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Lessons Learned From Development Of The First Norwegian CSS Project

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Summary

Gassnova is working to establish what could become Europe's first industrial CCS project. The project will demonstrate that carbon capture, transport and storage (abbreviated to CCS) is possible and safe to implement. A full-scale CCS project can provide lessons and experiences that new CCS projects can take advantage of. In this abstract we present some experiences from the maturation of storage sites on the NCS.

Introduction

More than 10 Years of regional mapping and detailed investigations show that the Norwegian continental shelf (NCS) holds numerous areas where it is possible to realize safe long-term storage of CO_2 (Halland *et al*. 2011). Mapping areas of possible storage concepts has been part of the Norwegian authorities' efforts to develop full-scale carbon capture and storage in Norway.

There are challenges going from early exploration for storage sites towards "bankable storage potential", such as;

- Area conflicts with active petroleum exploration
- Data-(un)availability in poorly explored areas
- Legacy wells in explored areas
- Reduction in project risk during stage-gate projects /" the devil in the details"
- Investment costs vs capacity

Development history

The search for a storage location on NCS has been going on since 2007 and started with feasibility CCS projects related to two gas fired power plants (Kårstø and Mongstad). Focus was on the Utsira Formation, (tested in the Sleipner project), and the Jurassic\Triassic sandstones in vicinity of the giant Troll gas field, (the Johansen Formation). Abandoned/ late lifetime gas fields have also been investigated (the Heimdal field and the Frigg fields). The Utsira Formation was thoroughly investigated but was not chosen since both legacy wells and insufficiently sized structural closure in non-licensed areas. In the abandoned gas fields there are risk related to old legacy wells but also challenges related to lifetime of infrastructure. During the last 4-5 years the main focus has thus been on aquifers in the area surrounding the Troll Field.
Both the Smeaheia storage site (Figure 1)) and the Johansen storage sites (now named Aurora by the Northern Lights consortium) are situated in this same geological province offshore western Norway (Figure 1). Both storage sites underwent detailed studies by Gassnova in the periode 2008 to 2014. Work were however temporarily stopped following the cancellation of the Mongstad project in 2014.

In 2014, Gassnova began a Full-scale pre-feasibility study of several storing sites. This lead to a feasibility study where Gassnova and Equinor pointed towards three different storage opportunities. The feasibility study (DG1) recommended the Smeaheia storage site with Sognefjord Formation sandstone as the primary target. The Smeaheia site is a fault-block structure in close vicinity of the Troll East gas field, approximately 50 km from the coast. The main advantages being close vicinity to shore, proven reservoir, shallow depth and no area conflict with petroleum industries.

Gassnova awarded Equinor the contract for the first phase of the Full-scale storage project. At the same time Norske Shell and Total E&P Norge entered the project as equal partners, forming the Northern Lights consortium. When the storage concept study started, new seismic date became available (CGG17M01). The new seismic date gave revealed new problems. As a result of this the Smeaheia storage site was concluded not to have been mature enough to pass a DG2 decision. The problems identified were: 1) Wedging and erosion of overburden units, making challenges for depth conversion and potentially reducing the secondary sealing and storage; 2) The primary storage unit juxtaposed fractured basement across the Øygarden Fault Zone, making the eastern part of the structure not suitable due to leakage risk both across and along the Øygarden fault zone; and 3) Several relay-ramps were detected, which could enable pressure draw-down in the primary storage formation due to Troll East depletion.

Following the downgrading of the Smeaheia region, the well-studied Johansen Formation was reestablished as the preferred storage site. Through extensive studies of seismic data and geological modelling it has earlier been concluded that the Johansen Formation in quadrant 31, SW of the Troll Field, is a potentially good storage formation, possibly also capable of storing the required CO_2 stream for a future European infrastructure project.

Roadmap for the "Norwegian Storage Development Region"

The Johansen Formation is a saline aquifer, bound by faults to the east and north in the storage area while a shale out is expected to the west. The southern limit is defined by pinch out of the formation. The northern part of the complex is heavily faulted and there might be possible communication points to overlying formations. The Drake Formation defines the top of the storage complex, where Lower Drake Formation is defined as the primary seal.

