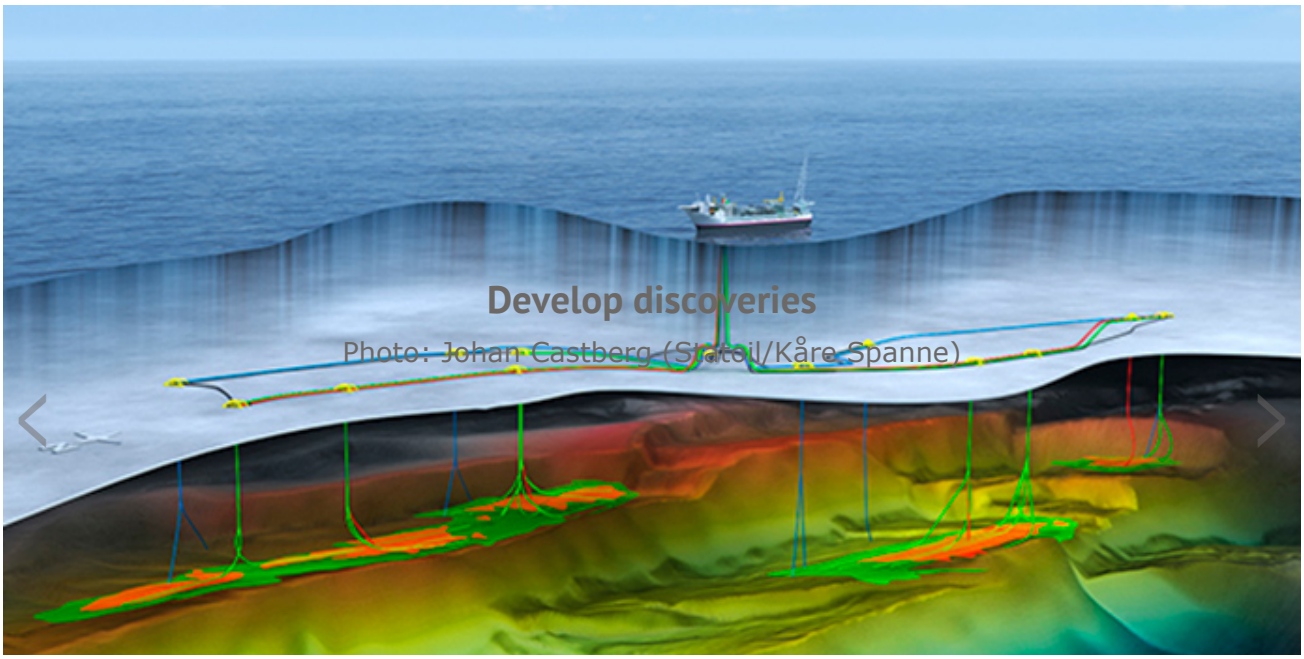
RESOURCE REPORT 2017

Much to be done

Oljedirektoratet 14.06.2017

Coordinated solutions, adoption of new technology and exchange of experience between players will help to increase value for new projects on fields and discoveries.



Players in the petroleum industry have done good work over many years in proving resources and finding solutions which ensure that the resources can be produced.

Drilling production wells

The most important way of securing output from a field is to drill production wells. Testing and adopting new drilling and well technology can help to grow reserves by making more challenging targets accessible.

Coordination and area solutions

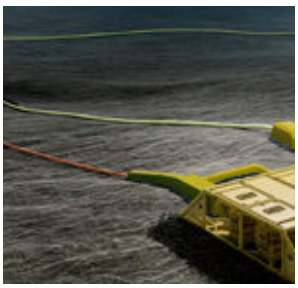
Most discoveries are developed with seabed installations tied back to existing facilities. In this way, good collaboration across production licences can reduce overall development costs in an area while also making it possible to improve recovery from the host Field

(Photo: Statoil/Harald Pettersen)

Projects on fields create significant value

Recoverable resources in projects on fields are estimated to total 845 million scm oe. Many projects are planned and implemented on fields which will yield a substantial growth in reserves. Continuously identifying and maturing projects is important for maintaining value creation.

Projects on fields grow big reserves



(Photo: DEA)

Big opportunities in discoveries

The Norwegian continental shelf (NCS) had 77 discoveries with estimated recoverable resources totalling 697.5 million scm oe at 31 December 2016. A number of these are relatively small, and therefore depend on existing fields or coordinated solutions to be brought on stream. The companies have worked well in recent years to improve their development plans and concepts.

Good area solutions mean more profitable developments

(Photo: Reelwell)

Develop and adopt new technology

The NCS has been a laboratory for developing new technology from the start. Unfortunately, many good ideas fail to get beyond laboratory testing. As fields age, further work on cost-effective solutions which make it possible to recover remaining resources is becoming a matter of urgency. Developing new drilling and well technology represents an important measure which should be given priority.

