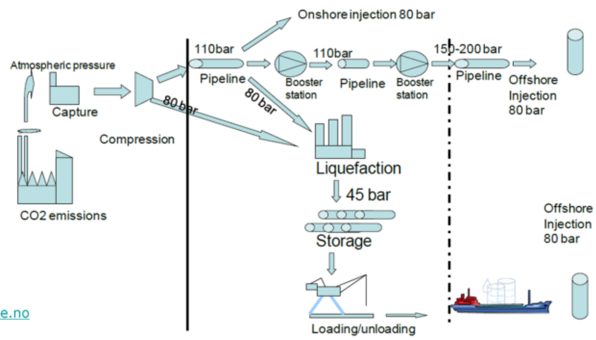
Pre-study on transportation and storage
Costs and concepts



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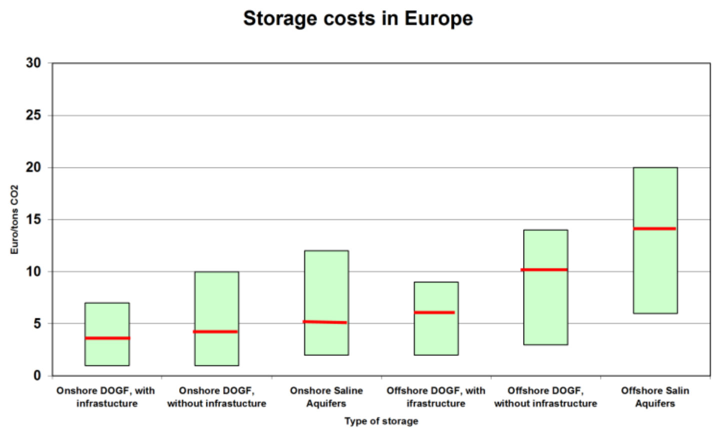
Yesterday we presented the challenges arising from the sources and sink structure in the BASREC region. Today we will look into cost structures in storage and transportation operations. As can be seen from the above figure key cost elements after the capture plant are the cost of compression for pipeline transportation, costs of pipelines and booster station, then storage costs comprising injection equipment and operations. Pipeline costs can be divided into construction costs and materials.

Costs varies according to the complexity of the routing, mountainous rock beds are fare more costly than flat land soil bed routing. Offshore is as a rule of thumb 40% more expensive than land routing, but is not necessarily true in the Baltic Sea and Skagerrak.

Cost estimation is time consuming and expensive and must be done in true time. They will be fluctuating inter alia with business cycles. Construction and material costs almost tripled in the boom years 2004- 2008. Never the less we will try to give some insight to the cost structures.

The report was prepared by Halfdan Wiig from INSA, Lise Siverts from Kvale Advokatfirma DA and Reidar Kierulf from IPAN.

Storage costs



Source: ZEP, INSA

+ «backyard» cost

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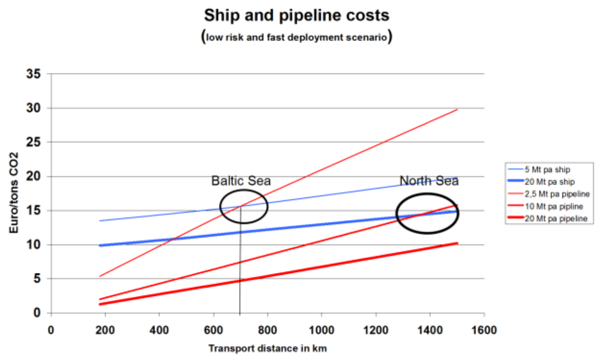
Cost of storage varies considerably. Typically offshore storage is more expensive than onshore, Salin Aquifers more expensive than depleted oil and gas field, and large capacity sites are less expensive than sites with limited capacity. Injectivity and possibilities for using existing infrastructure on hydrocarbon depleted fields are as well important factors.

As can be seen from the above chart (source Zero Emissions Platform), costs varies considerably within each category and storage costs may vary between 2 and 20 Euro/tons.

