

2.3 Petroleum Resources on the Norwegian Continental Shelf

Arild N. Nystad, Previous Petroleum Resource Manager, NPD (now Sodir).

Norwegian Continental Shelf Oil and Gas (Figure 1)
Petroleum investments on the Norwegian Continental Shelf (NCS) have been a cornerstone of the Norwegian economy since production began in 1971. The petroleum asset of 100 billion bbl recoverable oil and gas, together with a joint collaboration between Norway and the international oil industry, resulted in a very successful story of exploration and exploitation, highlighting efficiency, safety and environment.

Norwegian Petroleum Directorate (NPD) was established in 1972, together with State Oil Company, Statoil. Norway experienced the Bravo Blowout in 1977 and the Alexander Kielland disaster in 1981, where 123 people died. These two accidents resulted in major changes in the safety philosophy in the 1980s. The Petroleum Governance in Norway had a new revision in 2001 by establishing 100% state owned company Petoro, taking over State Direct Economic Interests (SDØE) managed by Statoil since 1985, and 100% state owned Gassco, operating about 9000 km gas pipelines to continental Europe, including the facilities onshore in Norway as well as the facilities at each landing point in Europe. The fiscal system has been a most efficient collector of economic rent, transferring petroleum assets over to international financial assets.

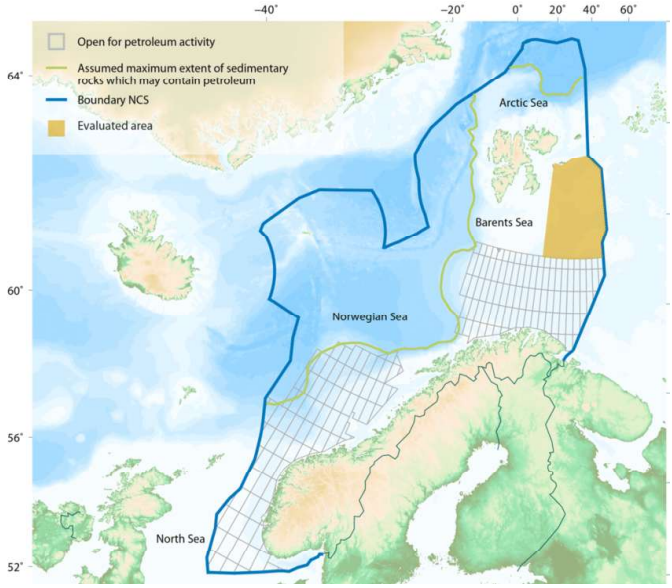


Figure 1: Norwegian Continental Shelf (Sodir)

The huge amounts of investment in fields and infrastructure is still in operation. This is a unique economic opportunity to use the existing facilities to capture remaining marginal resources in existing fields and tie-in resources in marginal smaller fields, resulting in very competitive break-even prices and low CO2 emissions relative to other producers.

Policy implication: The NCS is expected to be an efficient resource base to assure energy security for Europe the next 30 to 50 years, with continued focus on efficient petroleum resource management, safety management, and reduced emissions.

High-tech petroleum industry (Figure 2)
Petroleum exploration and exploitation value chain is a complex high-tech remote operation of resources 2-4 km into the ground, geographically spread over huge areas, water depths of 100-1000 m, horizontal drilling up to 10 km, complex offshore sub-sea installations and platform production facilities, and advanced logistics to the market. The petroleum industry complex is a super driver for future technology development, applying Emerging AI technologies and Agentic AI for Integrated Operations (IO), resulting in improved efficiency, resource recovery and safety.

Policy implication: The oil and gas industry is a high-tech innovation driver for emerging AI technologies to improve safety and resource efficiency, with cross-over opportunities to several other sectors in the society: medicine, healthcare, space, aviation, military, and other industries.

