***Economic analysis of undiscovered petroleum resources in the Arctic: Case Barents Sea South East in Norway***

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## Overview

Norway was in 2011 the third largest exporter of natural gas in the world after Russia and Quatar, and the seventh largest exporter of oil. Based on current expectations for the resource base, in 2030 almost 40 per cent of petroleum production on the NCS will derive from discoveries which have yet to be made.

Although substantial discoveries have recently been made in both mature and frontier areas, the opportunities to make large discoveries are probably higher 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, estimate the resource potential of these waters and calculate the potential economic value of the undiscovered resources. This paper describes the methods and the results of the economic valuation.

## Methods

Valuation of the undiscovered petroleum resources in the Barents Sea South East is based on the resource distributions from the geological play analyzes. The valuation uses a stochastic approach (Monte Carlo simulation) where for each outcome in the resource distributions we calculate an economic value. The model's principles are described in Newendorp, PD (1984) and Snow, Doré and Dorn-Lopez, (1996). In addition to an expected cash flow, the stochastic calculation models will give uncertainty distributions for the cash flows. Input variables are stated as uncertainty distributions, such as for resource outcomes, costs and prices. A Monte Carlo simulation takes discovery probabilities into account, and draws randomly from all the uncertainty distributions. Thereafter, the present value is calculated for each set of draws from all distributions. If such random draws are performed a sufficient number of times, this method will yield an uncertainty distribution of present value, in addition to expected present value. This distribution, then, is dependent on model specifications, including distributions (type and range of distributions), that have been given for input variables and dependencies between the underlying parameters and variables.

The calculations of the expected present value is based on an immediate decision. This could potentially underestimate decision flexibility in a project and the value of a stepwise exploration through gradual disclosure of geological information. Such option values related to exploration decisions are a function of the uncertainty about how much resources we will discover and fluctuations in oil prices and costs. This means that it will be interesting to quantify the value of an upside case, because active management and control of downside risk (eg through stepwise exploration) can provide a significant added value. Thus, it will be important to identify upside potential in addition to the expected profitability when making decisions related to exploration activities.

There are various methods to try to reveal the upside and potential real options. 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. 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. In an earlier paper (Henriksen et al. (2012) we estimated the economic value of undiscovered petroleum resources in the sea areas off the Lofoten islands in Norway combining the two methods.

In this paper we develop three main scenarios. The scenarioes differs based on possible discoveries and resource outcomes of the exploration activity in one area, the Bjarmeland Platform. The Bjarmeland Platform is characterised by relatively few geological structures, but certain large ones could be important as gas traps. Large discoveries in this area would be considerable important to develop gas infrastructure in the area to support smaller discoveries to become profitable to develop as fields.

## Results

Based on the resource distributions from the play analysis and the given assumptions, we calculate a positive expected present value using a 4 percent real discount rate.

Based on the given assumptions there will be about 75% probability that the net present value is positive and consequently 25% probability that the NPV is negative.

However, there is significant upside-value that also is estimated. The analysis also shows that if exploration on Bjarmeland Platform provides great discoveries it will be five per cent probability that the net present value is equal to 235 billion or more.

## Conclusions

The analysis shows that there can be a significant resource and value upside related to petroleum activities in this area.

Through a step-wise exploration of the area, the cost of clarifying the resource potential is limited, while the upside could be significant.

Based on the economic analysis only, a step-by-step exploration of the area, which starts with the potential big accumulations, will serve as a robust strategy to clarify the potential volumes in the area, and to clarify whether we have resources that can be produced.

## References

Alessandri, T. M., et al. (2004):”Managing risk and uncertainty in complex capital projects”, The Quarterly Review of Economics and Finance 44(5), 751-767.

Cornelius, P., M. Romani and A. r Van De Putte (2004):”Three decades of scenario planning in Shell: experience and possible extensions in the future”, Paper presented for the 24th IAEE conference, Washington D.C, July 10th 2004.

Courtney, H. G., Kirkland, J. and Viguerie, S. P. (1997): “Strategy under uncertainty”, Harvard Business Review, November-December 1997, pp. 81-90.

Henriksen, B., Kvaløy, M., Petterson, C, Sorenes, T.& Toft, A (2012): Economic Analysis of Undisovered Petroleum Resources in the Unopened Sea Areas off the Lofoten Islands in Northern Norway: A Combined Monte-Carlo and Scenario Planning Approach, USAEE Working Paper No. 12-134

Miller, K.D and Waller, H. G. (2003):”Scenarios,real options and integrated risk management”, Long Range Planning 36(1), 93-107.

Newendorp, P. D. (1975): Decision Analysis for Petroleum Exploration. PennWellBooks,Tulsa Oklahoma.

Snow, Doré og Dorn-Lopez, (1996).

Wright, G. & P. Goodwin (2009): “Decision making and planning under low levels of predictability: enhancing the scenario method”; International Journal of Forecasting 25(2009) 813-825.