New technology can make production more profitable

More players on the NCS

Large companies dominated activity on the NCS until the turn of the century. At 31 December 2016, 46 licensees were represented in 523 active production licences. Several companies are pursuing developments off Norway for the first time. Good experience transfer between new and experienced players on the NCS is important.

How the number of players has developed

Go to next topic: Cessation

RESOURCE REPORT 2017

Projects on fields yield big reserve growth

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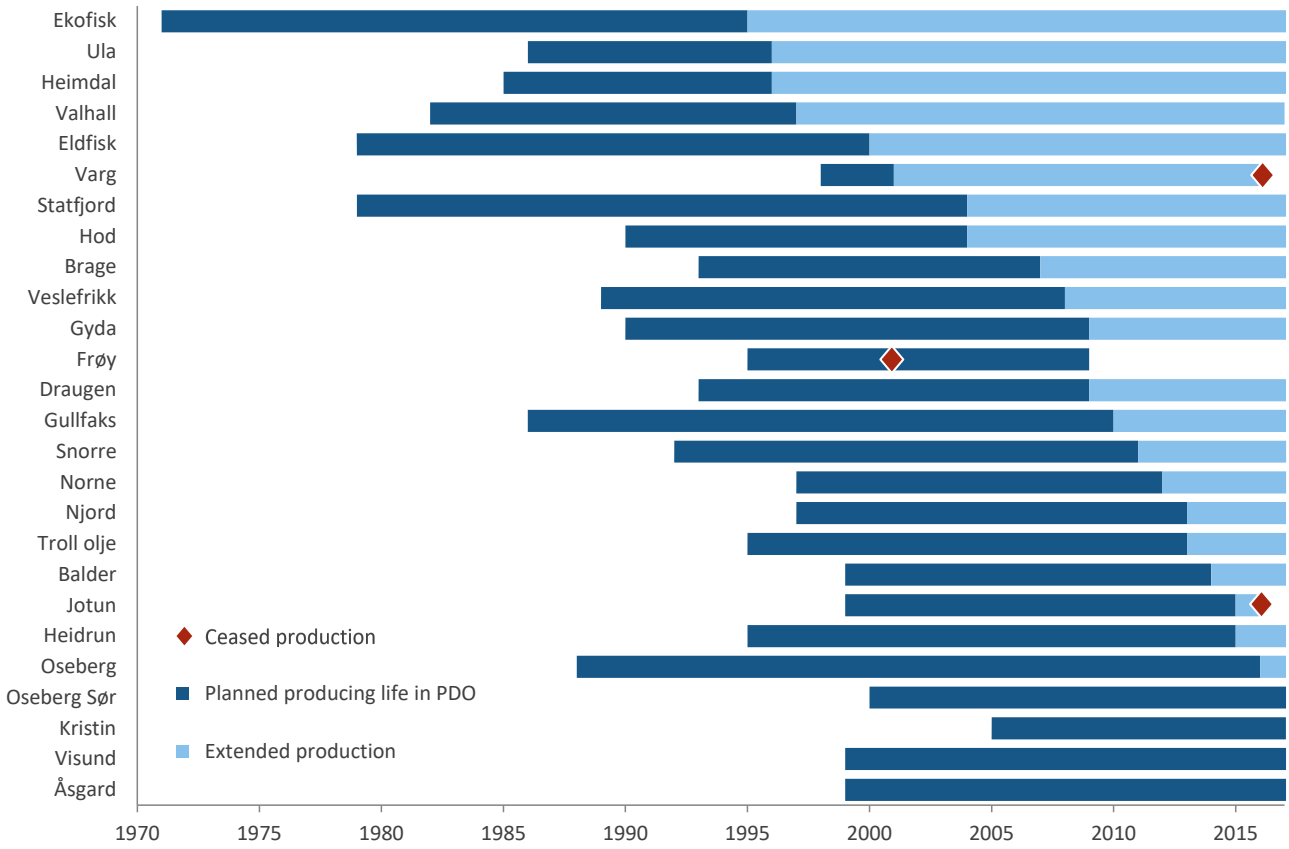
Continuously identifying and maturing projects through to production is important for maintaining value creation. Many projects being implemented lead to substantial growth in reserves. The 2016 resource accounts include 320 projects for increased oil and/or gas production and extended producing life. These amount to 845 million scm oe.

Fields are producing longer than planned

The commercial life of Norwegian offshore fields on stream has increased by an average of 12 years from their original plan for development and operation (PDO). This partly reflects a big commitment to further development on many fields.