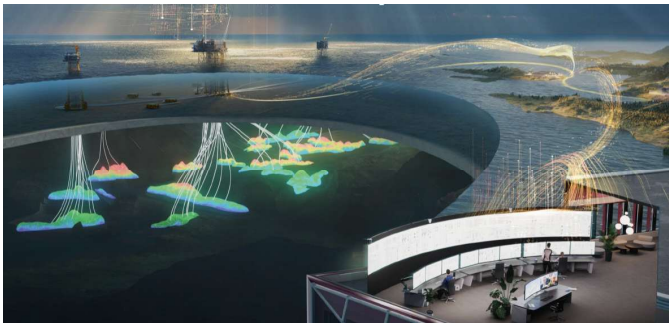


Figure 2: Yggdrasil Remote Operations of the underground (AkerBP)

Sedimentary basement and licensing (Figure 3)
The NCS covers about 2 040 000 square kilometers and is six times larger than mainland Norway. Two-thirds of this area comprise sedimentary rocks with potential for petroleum. The NCS has been opened for petroleum activities gradually since the first licensing round in 1965. The first blocks in the Norwegian Sea and Barents Sea were awarded between 1981 and 1989. Deepwater areas in the Norwegian Sea and part of Norland VI area off Lofoten were opened for petroleum activities in 1994. Two decades then passed before Barents Sea southeast was opened in 2013. The Norwegian Authorities have had prudent step-by-step awards in order to gain information from one step

to the next. An extensive set of policy instruments has been developed on the NCS to take account of other industries and the environment in all phases, from the opening of new areas, through awards, exploration, development and production to decommissioning.

Policy implication: There are still unexplored areas with sedimentary rocks on the NCS. The key to produce future discoveries on the NCS is geoscience, exploration models and technologies, together with companies' innovative exploration teams, and access to new areas. Important to keep the integrated geoscience expertise for cross-over learning between new petroleum areas and existing areas, to assure efficient solutions.

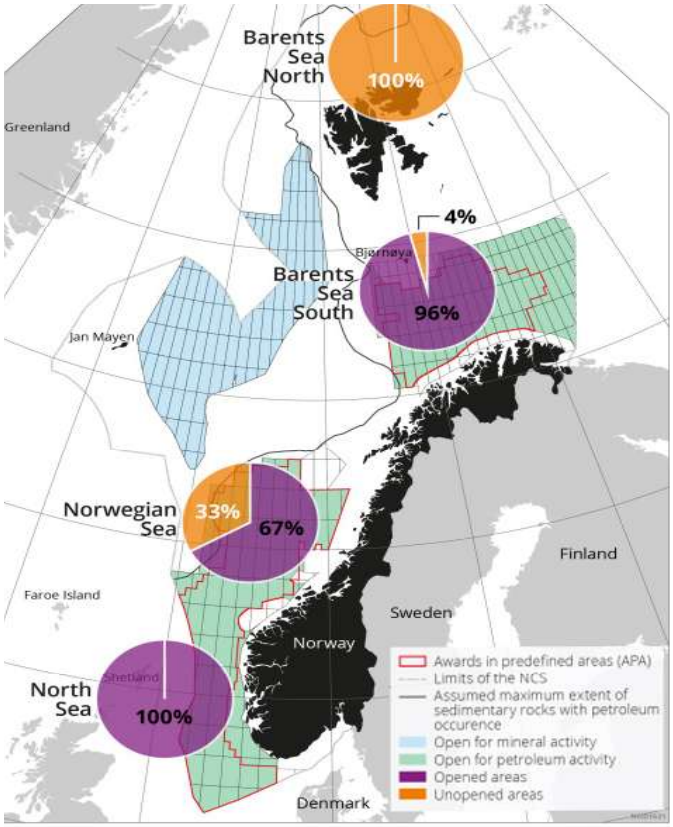


Figure 3: Norwegian Continental Shelf: Open and unopened areas (Sodir)

Petroleum Resources (Figures 4 & 5)

The Offshore Directorate resource accounts provide an overview of total expected recoverable resources, including those remaining to be discovered and form the basis for the production forecast. Total recoverable resources on the NCS are estimated to be 15.6 billion scm o.e. (about 100 billion bbl) of which 58% is oil and 42% is gas. The original hydrocarbons in place might be the double (about 200 billion bbl).

Norway has depleted 56 billion bbl o.e. during 55 years since 1971, average production 2,8 million bbl/d o.e, peak production some years 4 million bbl/d o.e. Norway has still 44 billion bbl o.e. for the future, of which 22 billion bbl o.e. already discovered, and 22 billion bbl o.e. yet to be found. The future with 44 billion bbl o.e. has an uncertainty spread: 95% probability to be at least 32 billion bbl o.e., and the upside of 5% probability to be at least 57 billion bbl o.e. Reference to Petroleum Resources and Fig 4 & Fig 5.

Policy implication: NCS has another 44 billion bbl o.e. for the future. The future is smaller fields, more complex accumulations, greater uncertainties, spread over geographical areas, thus demanding new innovative technologies and solutions.

