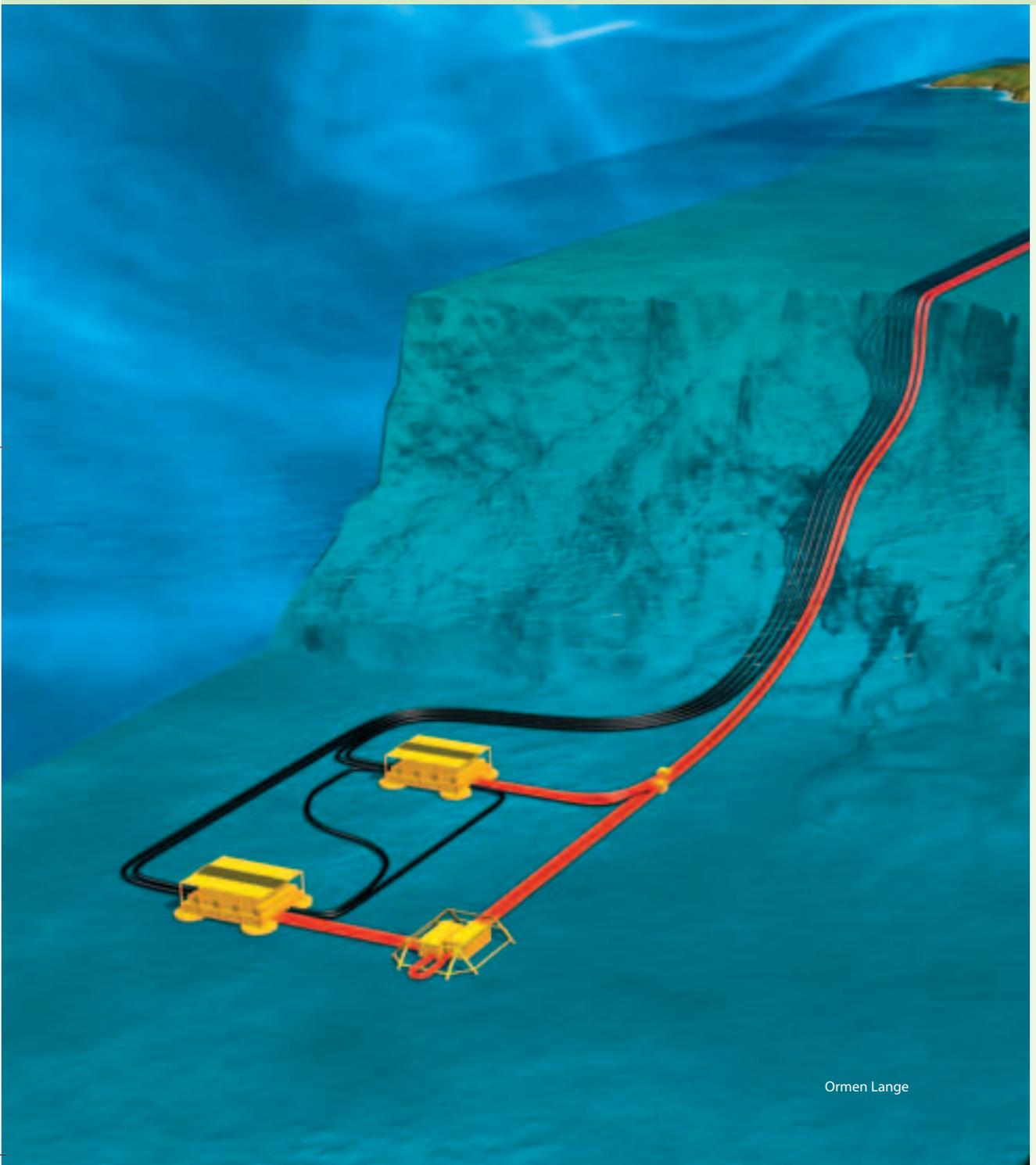


4 Development and operations



Ormen Lange

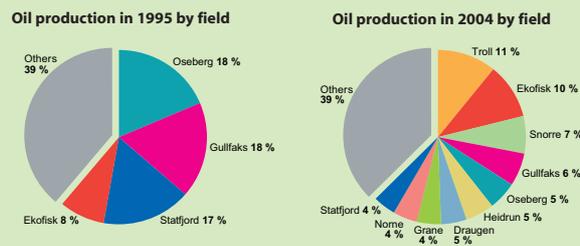


Figure 4.1 Distribution of oil production by field on the NCS
(Source: NPD)