A number of new facilities have been constructed, additional deposits are incorporated in the fields, and measures to improve recovery have been implemented. In addition, a number of fields are being used to produce nearby discoveries. These moves have boosted reserves in fields by 2 900 million scm oe since their PDOs were submitted.



A selection of fields, showing their planned producing life in PDO, extended producing life and cessation. Of the 26 fields presented, 23 are still on stream and most will remain so for many years to come.

Contributors to reserve Growth

- Drilling far more wells than originally planned
- New or amended drainage strategies and increased reservoir understanding
- Implementation of new technology
- Expanded infrastructure capacity and flexibility
- Tie-in of third-party fields, which extends producing life and therefore output for the host field.

A continuous commitment to and good utilisation of the infrastructure can maintain this positive trend and extend producing life even further. The result could be that more discoveries can be tied back to fields in the future, and thereby boost value creation

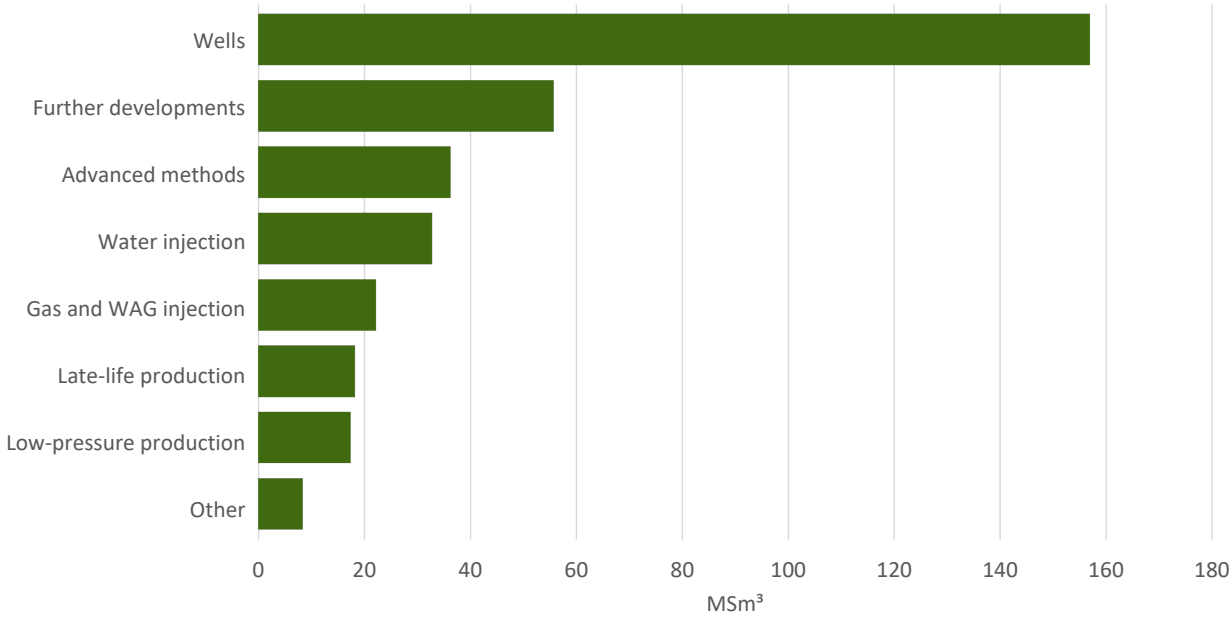
SEE ALSO: Coordination makes small discoveries commercial

Projects on fields occupy various classes in the NPD's resource classification system, depending on how far they have come towards development. Projects are also grouped by production method for analysis purposes.

Note that redevelopment of fields and planned further project phases (Johan Sverdrup phase 2) are not included in the overview below. This is because they are regarded as field developments, while the remainder of the portfolio represents (supplementary) projects which help to improve recovery from fields on stream.

Projects for improved oil recovery (IOR)

New projects with associated investment are sanctioned by the licensees after a detailed evaluation. A number of projects on fields are assessed every year. Some are sanctioned and implemented, some are subject to further study, others are postponed and some are shelved. The size of these projects varies considerably in terms of both production effect and costs. As the figure below shows, however, substantial volumes of oil have been identified in projects on fields. Gas volumes are not included in the portfolio, even though it also contains projects which could improve gas recovery.



Oil resources in projects on fields by project type.

Well-related projects

The survey shows that almost half the oil in this project portfolio could be recovered by drilling more production wells. A steady increase in the number of producers has also helped to boost recovery on many fields.

Further development projects

These are major upgrades and plans for new installations, such as subsea facilities or unmanned wellhead platforms (UWPs) tied back to existing fields. The biggest member of this category is the Snorre Expansion Project. Snorre has large remaining resources, and the

licensees are planning further development of the field with the aid of extensive subsea installations.

