should be realized. The Government will present its assessment to Stortinget.

At the time of the investment decision, the following aspects will be important:

- Results from FEED, including costs, risks, learning effect vs. resources spent and whether a CCS project in Norway will be an efficient contribution to global efforts against climate change.
- How demanding it is within the budget constraints to finance the project without considerable support from other sources.
- Equivalent public funding for other climate mitigating options could provide larger emission reductions.