In 2004, Norway produced more oil and gas than ever before, a total of 3.2 million barrels of oil per day (including NGL and condensate) and 78 billion standard cubic metres of gas. Total production of oil and gas is expected to remain at these levels over the next few years, with a slight increase up to the anticipated peak year of 2008. In the future, oil volumes will decrease while gas volumes will increase. 10 years ago, gas made up 15 percent of total production, in 2004 this had increased to 30 percent and it is expected that, by 2014, gas will exceed 50 percent of the total production. Figure 1.1 in chapter 1 shows historical and future trends in petroleum production from the Norwegian Continental Shelf (NCS).

In 2004, before Frigg was shut down, there were 49 fields in production, 43 in the North Sea and 6 in the Norwegian Sea. With the Snøhvit field, coming on stream in 2006, petroleum will also be produced from the Norwegian sector of the Barents Sea.

Production on the NCS has been dominated by some large fields. Several of these are now in decline, while new fields have been added, with the result that current production is distributed over more fields than previously. This is a natural development. When the North Sea was opened up for petroleum activity, the most promising areas were explored first. This led to world-class discoveries which were then put into production, under field names such as Ekofisk, Frigg, Statfjord, Oseberg, Gullfaks and Troll. These fields have been, and still are, of great significance for developments on the NCS. The large fields have contributed to the establishment of an infrastructure that subsequent fields have been able to tie themselves into.

Figure 4.1 shows that 60 percent of oil produced in 1995 came from only four fields. In 2004, the

equivalent proportion of the production was distributed over 10 fields. In the same period, the number of crude oil fields increased from 29 to 37.

As the Norwegian petroleum industry has moved northwards, it has entered into areas containing huge gas resources. Consequently, a number of gas fields have been developed and a comprehensive gas transport infrastructure established, which has made it possible to develop additional gas resources. Development of the gas fields, combined with falling production from major oil fields, has meant that gas is becoming an ever more important part of Norway's petroleum production.

The number of fields on the NCS is increasing and they are found in an increasing geographical area. Decreasing production from the major oil fields, combined with development of new fields, makes production less concentrated than it used to be, at the same time as the gas share is increasing.

Fields and infrastructure – potential for efficient exploitation

To protect society's interests vis-à-vis development and operations, the authorities have established frameworks for these activities, which are intended to ensure that the companies make decisions that are also to the benefit of society at large. It is important for these frameworks to be clear and to create predictability in relation to the companies' decisions. Hence, the authorities have created a model that is characterised by both cooperation and competition between the players, with the intention of creating a climate for sound decisions that benefit both the companies and the rest of society.

The petroleum industry frameworks commit the companies to prudent development and operations of

the petroleum resources. This means that it is the companies which are responsible for putting forward and executing new projects, while it is the authorities which give the final consent for implementation. In the case of large projects, plans must be submitted for approval by the authorities. As part of the approval process, stakeholders may express their views, ensuring that all relevant factors are taken into account. Project approval is hence contingent upon optimal recovery and acceptable consequences.

Development of proven petroleum resources lays the foundation for current production and value creation from the petroleum industry. Development of 48 fields on the NCS, however, also provides the opportunity for further exploitation of resources in the vicinity of producing fields. Overall, at issue here is a considerable potential, which, sensibly utilised,

is capable of generating huge value for society, and which comprises a number of elements. In respect of existing fields and infrastructure, this potential can be divided into essentially two categories:

- further development of producing fields
- tie-in of discoveries and exploration for new deposits

Further development of producing fields

Although the total production of oil and gas has never been higher, many fields are facing declining production. This applies especially to the major oil fields that came on stream in the 1970s and 1980s. Despite decreasing production, there is still a great potential for increased recovery from producing fields. This is illustrated in figure 4.2, which shows resources in fields that are on stream.