Valhall and Ekofisk are examples of fields where major upgrading projects have been pursued. (Photo: Valhall/BP)

Enhanced oil recovery (EOR) methods

These have yet to be adopted on the Norwegian continental shelf (NCS), but some have been tested in pilot projects as on Heidrun. See the description of seven different EOR methods which could be relevant for Norwegian oil Fields.

Water, gas and WAG injection

Drilling new injection wells is important for maintaining production from the fields. Injecting water and/or gas into a reservoir will maintain or increase its pressure and allow more oil to be produced. The project portfolio includes plans to optimise injection of water, gas or water alternating gas (WAG).

Late life Production

Upgrading, modifications or new calculations can lay the basis for extending field life. This type of project can often be combined with other measures. If nearby discoveries are to be tied back to the field or other major measures are to be implemented, the field's producing life must be assessed. Norne is an example of a field where its expected time on stream has lengthened because a number of other fields have been tied back to its production ship.

Low pressure production

Such projects involve installing equipment which makes it possible to produce with lower wellhead pressure. This yields a quantity of extra oil, but makes its biggest contribution in terms of improved gas recovery.

Projects for improved gas recovery

The most important measure for recovering more gas is to enable production with the lowest possible wellhead pressure. This often calls for the installation of additional compression to export the gas. In addition, measures to secure extra oil will often also yield more gas on fields where much gas is dissolved in the oil.

Ormen Lange Late Life Recovery is one of the biggest projects for low pressure production. Its first phase embraces land-based compression of gas from the field, with the licensees evaluating a compression solution in 800-1 100 metres of water as a second stage.

See article on: Improved gas recovery from Ormen Lange

The gas processing plant at Nyhamna in western Norway. This can increase gas recovery from the Ormen Lange field in the Norwegian Sea by 25-30 billion scm. (Photo: Statoil).

Subsea compression on Åsgard is another example of a major project to maintain gas production. It ranks as the world's first seabed gas compression solution.

Magazine NORSK SOKKEL 2/2016: Groundbreaking technology is boosting recovery from the Åsgard area

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Develop all profitable discoveries

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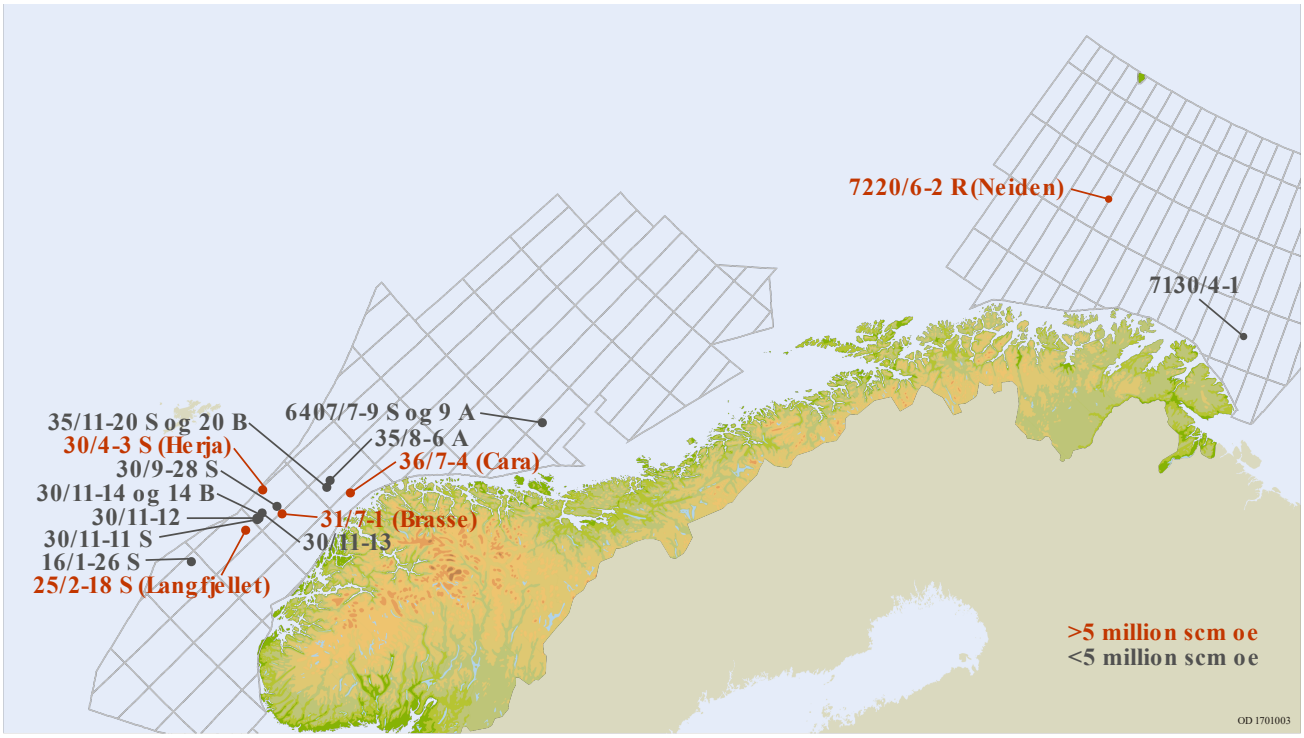