Transportation solution

- Considerable economics of scale
- Ship freight for small volumes long distance
- Combinations in ramp up periods



Sources: ZEP, INSA, etc

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Economics of scale is an important factor in planning the development of efficient CO_2 transportation solutions. This is in particular evident for pipeline transportation. It costs about 3 times as much to transport in a 2,5 Mt CO_2 pr. year as in a 20 Mt/year capacity pipeline. Such an increase in transported volume means a reduction from 15 to 5 Euro/tons for a typical Baltic Sea solution for the region.

Ship transportation is typically more cost effective for small volumes and long distance transportation.

Combinations between ship transportation and pipeline transportation may be favorable in the so called ramp up period to full capacity utilization. Ships can then be used until sufficient volumes are developed to utilize large pipelines.

Transportation solution

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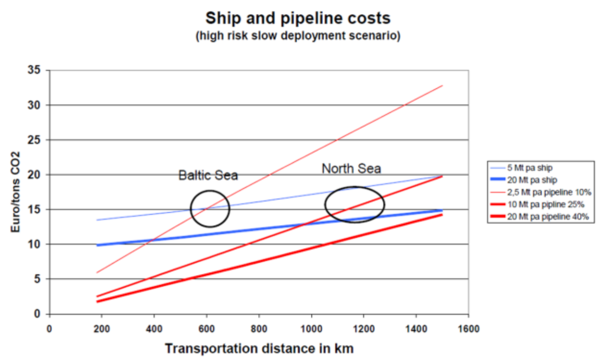
- Ship freight for small volumes long distance
- Combinations in ramp up periods



Sources: ZEP, INSA, etc

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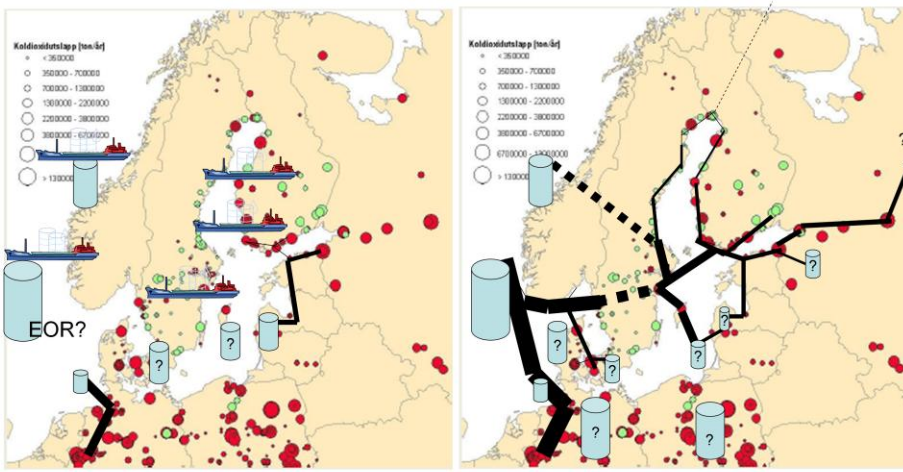
Possible concepts



Source: INSA, Chalmers (sources maps)

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Possible solutions in the early and mature phase of transportation and storage development is highlighted in the above chart. In the early phase it is assumed that shipment of CO_2 from larger plants located along the cost of Sweden and Finland to enhanced oil recovery (EOR) projects in the North Sea will be economically viable. The value of CO_2 in EOR may cancel out the extra transportation costs.

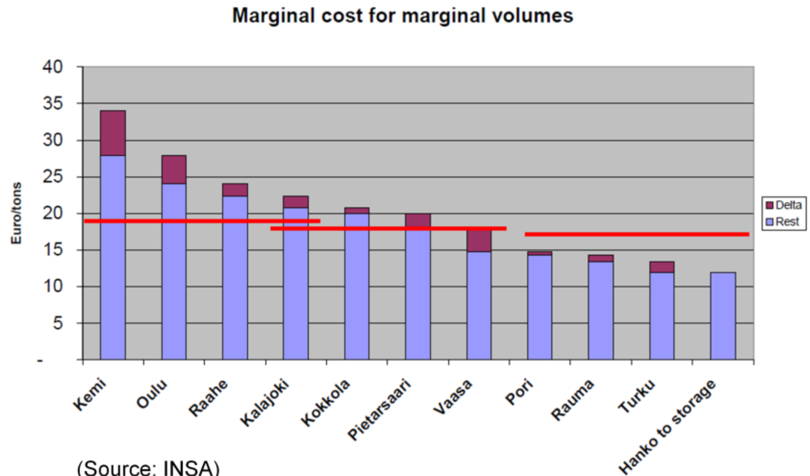
If Germany does not allow for onshore storage, large scale transportation from the Ruhr area to offshore storage in their North Sea sector may be possible.

