

Improved recovery from existing fields

A survey of decision criteria¹

By

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Abstract

The decline in oil prices, combined with high costs which are slow to deflate, has brought forward the date when some fields on the Norwegian continental shelf (NCS) will cease production. Measures are therefore urgently required to extend the producing life of these fields and to improve their recovery factor. The government has identified a number of projects in this area which it believes will provide a good return for both society and the oil companies, but which have nevertheless been postponed or not realised. Against that background, this article surveys oil company decision criteria for projects which could improve oil recovery. Subjects we discuss include parameters for measuring financial performance, management parameters in the companies, organisational structures, and research and development incentives.

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1. Introduction

A great deal stands to be gained in economic terms from improving recovery factors on the Norwegian Continental Shelf (NCS). An increase of just one per cent in oil recovery over and above existing plans would yield revenues in the order of USD 17-25.5 billion² at today's oil price.³

Revenues must be balanced against costs, as always, but all the signs are that projects can be found here which are profitable for both government and oil companies. Improved oil recovery (IOR) can be defined as measures or activities which increase oil production by mobilising the residual potential (remaining reserves) in a field. This embraces supplementary activities and processes which are not already part of the prevailing drainage or production strategy or of other operational practice.

Compared with other countries, relatively high recovery factors have been achieved on the NCS.

² Monetary amounts have been converted from Norwegian kroner to US dollars at an exchange rate of NOK 1 = USD 0.17.

³ Interview with Johannes Kjøde, Norwegian Petroleum Directorate, *Norwegian Continental Shelf* no 2, 2009, p 6.

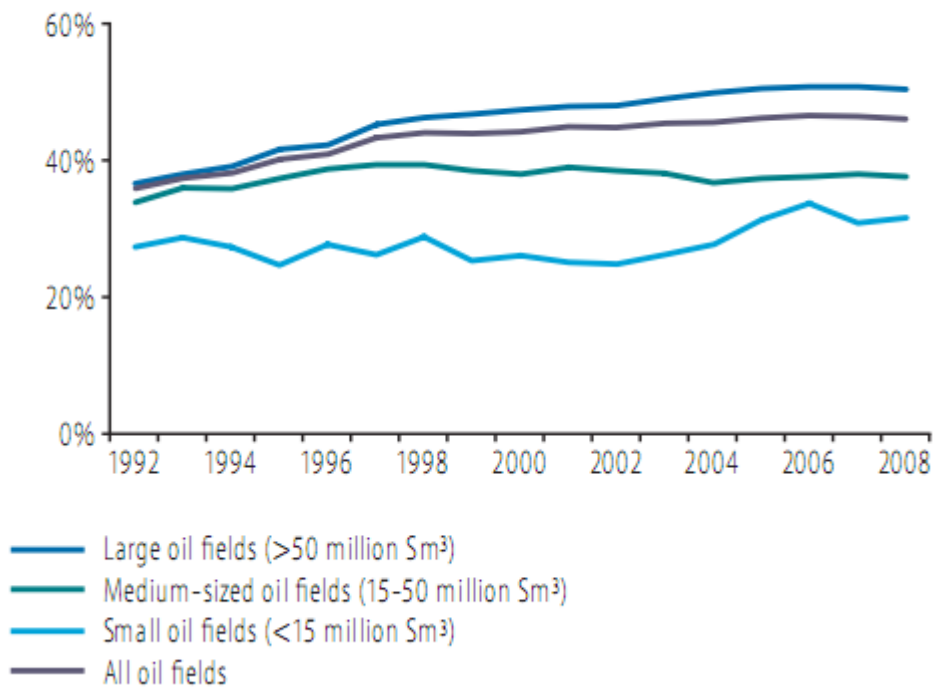


Figure 1. Development of the average expected recovery factor for oil. Source: Norwegian Petroleum Directorate (2009), *Petroleum resources on the Norwegian continental shelf*.

This reflects such factors as legal requirements for injection of water and/or gas from day one if this is socio-economically profitable, drilling of a far greater number of wells than expected with the aid of more advanced (horizontal and multilateral) techniques, and enhanced knowledge of the fields through advanced seismic surveying and other methods.