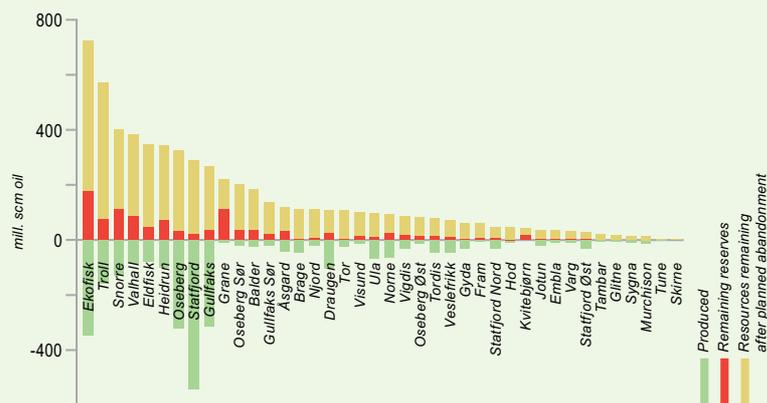


Figure 4.2 Distribution of resources – on-stream fields (Source: NPD)

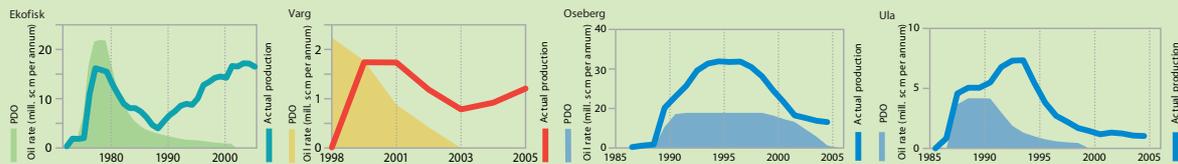


Figure 4.3 Production trends for the Ekofisk, Varg, Ula and Oseberg fields.
(Source: NPD)

The figure shows a three-way split of the resources:

- produced volumes
- remaining reserves; i.e. resources for which plans exist for recovery (reserves)
- resources for which plans for development and operations have not been approved, and which will remain unexploited after planned decommissioning

This last category offers a significant potential. Based on figures reported by the companies, projects are being considered that will increase recovery of oil from on-stream fields by around 230 million scm of oil. This is equivalent to 8 new Alvheim fields¹. In addition, the Norwegian Petroleum Directorate (NPD) has estimated the potential yield from further measures to be in the vicinity of 290 million scm of oil. In all, a potential for increased recovery which exceeds half a billion scm of oil has been identified. This volume has a gross value of around NOK 750 billion² and illustrates that increased recovery can create huge values.

A number of measures are necessary if this potential is to be realised. They can be divided into two groups – *efficient operations* and *increased recovery*.

Efficient operations impact upon production costs, and will for this reason affect resource recovery, because it is possible to maintain profitable production longer when production is more efficient. As production falls, many fields face a situation in which costs must be reduced in order to justify profitable production at lower levels. At the same time, communication technology has paved the way for new methodologies. Ways of exploiting these are often referred to as “e-operations” or “smart operations”. E-operations involve using information technology to change work processes to achieve better decision-making, to control equipment and processes

remotely and to move functions and personnel onshore. The basis for e-operations is computer technology which makes it possible to transfer information over long distances more or less instantaneously. Onshore personnel can thus receive the same information at the same time as offshore personnel, and this offers the potential for changes in working practices. Different technologies and expertise are brought together into a single unit that enables new constellations between offshore and onshore, oil companies and subcontractors. Reduced costs and smart operations are, therefore, elements that will contribute to efficient operations, and consequent increased production.

In addition to efficient operations, it is possible to implement a number of measures that affect revenues more directly in the form of increased recovery. Some examples include infill drilling, injection into the reservoir to enhance recovery, modifications of processing equipment, etc. The development and use of new technology has been, and is, extremely important. Progress in technology makes it possible, for example, to drill wells and develop fields in ways that have previously been technically impossible.

