Investigation of optimal infrastructure options for CO_2

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Keywords CO_2 transport, CO_2 value chain

Introduction

This paper is analyzing options for cost efficient transport solutions for the CO_2-emissions sources in the Skagerrak and Kattegat region (i.e. Eastern Norway, Western Sweden and Northern Denmark). The work is part of a larger project investigating all aspects of implementing CCS in the region; hence both capture options for the point sources as well as possible storage sites in the region are investigated in addition to legal aspects of CCS.

This work is partly financed through Interreg/KASK and public funding from Sweden and Norway, and partly by industry and Gassnova – the Norwegian state enterprise for carbon capture and storage. Current industry partners are: Preem AB, Vattenfall, Borealis, Göteborg Energi, Skagerak Kraft, Yara Norway, Esso Norway and Statoil. In addition to Gassnova, public funding is from Swedish Energy Agency, Telemark County, Vestfold County, Gothenburg Region and Innovation Norway. Research partners are Chalmers Technical University in Gothenburg, University of Gothenburg, University of Oslo, Telemark University College, Sintef and Tel-Tek.

The major point sources in the region (both industrial sources and power plants) are located within a small area as shown in the figure below. All the main sources are located within a radius of about 150 km and the total emissions of CO_2 in the region is about 13 $MtCO_2/a$. The short distance between the sources and the potential storage site makes the region well suited for cost efficient transport of CO_2. However, the initial cost estimated of pipelines and ship alternatives show that the transport costs are a significant part of the overall cost of CCS.

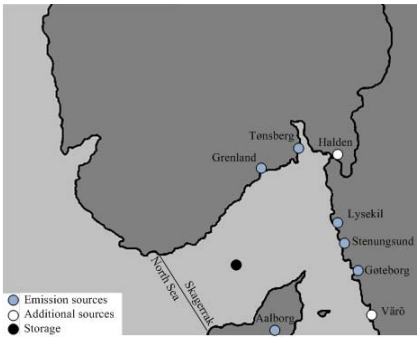

Figure 1 Map showing the locations of the point sources and the potential storage site in the region.

Transport cases
Transport solution cases in the Skagerrak/Kattegat region that will be cost estimated are as follows;

Case 1: All of the emissions sources in the region are connected in a pipeline network for transport to permanent storage in Skagerrak. First steps have been taken in order to identify possible pipeline routes and an optimal solution will be proposed. It is assumed that the pipeline network will have 100% utilization of pipelines from day one of operation.

Case 2: Ship transport is considered for all of the sources in the region. It is foreseen that emission sources that lie close to each other geographically will share a ship. An optimal onshore hub location will be investigated; the alternatives are the Grenland region and Grimstad in Norway, Stenungsund in Sweden and Hanstholm in Denmark. A pipeline will transport CO_2 from the hub to permanent storage in Skagerrak. Offshore unloading directly at permanent storage will also be considered.

Case 3: Transport to permanent storage form emission sources will either be by pipeline or a combination of ship and pipeline. A central pipeline network based on CO_2 emission sources in the Grenland region in Norway, Gothenburg and Värö in Sweden and Aalborg in Denmark. Ship transport from smaller single source locations in Norway and Sweden. One ship of suitable size is foreseen to serve all sources. The ship will unload at an onshore hub with pipeline transport to permanent storage in Skagerrak. The hub location is foreseen to be in the Grenland Region in Norway.

Case 4: The case is based on Case 1, but an increased amount of CO_2 will be considered for the pipeline network. Large CO_2 emission sources are located outside of the Skagerrak/Kattegat region and could be included in the pipeline network. The cost of this will be evaluated against Case 1 to highlight the effect of a higher capacity pipeline network.

Sensitivity analysis will be performed on the cases. Important variables are pipeline utilization and CO_2 volumes.

Results
The preliminary cost estimations show that pipelines are more expensive than ships and a combination of ships and pipelines are the most cost efficient transport option for the region as shown in the table below:

	CAPEX(€)	OPEX (€)	Cost (€/tCO2)
Case 1	2500	10,4	15,5
Case 2	1020	86,3	12,0
Case 3	1520	36,3	11,5

The transport alternatives will be further analyzing during spring 2011 and results will be available in due time before the conference in June.