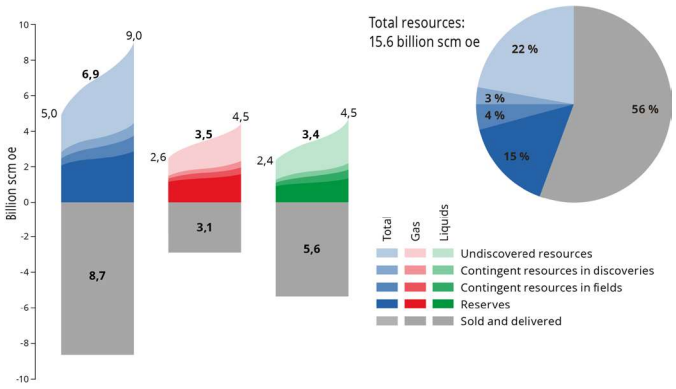


Figure 4: Total Resources (Sodir)

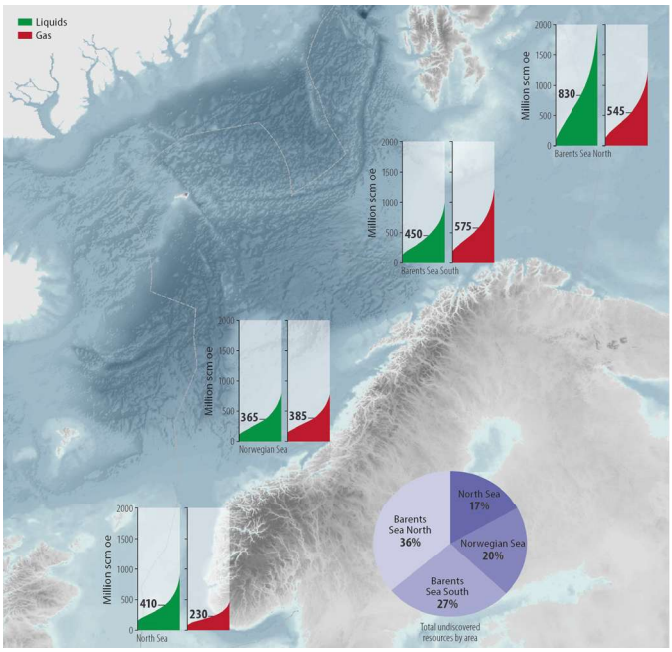


Figure 5: Undiscovered resources (Sodir)

Remaining resources in existing fields (Figure 6)

Remaining resources in existing reservoirs have a huge upside potential. This refers to the remaining oil in place in the major "old" oil fields: Ekofisk, Troll, Snorre, Eldfisk, Valhall, Statfjord, Heidrun, Oseberg, Gullfaks and several smaller fields. Sodir estimates the remaining oil in place after planned production in the 25 largest oil fields to be about 3,5 billion scm oil (22 billion bbl). This is an ultimate target for future game-changing emerging AI technologies. We are talking about significant resources in well-established producing fields and with installations in place ready to be used. Future field development will also involve smaller projects tied back to existing infrastructure. Technological advancements will continue to enhance recovery rates and extend the lifetimes of existing fields.

Policy implication: Technologies and competences for marginal resources in existing fields, as well as tie-in of marginal resources in separate smaller fields, shall assure these resources that are critical in terms of time. Drilling & Well technologies stand for 50%-60% of the total cost, being the most efficient technologies to capture these resources and for improved recoveries.

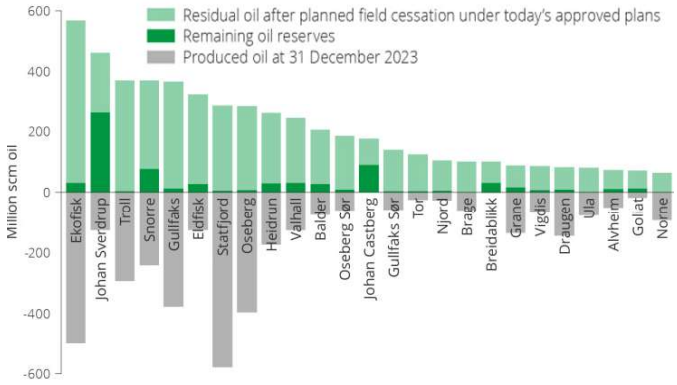


Figure 6: Oil Reserves: Produced, remaining and planned to be left (Sodir)

Production scenarios (Figure 7)

Operational efficiency will be key to maintaining production levels. The Norwegian Offshore Directorate focus on ensuring that companies implement necessary measures to utilize all valuable resources before fields shut down. Investments in new technology and infrastructure will be essential to achieving this goal. Production forecasts indicate stable levels in the short term, with expected natural decline over the next 30 years. New discoveries and investments will be crucial to maintaining production levels in the long term. Sodir scenarios for future production highlight the importance of exploration and technology development. Figure 7 illustrate Sodir production scenarios of the future, including tentative AI innovation ambitions.