Figure 4.3 shows production trends for the Ekofisk, Varg, Oseberg and Ula fields. The figure shows that actual production from these fields has proved to differ greatly from the estimates made when the original development plans were submitted. Based on the original plans, these fields should now have been decommissioned. Due to efficient

¹ Alvheim is a medium-sized field that is currently being developed.

² The gross value is based on an oil price of NOK 230 per barrel.

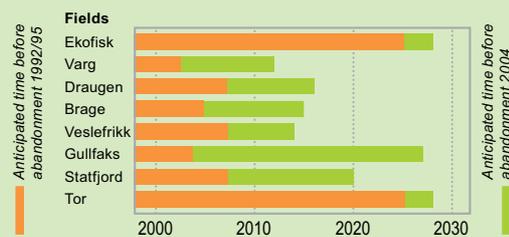


Figure 4.4 Lifetimes for selected fields
(Source: NPD)

operations and increased recovery these fields will, however, remain on stream for many years to come. At Ekofisk, the operator hopes to continue production until 2050.

These examples illustrate that considerable value can be created by increased recovery. Figure 4.3 also shows that increased recovery extends a field's lifetime, which is beneficial, because it makes room for implementing further development measures, and implies that the infrastructure will remain in place for a longer period.

Figure 4.4 shows that a field's lifespan changes over time. This is because the production period provides increased insight and knowledge – which, in turn, provides the basis for implementing supplementary projects that could not be decided at the time of development. In addition the development and use of new technology have made it possible to implement projects that were formerly not profitable.

Tie-in of discoveries and exploration for new resources

By year-end 2004, just below NOK 1,800 billion in current monetary value has been invested on the NCS. This is equivalent to more than NOK 1 billion each week over the whole period. The investment has led to the establishment of an extensive infrastructure that makes it possible to produce and market petroleum, but also forms a basis for the development of further resources in a cost-efficient manner.

As production falls, spare capacity in the existing infrastructure will often be available. Exploitation of such capacity may provide for an effective utilisation of resources that can be tied back to existing infrastructure. In some cases, the use of existing infrastructure will be a prerequisite for profitable development of new fields, because some of these are too

small to carry their own infrastructure. It follows from this that the resource potential in the areas around existing infrastructure must be explored thoroughly before such infrastructure is decommissioned. Failure to do so may cause society to miss out on significant value.

Estimates from the NPD indicate that around two thirds of the undiscovered resources on the NCS are likely to be in the North Sea and the Norwegian Sea. These are the areas on the NCS that currently have an extensive infrastructure established. In order to map the prospects in these areas, and to be able to exploit the opportunities offered by the existing infrastructure, the authorities have established a proactive exploration policy for mature areas. Large areas are made available to oil companies in a predictable way, while stringent requirements are set for those companies that are awarded exploration acreage. In extension of this policy, and in the light of the fact that a number of fields are approaching decommissioning, it is important that the existing infrastructure is exploited effectively, whether by the owners themselves or by third-party users.

Even though the NCS is populated by many platforms, and an extensive network of pipelines, third-party users of the existing infrastructure often face a monopoly situation, or at least limited competition. If we are to ensure effective exploitation of the petroleum resources, the infrastructure owners must not take advantage of such a market situation. Third-party use is an example of a “win-win” situation. The host field can share fixed costs among more users, and third-party users may benefit from investment that has already been made. This will often prove positive for resource recovery in both the host field and satellite fields.

In order to ensure that the potential in and around

producing fields is exploited, it is important that the participating interests are vested with the companies which want to make the most of them. This is why the authorities take a positive view of transfers of participating interests. In addition, the authorities have opened up for a broader range of players; cf. the discussion of new players in chapter 3. Other countries in which the petroleum sector has reached a mature phase have experienced that established companies do not always prioritise activities in fields where production has fallen to a low level. They would rather sell, to the benefit of companies for which such activity is a core area. With this in mind, the Norwegian authorities believe that a diversity of players, making different assessments and priorities, makes for a positive contribution to realising the resource potential on the NCS.