I 2016 ble det gjort 18 funn på norsk sokkel. (Oversettelse mangler)

The discovery portfolio at 31 December 2016 contained 77 discoveries under consideration for development. While the largest of these are in the Barents Sea, the majority are in the North Sea.

Discovery portfolio

The portfolio comprised 77 discoveries at 31 December 2016. While the largest of these are in the Barents Sea, the biggest number is in the North Sea. In addition come 145 discoveries which are not currently expected to be Commercial.

READ MORE: Large oil and gas resources in the discovery portfolio

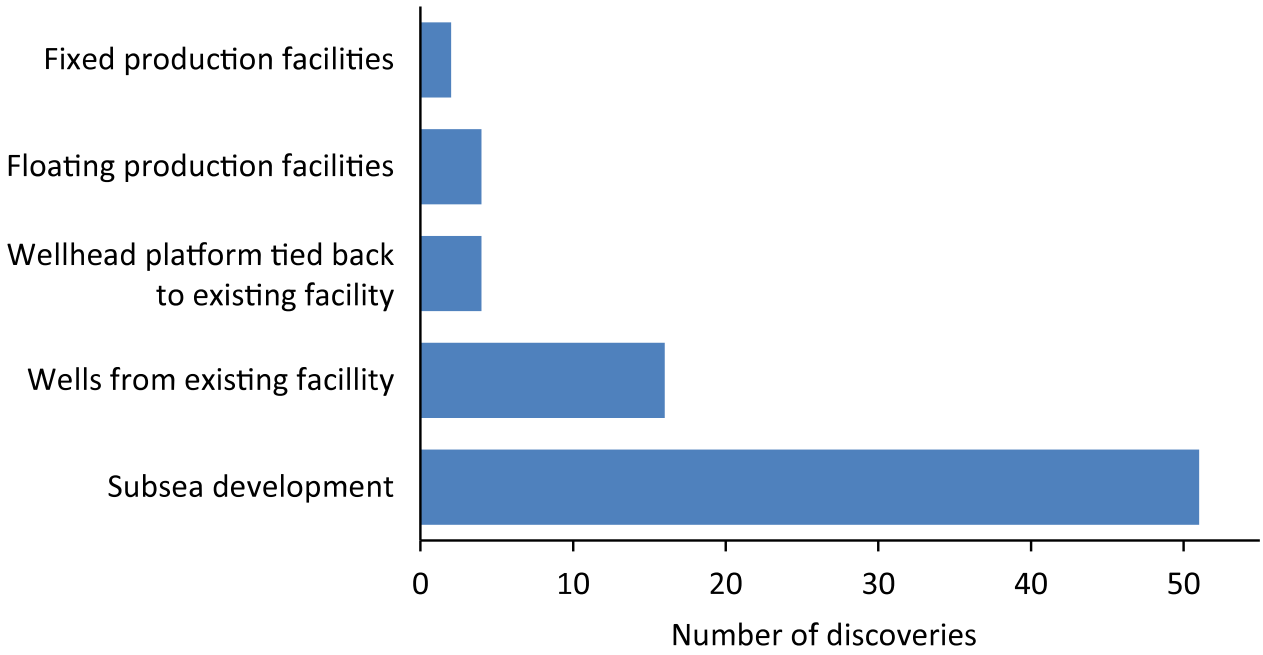
Area solutions

Most discoveries in the portfolio will be produced by phasing in new subsea installations or by drilling wells from existing facilities. Almost NOK 2 500 billion in 2016 value has so far been invested on the Norwegian continental shelf (NCS) in the form of installations, pipelines and

land-based plants. Exploiting this infrastructure efficiently is important. Many discoveries can utilise existing facilities which have spare process and export capacity.

In both the North and Norwegian Seas, proximity to infrastructure helps to make small discoveries profitable to develop. Infrastructure in the Barents Sea is limited at present. The biggest discoveries there are currently being developed with stand-alone solutions. Planning these so that they can also be utilised to develop possible new finds in the area will be important.

