

## **Economic analysis of undiscovered petroleum resources in the Norwegian Arctic: A Combined Monte Carlo and Scenario approach**

Benvenutta Henriksen, Mari Kvaløy and Terje Sørenes  
Norwegian Petroleum Directorate, Stavanger, Norway

### **Abstract**

Norway, the largest holder of natural gas and oil reserves in Europe, provides much of the oil and gas consumed on the continent. In fact, Norway was the second largest exporter of natural gas in the world after Russia, and the seventh largest exporter of oil.

In 2010, crude oil, natural gas, and pipeline transport services accounted for almost 50 percent of Norway's exports revenues, 21 percent of GDP, and 26 percent of government revenues.

Although Norway's oil production peaked in 2001 at 3.4 million barrels per day (bbl/d) and declined to 2.0 million bbl/d in 2011, natural gas production has been steadily increasing since 1993, reaching 3.6 trillion cubic feet (Tcf) in 2011.

Production from the Norwegian Continental Shelf (NCS) depends in the long term on new discoveries being made which are capable of being developed. Based on current expectations for the resource base, future production and exploration activity, almost 40 per cent of petroleum output on the NCS in 2030 will derive from discoveries which have yet to be made. The number and size of finds will be crucial for the size of Norway's future production.

Discoveries need to be generally larger than has been the case over the past 10 years if the object is to maintain the level of production over a long period. Although substantial finds have recently been made in both mature and frontier areas, the opportunities to make large discoveries are probably greater in parts of the unopened areas than in those already opened.

Extensive unopened areas still exist on the NCS. In 2013, one of these areas, Barents Sea South East, a sea area in Norway close to the Russian border, was opened for petroleum activity. Prior to the opening the Norwegian Petroleum Directorate (NPD) was given the assignment of conducting geological mapping of potential petroleum deposits in the areas and estimate the resource potential of these waters. This paper describes and quantifies the expected and potential economic values based on the assessments of petroleum resources in the area.

Economic analysis of undiscovered petroleum resources in an unopened area is often done deterministic by calculating the value of the expected resources based on a mean development scenario (see Northern Economics (2009)). In this analysis we have used economic Monte Carlo simulation based on geological play analysis to calculate the expected economic value of the whole resource distribution.

However, the resources or petroleum prospects are said to be "dependent" or "associated" if drilling success in one petroleum prospect increases the probability of success of others. This creates option-values that can be reached by sequential exploration of the dependent resources. In this paper, along with the strategic management literature, we argue that it may be useful, in addition to the stochastic Monte Carlo analysis, also to employ a scenario-modeling approach when faced with high levels of uncertainty and sequential investments.

In order to illustrate our arguments, we combine scenario planning and Monte Carlo simulating techniques to value yet to find petroleum resources in the Barents Sea East. Combining economic Monte Carlo simulation based on geological play analysis with scenario analysis represents, in our view, a useful approach to estimating the economic value of undiscovered oil and gas resources in an unknown area.