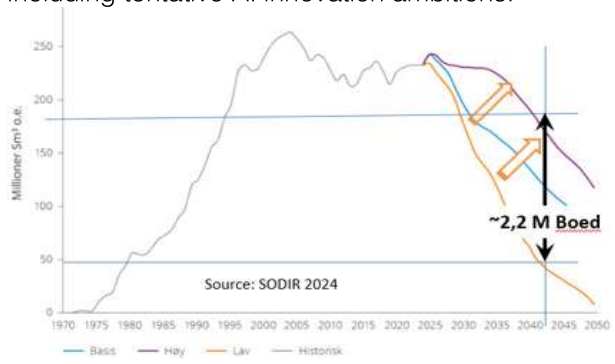


Figure 7: Production scenarios (Sodir) including Agentic AI innovation opportunities

Policy implications: We believe that emerging AI Technologies shall contribute to assure the production opportunities further, from low to base and from base to high, and tentatively even further improvements with Agentic AI supporting Integrated Operations in the value chain, in combination with drilling technologies. New transparent access to giga-volumes of all types of data is needed, for Agentic AI Innovation, training of the separate Agents working together to maximizing asset value.

Efficient fiscal system for optimal petroleum resource management

Norway has had a stable fiscal system, combined with stepwise improvements since 1985 of the fiscal incentive structure, approaching a neutral cash flow system for optimal economic efficiency seen from Norway, assuring that the society economic solutions are equal to the business economic solutions, with an optimal society economic recovery rate. The equity share of the State Direct Economic Interests (SDØE) operated by Petoro, is by definition a neutral cash flow fiscal instrument. The public governance has been fundamental for efficient Petroleum Resource Management maximizing the society value.

Policy implication: The petroleum taxation system together with equity share of Petoro, has been a most efficient rent skimming system for Norway, transferring the physical petroleum assets over to financial assets in the international market, operated by the Norwegian State Pension Fund (Petroleum Fund).

International competitiveness (Figure 8)

Environmental aspects have had focus in Norway since the very beginning. Norway decided early on to ban flaring of gas to reduce CO2 emission, in combination with a CO2 emission fee. The CO2 emission fee has given incentives over the years to develop and apply technologies with minimum CO2 emission. In recent years the industry has invested in electrification from shore as an additional mechanism to reduce CO2 emission in production and operations offshore.

Policy implications: The emission policy has given Norway a competitive advantage compared to international producers. As long as the market needs hydrocarbons, it is not environmentally efficient internationally to cut Norwegian production as the first player. An international collaborative strategy is complex but needed.

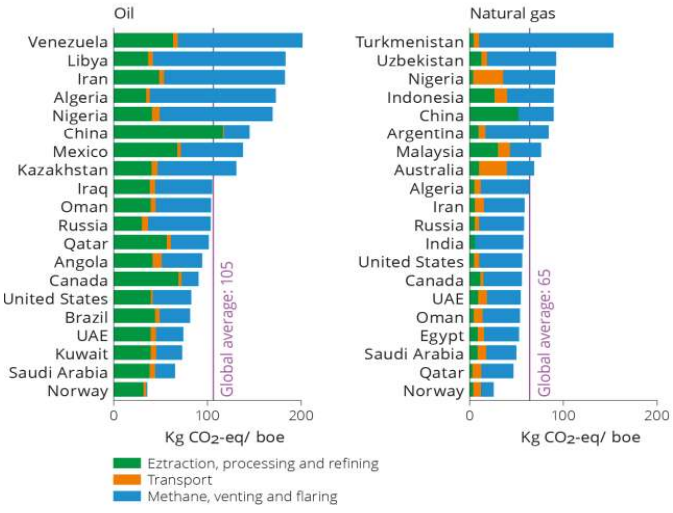


Figure 8: Emission of CO2 in different petroleum countries (Sodir)