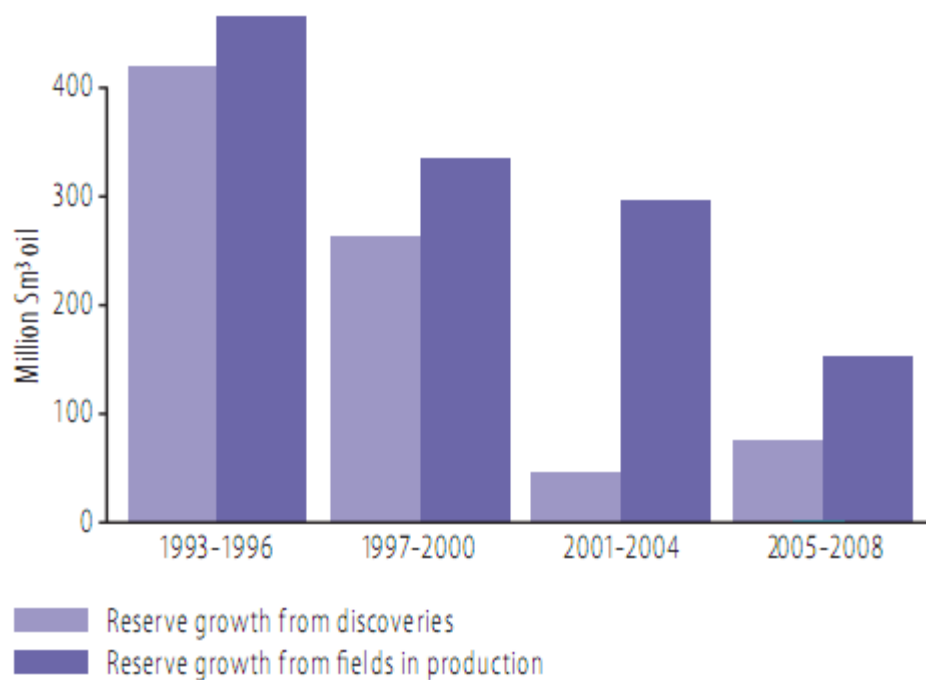


Figure 2. Historical growth in reserves. Source: Norwegian Petroleum Directorate (2009), *Petroleum resources on the Norwegian continental shelf*.

Figure 2 shows that the proportion of reserve growth from existing fields is increasing in relation to new oil fields being developed. The recovery factor varies from field to field, and depends on such considerations as reservoir properties, development strategy and technology advances. Since 2000, however, oil production from the NCS has declined steadily. Important decisions are due to be taken in coming years which will have major consequences for recovering significantly more oil and possible additional value. Declining production rates, falling petroleum prices and increased costs have brought forward the cessation date for a number of fields in recent years. Tying new resources back to existing fields in order to extend their producing life is accordingly time-critical. This would improve resource utilisation in fields already on stream, extend the use of existing infrastructure and thereby permit the development of small supplementary resources, as well as postponing removal costs.

2. Method

This article draws on a number of meetings and conversations with key specialists in oil companies, contractors, oil service enterprises and government. In analysing the incentive structure in the contracts regulating the industry, we make use of contract and incentive theory – e.g, Hart (1995) and Bolton and Dewatripoint (2005). To understand how the behaviour of oil companies is affected by their perception of the way oil companies are valued by capital markets, we benefit from behavioural economics studies of the petroleum sector. See e.g, Osmundsen et al (2006, 2007).

3. Project stoppers

The Norwegian Petroleum Activities Act is based on the concept of optimum recovery. Production and drainage strategies must be approved by the authorities, and the requirement to update and submit a resource development plan annually means that the companies have to demonstrate that they are applying high standards in diagnosing, understanding and planning of development and operation with regard to recovery over the coming year. The authorities review these plans every autumn before giving permission for recovery during the next 12 months. That gives the government instruments for use with the companies. These will be particularly important in the years to come, when many fields are heading for tail production while infrastructure – platforms with equipment and pipelines – is still in place.

General project stoppers for IOR
Conflict between short-term and narrow KPIs and long-term profitability
Insufficient effort devoted to research and development
No market for injection gas
Insufficient valuation of flexibility when selecting a development solution
Allocation of scarce inputs – rigs and personnel

Organisational challenges

High rate-of-return requirements

Table 1: List of potential stoppers for IOR projects.

Table 1 lists general project stoppers for IOR. Not all IOR projects are profitable, of course – as in all other contexts, revenues must be weighed against the costs incurred as well as against alternative measures. In some cases, society may assess costs differently from the companies. Society will normally have a lower required rate of return than the companies, for instance, which means that it wants more IOR projects. Differences in profitability calculations could particularly arise in the case of long-term IOR measures. In other cases, the project stoppers will be a shared challenge for the companies and the government. That applies to issues related to lack of information and management failures – if the companies define their key performance indicators (KPIs) too narrowly, for example, or if a company’s decentralised management system provides insufficient coordination of its R&D commitment.