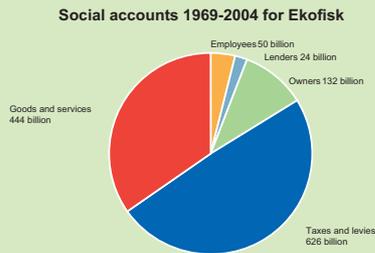
Increased recovery, extended lifetimes and tie-in of resources in the vicinity of producing fields forms the basis for the creation of extensive added value for society. However, increased recovery and extended lifetimes are only acceptable if they can be achieved within justifiable frameworks with regards to the

natural environment, health, working environment and safety. Further development of resources in and around existing fields often involves the use of existing infrastructure. This provides less freedom of action compared to new developments, because companies are not at liberty to choose whichever technical solution they prefer, due to limitations of existing equipment, weight limitations, etc.

Looking ahead it is important to ensure that the decline in Norway's oil and gas production is minimised and that the fields' lifetimes are extended. On the basis of existing plans, we know that large volumes of oil and gas will be left behind when the fields are abandoned. Today, it is not profitable to recover these resources, but they represent a considerable potential that might be unlocked

in the future. To realise this potential, work will be required on many fronts, to ensure that all the opportunities at issue are evaluated. For the long term, where the ambition is to produce oil until 2050 and gas until 2100 or beyond, it is crucial to realise all the opportunities that allow petroleum to be recovered profitably and within a justifiable framework.





Total value creation from the Ekofisk sector to the end of 2004 (at 2004 values) was NOK 1 260 billion

(Source: ConocoPhillips)

Ekofisk – an example of a successful partnership between oil companies, the supply industry and research institutions

Half of the world's petroleum resources are to be found in chalk reservoirs, the type present in the Ekofisk area. In general terms, chalk can be said to have relatively poor production qualities and a relatively low recovery rate. This was a very serious problem in the early development phases of the Ekofisk field, and in 1971 the recovery rate, in other words how large a proportion of the total petroleum reserves could actually be recovered, was estimated at 17 percent for the main Ekofisk reservoir. Broad-based research and technological developments have increased this estimate to 46 percent in 2005. The Ekofisk area is currently home to 29 facilities, around 1,100 km of internal pipelines and two export pipelines – one for crude oil and NGL to Teesside in the UK, and one for dry gas to Emden in Germany. After 30 years on stream, Ekofisk is still one of the highest producing fields on the NCS. The aim is to maintain activity in the area until 2050.

In order to achieve this, great emphasis has been placed on a continuous and interactive process between the oil companies' operational and in-house research communities, as well as close cooperation between oil companies, the authorities, research institutions and the sub-contractor industry.

As early as 1980, the Joint Chalk Research project was initiated by Norwegian and Danish authorities, in collaboration with the oil companies who were licensees in the various chalk fields of the North Sea. This research continues in 2005. Since the mid 1980s, the Ekofisk licensees have supported chalk studies at the University of Bergen, in order to gain a detailed understanding of the fundamental mechanisms connected to water injection into fissured chalk. Many Master and PhD students have taken part in this work. The RUTH and SPOR research programmes have been carried out within the framework of the Norwegian Research Council, studying injection of water and gas into the reservoir. Sintef, Rogaland Research, Reslab and IKU have also participated in this. A separate project, ThermicAiroil, has investigated air injection to increase recovery, with both national and multinational research institutions participating. A further project for increasing recovery, Corec, has been financed by the licensees and carried out in collaboration with Rogaland Research and the University of Stavanger. In addition to project financing, the oil companies provide project data, priorities and, not least, practical experience for the research.

At the end of 2004, figures for the Ekofisk area show that a total value of around NOK 1 260 billion had been created. NOK 444 billion was used for products and services, NOK 50 billion for salaries and other employee benefits and NOK 24 billion to loan providers. The licensees were left with NOK 132 billion, while the state received NOK 626 billion in taxes and levies (all in 2004 values).