When additional production from a discovery is tied back to a host field, it usually opens new opportunities for the latter. Increased revenues can contribute to extending its producing life, and new measures for improved recovery can be implemented.



Most discoveries in the portfolio will be produced by phasing in new subsea installations or through wells from an existing facility.

Download data

Subsea installations

The most relevant development concept is the installation of subsea facilities phased into the existing infrastructure. This means that the development of many discoveries depends on capacity in nearby host facilities. Subsea solutions are constantly being developed and optimised, and continued advances in this area are likely to offer opportunities for cost savings

Wells from existing facility

Many of the discoveries could be developed by drilling wells to them from existing facilities. That can make even very small finds profitable if they lie close to other discoveries or fields.

Wellhead platform tied back to existing facility

The NPD has observed an increase in the number of discoveries where an unmanned wellhead platform (UWP) tied back to an existing facility is being considered as a development concept. This solution could be cost- and production-efficient as an alternative to subsea installations in shallower waters.

Fixed or floating production facility

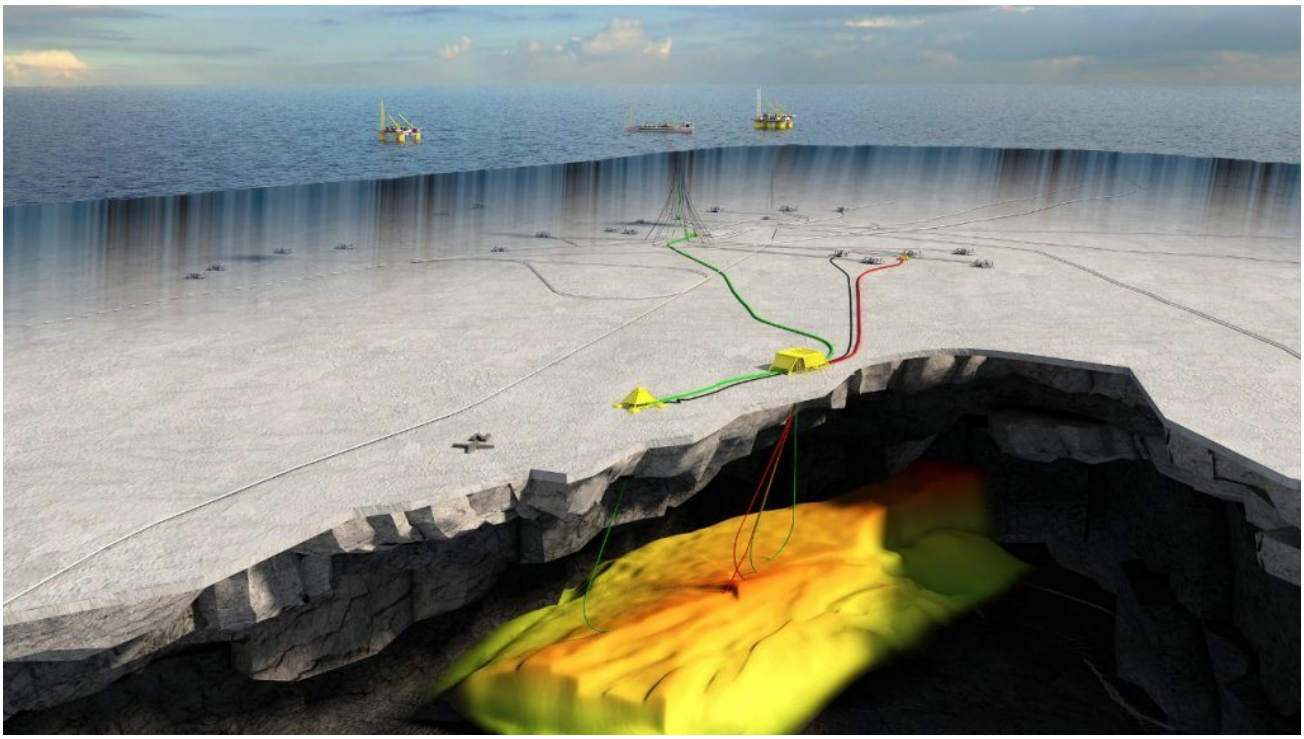
A floating production facility is under consideration for four of the discoveries in the NPD's portfolio, while a fixed installation is planned for two

Projects with a critical time frame

A number of developments could be dependent on a specific window of opportunity because they have to be tied back to infrastructure with a limited commercial life span. The NPD considers that a number of discoveries fall into this category, because the profitability of a development could be weakened if it is not implemented in time. Should a project be delayed for a lengthy period, it runs the risk of not being implemented.

All the discoveries with a critical window of opportunity depend on the operational life of the host facility. Found in both Norwegian and North Seas, these discoveries account for 15 per cent of recoverable resources in the total Portfolio.