IOR is an umbrella term which covers many different types of projects, and the survey of project stoppers accordingly needs to be supplemented with stoppers for specific categories of IOR measures. See Table 2.

	Method	Possible project stoppers
<i>Conventional methods</i>	Pressure maintenance and drainage - Water injection - Gas injection - Water alternating gas (WAG) injection	Price assumptions Adequate number of wells and maintenance Short-term focus – desire for gas at an early stage (or possible loss of options) Availability of gas
	Wells - Drilling, pressure and underbalanced drilling - Maintenance	Availability of rigs Maintenance costs
<i>Advanced methods</i>	Chemical flooding - Polymers: polymer flooding, linked polymer solution (LPS), bright water, silicates, etc - Surfactant flooding - Low sal, low sal + surfactants - Microbial methods - Foam	Decision on pilots – potential for market downturn Technical risk – a number of methods call for pilot testing and will require major modifications to existing installations Logistical challenges Chemical consumption – chemicals not sufficiently “green” Upsides/options not protected
	Gas-based injection - Rich gas - CO ₂	Decision on pilots – potential for market downturn Availability of gas (or CO ₂) Major modifications required for carbon injection
	Advanced wells - Pressure and underbalanced drilling	Decision on pilots – potential for market downturn Health, safety and environmental (HSE) considerations

Table 2: Detailed list of potential project stoppers. Various IOR measures are classified as conventional or unconventional, and specific examples of IOR measures are given for each group. Potential project stoppers are listed against each example.

4. Gas injection

It would be instructive to describe and analyse a specific IOR measure. Gas injection has been selected here, both because it is a key measure and because it is the subject of discussion over its optimum scope.

The value of injection is uncertain and complicated to calculate. Its purpose is to achieve IOR through the use of gas for pressure support. Assuming that other injection options (such as water) are not available, the expected income side is given by expected sales revenues from the expected additional oil recovered. This must be based on an expected price trend for oil. Account must be taken of the probability that a significant proportion of the injection gas can be recovered. Key cost elements for injection are accordingly the alternative cost of the (uncertain) proportion of the gas which is lost as well as the net present value associated with postponing the sale of the recovered gas. In order to calculate the latter, one must have a justified perception (expectation) of current gas prices compared with the prices which will prevail when recovery starts. Water injection is otherwise an alternative (or supplement) to injecting gas. The value added by gas injection in these circumstances is given by the value described above less the added value of water injection.

Gas injection is often more efficient than the water alternative, which represents an important reason why such projects have been chosen despite the income delay from the deferred gas sales. The companies are generally less patient than the government, i.e., they apply a higher discount rate. That can also yield differing views about gas offtake. This is significant because, in many cases, gas production will mean the loss of an IOR option. The time frame is also important in prioritising drilling commitments. When oil prices are high, drilling and workover of injectors may be given a lower priority than production wells. That can yield a short-term gain, but potentially at the expense of overall recovery.

The commitment to IOR appears to have lost out in the competition with exploration activity in recent years, while the opposite applied in the previous period. Figure 3 illustrates the decline in gas injection activity on the NCS.

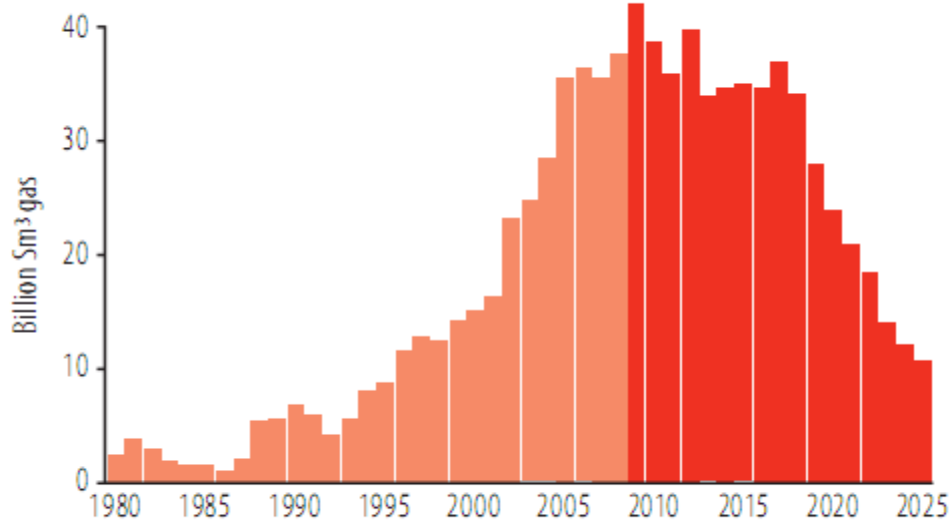


Figure 3. Historical gas injection and forecasts for gas injection (based on approved plans) Source: Norwegian Petroleum Directorate (2009), *Petroleum resources on the Norwegian continental shelf*.