Sources from south Finland and Estonia may be transported in pipelines co-routed with gas pipelines and stored in sites in Latvia. This route may later be extended to the Baltic Sea. The solutions with preliminary cost figures are discussed in the report.

In the above chart it is assumed that Poland will allow for onshore transportation and will hence not have the same need for transboundary solutions.

Future development of a transportation and storage system will inter alia hinge on the actual storage capacity, public and political acceptance and costs in Poland, Germany, Denmark, as well as the actual costs and capacities of storage in the Baltic Sea. Storage opportunities in Russia will as well be important for system development. A common pipeline system between Sweden, Finland and Estonia may constitute a nucleus with high real option value since connection with large scale trunk- lines to the North Sea, Norwegian Sea, Russia, and/or the Baltic Sea may be possible.

Trunk and feed line costs



(Source: INSA)

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Cost assessments

	Geocapacity	Indicativ	
Captured volume	10,7		Mt pa
Transportation distance	800		km
Cost of CO2 avoided	37		Euro/tons
Transportation cost	5,3	8,5	Euro/tons
Storage cost	3	5,4	Euro/tons

Source: Alla Shogenova, ZEP, INSA

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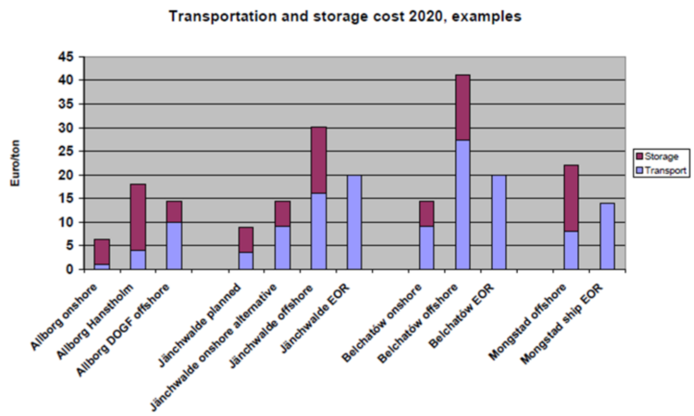
Estonia and Latvia have earlier made a study of a possible projects capturing 10,7 Mtpa of CO_2 from Estonian plants , which is transported onshore co-routed with gas pipelines and stored in Latvia. The transportation and storage costs estimated for the projects were low and lower than the cost estimated by using the ZEP study and the INSA calculation tool. This can be explained by low costs of developing the depleted oil and gas fields, co-routing with gas pipelines, the surge in construction costs since the first study was made and possible lower than average construction costs in Estonia and Latvia.

The above example illustrated the need for more detailed feasibility studies, pre-engineering and cost estimates before final decisions on transportation and storage projects can be made. Such studies will normally be time and resource consuming.

Cost assessments



Source. INSA

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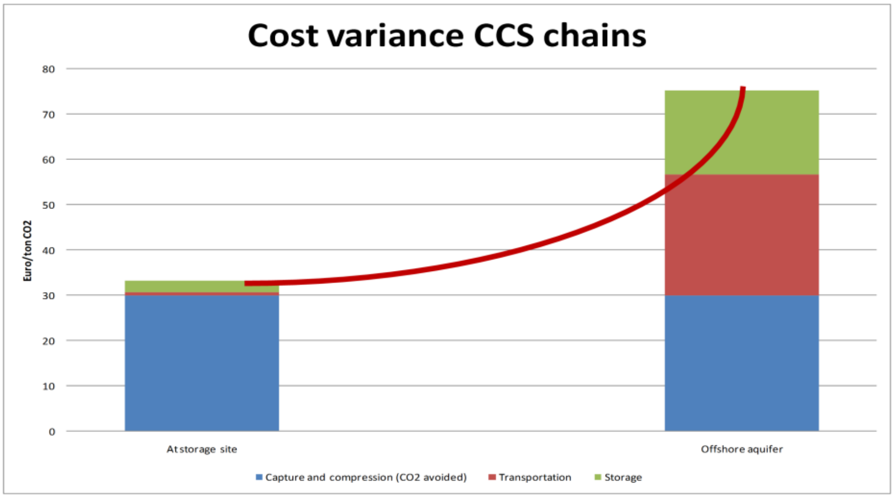
The above chart represents simplified calculations of transportation and storage costs in some potential short term CCS projects. The chart shows the costs of different singel purpose solutions for full scale demonstration projects. As can be seen the cost increases for long distance offshore solutions may be very high and may easily cause proposed demonstration projects to be stopped. The chart illustrates as well the costs of transportation to possible EOR projects. In these cases possible willingness to pay for secure deliveries on site is not accounted for. Possible combinations of CCS demonstration projects and EOR projects should be scrutinized further in connection with assessments of concrete projects.