The NPD considered Trestakk and Oda (formerly Butch) to fall within a critical time frame last year. Oda was important because its gas is to be injected in Ula and will have a positive effect on oil recovery from the latter. The NPD worked with the companies to secure a development, and the licensees decided in 2016 to develop both Fields.



Trestakk. (Artist's impression: Statoil)

READ ALSO: Maturing Trestakk to a plan for development and operation (PDO)

Using spare capacity in the surrounding infrastructure significantly reduced development costs. Better utilisation of host installations also helps to extend their commercial life and increase value creation from them.

Viewed overall, therefore, development of these discoveries represents substantial value both for the licensees and for society. Further utilisation of spare capacity in the existing process and transport system will thereby be the key to creating big value from the discovery portfolio on the NCS.

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Adopt new technology

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Norway has built up a petroleum industry with world-leading capabilities in research and technology development. This is a result of operator companies, suppliers, research institutions and government agencies joining forces to overcome both technical and financial challenges.

The Norwegian model, with extensive knowledge- and information-sharing between different players, has made and will continue to make an important contribution to innovation in the petroleum industry.

Many new ideas get no further than laboratory testing. Some show a substantial potential for success if development work continues, but lack opportunities for field testing.

The NPD's resource overview shows that large resources and big opportunities for value creation remain on the Norwegian continental shelf (NCS). Ensuring that all the expertise and capacity which has been built up gets fully exploited is important. The NPD wants to see more full-scale testing and field trials under real conditions. However, this requires that the licensees prioritise and conduct such tests. They must take the lead and display boldness, have a clear strategy, make capacity available and have a dedicated management.

Drilling and well technology must take priority

Drilling production wells is the most important measure for securing Norway's future oil and gas output. This work has recovered again over the past four years after a period with some reduction in drilling.

Fields which have contributed most to the increase are big, old producers such as Troll, Ekofisk, Statfjord and Oseberg. As fields age, continued development of cost-effective solutions which can maintain and permit the production of remaining profitable resources becomes a matter of urgency

Many new wells are being drilled in older fields on stream, such as Troll. (Photo: Øyvind Hagen/Statoil)

A high priority must therefore be given to developing and implementing new drilling and well technology. Experience with technologies already in use on certain fields must be shared and made available, so that these solutions can be adopted elsewhere. Examples include advanced wells, managed pressure drilling and managed pressure cementing. But it also applies to technologies still in the testing phase, such as solutions for drilling in shallow and tight reservoirs.

Drilling efficiency has improved

Improved drilling efficiency is positive, but continued willingness to produce resources in more complicated drilling targets will also be important. It could be unfortunate if part of the cost saving and improvement in drilling efficiency means that easier targets take priority over more demanding ones. That could be at the expense of technological progress and prudent recovery.

READ MORE: Number of production wells, cost developments and technology

Digitalisation

The petroleum industry has long been working to adopt digital solutions. Cases in point include integrated operations and automation of work processes. Various solutions for

automating drilling processes, for example, have been under development since the 1980s. Digital solutions could reduce problems and boost productivity through increased utilisation of well data and management during drilling. They also offer reductions in health, safety and environmental risk.

Rapid progress with digital capacity in recent years opens new opportunities. Digitalisation is regarded as an important key to a lasting reduction in costs through the development of new digital applications.

Digitalisation involves big changes to the way people work and not least how they think. Norway's national strategy for research and development in the petroleum sector (OG21) supports the importance of this revolution through targets on continued progress with automation, autonomous and ICT technologies.

This strategy also reflects an appreciation that players in the petroleum sector could have a lot to gain by drawing on available technology and experience from other sectors. Research centres with assignments across several disciplines can play a key role here. Examples are the International Research Institute of Stavanger (Iris) and Sintef in Trondheim.

AUTOMATION

Technology for automation and real-time monitoring of the drilling process has been adopted on Statfjord. Its basis has been developed by Iris and commercialised by the Sekal company, which is continuing to develop the technology and deliver solutions for use in the industry.

Well data are fed continuously during drilling into advanced computer models. These calculate the parameters which the operator must stay within in order to avoid problems and communicate them to the drilling system. In this way, real-time data from the whole well under the operation can be utilised to ensure an efficient drilling process.

This can also mean reduced formation damage in the well, enhanced productivity and lower health, safety and environmental risk.

READ MORE: Drilltronic (sekal.com)

Full-scale testing – a bottleneck

Historically, the NCS has served as a full-scale laboratory for many new solutions related to drilling, recovery, and subsea and flow technology. The NPD notes that a number of players in the industry are expressing growing concern over an increasing tendency for more time to pass between the development of new technology and field testing.