A significant consideration for the IOR commitment over time will be the relationship between the volume of injected gas and the amount of incremental recovery – is it constant, for instance, or declining over time for the NCS portfolio. As always, an important explanatory factor will otherwise be the development of current and expected prices for oil and gas. Exploration activity declined dramatically in a period of high oil prices. Unemployed rigs were used to maximise oil output at what could have been perceived as a price peak. In today’s conditions, much of the attention has shifted to exploration, which could indicate that oil and gas prices are expected to rise. Strictly speaking, the relevant consideration here is not only prices but also margins. Although oil prices are at a historically good level, margins are not particularly high for new projects because of the sharp increase in development and operating costs over a number of years.

Changes in the commitment to IOR versus exploration do not necessarily only reflect developments in relative energy prices, but could also be affected by changes in oil company strategy. At their extremes, exploration and IOR are very different. The first represents a search

for big discoveries (elephant hunt), while the other could be a matter of many small contributions which may individually attract little attention. Strategies for striking this balance can change between companies and over time. An oil company must handle both extremes. It is important to remember here that, from as far back as the relatively early 1980s, reserve growth on the NCS has related primarily to improvement measures and increased knowledge and understanding of driving more out of existing fields than to completely new discoveries. However, conditions for a high recovery factor are weaker for some new fields than for developments such as Statfjord, in part because of more heterogeneous reservoirs as well as lower porosity and permeability.

5. Pilot projects

The history of oil has taught us the significance of technological progress. One bottleneck lies in the transfer of innovative technologies and methods out of the laboratory or off the drawing board to a pilot project on an offshore field. Possible reasons for this include limited oil company capacity in terms of personnel and physical restrictions on individual installations.

Decentralisation of the decision-making structure in the oil companies may also play a role – the individual project takes no account of the possibility that the increased knowledge could create value in other fields. It could be worth noting in this context that Norwegian oil history provides examples of pilot projects which have created hundreds of millions of dollars in added value.

These include testing the various effects of waterflooding on Ekofisk before launching the project on a field scale, and crucial pilots for oil production from horizontal wells before the Troll Oil development was sanctioned.

In many respects, a pilot represents an option for the oil companies. It is limited in scope, which means that new expertise is acquired at relatively modest cost. Work can continue if the pilot or project proves successful or be abandoned if it does not. This is analogous with the analysis of exploration investment. An option to wait is also available, with a full-scale project implemented if the oil price exceeds a specified critical level. For a relatively modest initial outlay, companies can thereby achieve a good return if the oil price rises. Probability calculations of future oil prices will play a role here.

Conclusion

We have identified some of the general stoppers for IOR projects. These include 1) the priorities set by oil companies for their resources (rigs, capital and personnel), between exploration and IOR, and between the NCS and other regions, 2) the conflict between short-term KPIs for decision-makers and long-term value creation, 3) organisational challenges (sub-optimisation), 4) overdimensioning of robustness requirements in investment analyses, and 5) the excessively long lead times for IOR measures compared with the producing life of the field.

Given the critical time frame, having IOR plans ready in advance is important. Pilot projects must be launched today, so that the increase in knowledge becomes available in time. That argues in favour of a collective IOR effort involving both companies and government.

The companies should ensure that short-term performance indicators cause the fewest possible distortions – financial decisions should be reached on the basis of a long-term criterion in the form of net present value. Furthermore, the companies should be aware of the time-criticality of IOR and put the necessary contingency plans in place. Testing should also be conducted now in order to learn as much as possible about effective IOR measures. The government should help to facilitate cross-licence coordination of pilot projects. Because of knowledge overspill (positive externalities) between licences, these should also provide direct support for such projects. The government should also continuously identify existing investment incentives in the companies in relation to socio-economic profitability in order to detect possible deviations.

Research in the form of pilot projects is important for exploiting this potential. But knowledge gained from such projects often accrues to more players than those who bear the investment cost. Coordination problems could consequently arise, and government intervention may be required to ensure that the work is done. A number of other challenges related to an IOR commitment are also faced at present. Oil prices are uncertain in the short term, and the industry has experienced a cost explosion. Pressure on margins could prompt a reassessment of cessation dates, and a number of IOR measures could have become more time-critical. On a more general basis, IOR projects also face challenges related to measurement problems. It is difficult to evaluate cause and effect with hindsight when asking which factors were the ones which improved recovery.

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