Significance of cost efficiency



Source: INSA

The above chart shows the large variance in transportation and storage costs, and illustrates the benefit of a cost effective development. The two bars illustrates possible low end and high end projects in the cost curve.

Plants close to low cost storage such as depleted onshore oil and gas reservoirs may face very low costs as illustrated by the left bar (cost for capture, transportation respectively by different colours). Suitable EOR projects may even offer considerable negative storage cost. Transportation from an inland source in a single purpose pipeline to the coast for further transportation by ship to an offshore saline aquifer may represent a high cost example (right bar).

The large cost variances makes it important to implement projects on the basis of their merit order in a marginal cost curve, both on and offshore in order to reduce total costs of CCS projects.

Market based systems will tend to sort out the most cost effective projects for implementation. But the frameworks must be developed in order to foster efficient solutions.

Challenges in developing cost effective transportation and storage system

- CCS is riddled with political risks
  - Climate policies
  - Regional storage opposition
  - Transportation permits
  - Costs
  - Markets
  - Technology
- The need for planning and coordination in order to reach cost effective joint solutions
- Long lead times for developing large scale joint storage and transportation systems.

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Planning and investing in capture, transportation and storage is currently a high risk prospect due to several layers of uncertainty. The political risk seems to be the most important.

Uncertainties regarding development in acceptance of onshore storage may represent a “catch 22” problem. Offshore storage will probably not be developed due to the risk of ending up with stranded investments, while large scale onshore storage will not be developed before experience from offshore storage has been gained.

The risks involved runs counter to the need of planning and coordination to reach cost effective joint solutions. The EU commission has made a very good foundation for national implementation. We think several governments have a job to do in order to improve their frameworks.

Recommendations
(continued from former presentation)

- Establish coherent stimulation of the whole CCS chain.
- Contribute to business participation and efficient organization of CO2 transportation and storage. Establish independent storage and transportation companies capable of long term system planning.
- Incentivizing CCS chain development by creating licenses/property rights and possible improved support and market systems.
- Intensify negotiations of transboundary agreements, regulating joint and transnational transportation and storage issues.
- In this way BASREC countries will help pave the way for an efficient roll out of CCS in due time for reaching the climate targets.
- The recommendation is based on the view that availability of storage sites is potentially a major constraint to the rapid and widespread deployment of CCS.

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Organizing transportation and establishing licenses/property rights for transportation and storage are two key issues. Establishment of storage concessions incentivizes development and supply of storage services. In the CCS Directive, a concession system for storage is envisaged. Such system will create a formal framework for privileges and duties of the concessionaire. In addition, it may create the incentives for development of different storage opportunities. It may be necessary to reinforce a concession system by a support system. This will mobilize resources for storage site development, establish better knowledge of costs and capacity of storage in the region and provide a more efficient supply of storage services. In theory, expected higher and firm prices on emissions may provide sufficient incentives for the required storage development. But such relations are weakened by the high level of uncertainty and considerable lead time in development of storage and transportation.

The development of shared CO2 transport networks will generate efficiency benefits on a system level, but the costs and benefits of such networks will go well beyond the interests and budgets of individual CCS projects. Consequently infrastructure companies able to execute long term system planning, like in the natural gas and electricity business, should be developed. Governments may need to play a role in fostering such