Different options for choosing injections sites exist and this is currently being studied. The tradeoff is aquifer volume vs depth to injection point and risk of deteriorating reservoir properties. Injections point south in block 31/5 enable huge storage volumes and long migration distance before the CO_2 plume reach the Troll Field area.

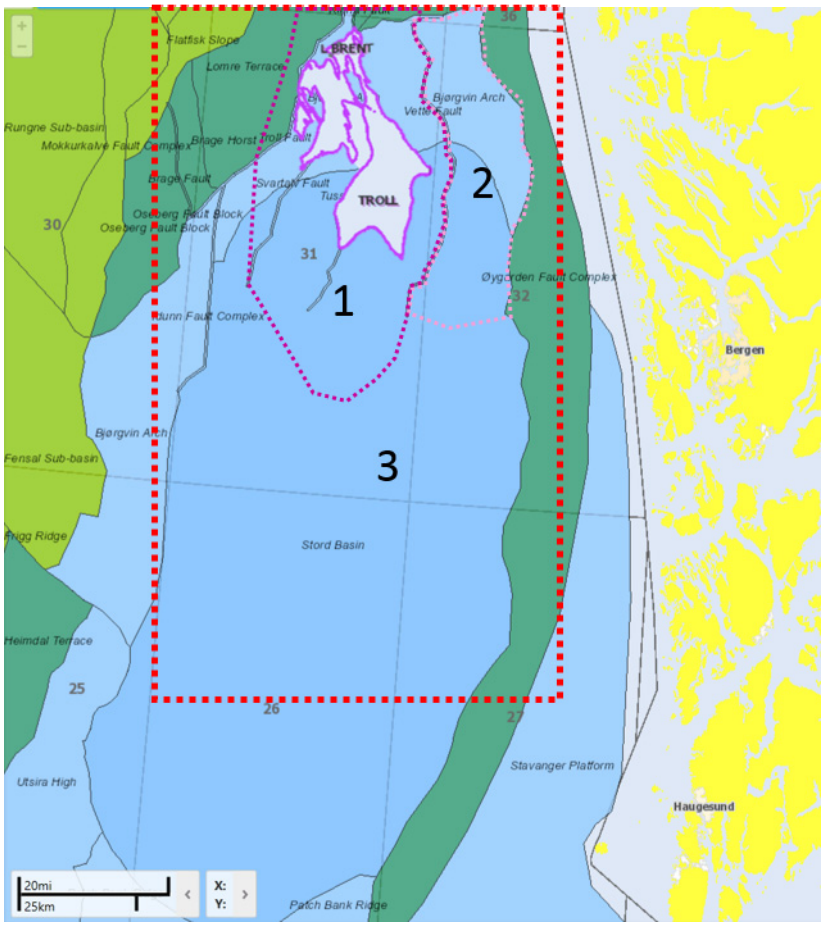

Figure 1 *Norway should aim to mature "bankable storage" within the Norwegian Storage Development Region (red box). The technical maturation is at different levels within different parts of the area. Area 1 with the Johansen Formation as a possible primary storage formation is matured towards a DG2 decision. Area 2, with Sognefjord Formation as a primary storage formation is taken back to research and development after discovery of several problems related to pressure depletion, old wells and risks related to fault systems. Area 3 within the Stord Basin has great potential; however low maturity due to low level of data availability. The storage concept study aims to mature the Johansen storage site ready for a DG2 decision.*

Conclusions

Possible conflicts with active petroleum exploration push CCS projects in areas with oil & gas exploration and production into unexplored areas where the data availability is limited. This is a returning problem in CCS projects and limited data (e.g. low well density, lack of seismic date) make identifying storage and sealing formations challenging. In the Johansen Storage Complex Study from

2012, the exploration area covers approximately 3500 km2 and only 40% of this area is covered with exploration wells penetrating the storage formation. The Johansen Formation has however considerable more information available than for other 'virgin' aquifers.

In Europe there is need to speed up the process going from regional "possible" storage concepts with low level of maturity to actual "bankable" storage sites. This can and should be done early in the process by involving a risk team to investigate how to mature the storage site to final investment decision level«FID-level».

Johansen Formation is a suitable reservoir for CO_2, with huge storage potential, inferred high porosity and permeability, ideal pressure and temperature conditions and high potential for trapping and immobilization of CO_2.

References

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