Åsgard subsea compression is an example of new technology which has been implemented and gives good results. (Photo: Statoil)

Instruments for getting pilots conducted

The NPD pushes for and encourages the development and application of new technology. Where the government considers it appropriate, approval of a plan for development and operation (PDO) can be made conditional on developing and piloting new technology. Johan Sverdrup in the North Sea provides an example. This field is now under Development, closely monitored by the NPD in the planning phase. It became clear at an early stage that a separate plan was needed for technology on the field. Staging a two-well polymer flooding pilot was one of the conditions set when the Government approved the PDO.

READ MORE: Polymer pilots on Johan Sverdrup and Heidrun

Eliminating bottlenecks through collaboration

The OG21 strategy from 2016, led by the Ministry of Petroleum and Energy, provides some explanations for why full-scale testing and implementation represent a bottleneck. Possible barriers can include:

- vague or uncoordinated strategies among licensees
- emphasis on risk
- emphasis on required rates of Return
- lack of clarification of the opportunities
- lack of incentives in contracts
- lack of access to real test conditions

- lack of standardisation
- lack of infrastructure
- lack of capital, expertise and priorities among minor players

Example of deferred full-scale testing

SWIT is a new solution developed to provide direct intake and treatment of seawater for injection on the seabed. All injection water currently gets treated on the production facilities, which is demanding in terms of weight, space and energy. SWIT could have the potential to cut costs and increase flexibility in positioning water injection wells. It has been assessed in the choice of concept for several developments on the NCS without being adopted. However, a full-scale prototype is now under construction for testing in deep water during early 2018 before being ready for field installation. This represents a collaboration between private investors and the Demo 2000 programme.

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Players on the NCS

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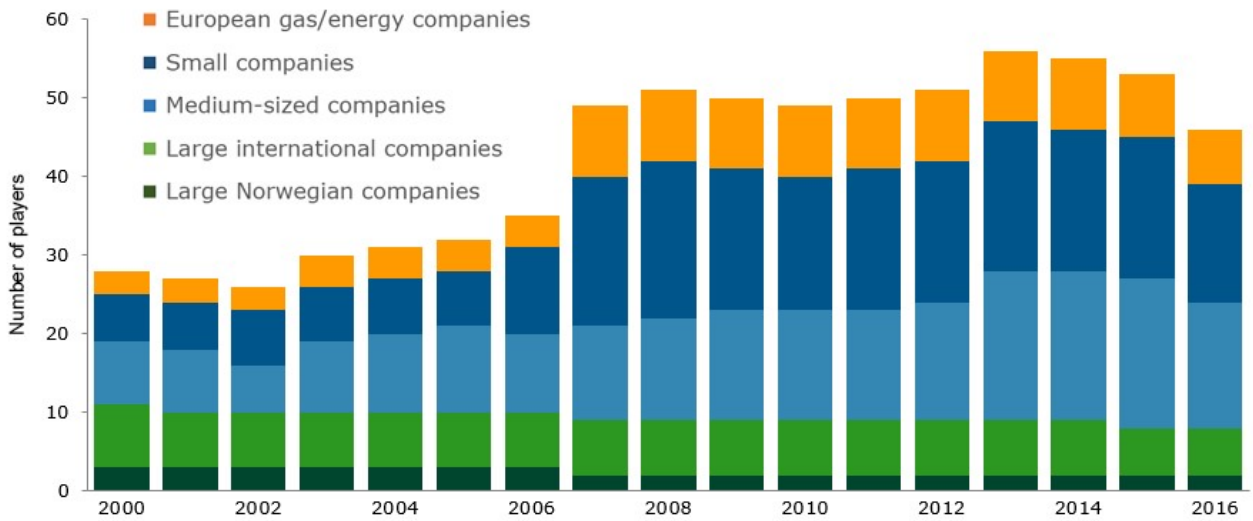
Activity on the NCS was dominated by large companies until 2000. Since then, different measures have opened the doors to various types of players and have greatly increased their number. A player picture which reflects the challenges facing the industry is positive in helping to realise the potential for resources and value on the Norwegian continental shelf (NCS).

Many of the new players are seeking other kinds of business opportunities than the big international oil companies – through exploration for smaller deposits in more challenging areas, for example. Players with different perspectives strengthen preconditions for value creation in both mature and less explored areas of the NCS.

Players

The biggest changes in the player picture occurred in 2002-07, when the number involved almost doubled. Participation has been more stable over the past decade. Nevertheless, market conditions appear to have influenced developments. High oil prices and considerable activity steadily attracted new companies in 2010-13. This increase has reversed to some extent in recent years.



There were 46 licensees on the NCS at 31 December 2016.

As in earlier periods with big price falls, the present downturn appears to have resulted in some company consolidation. While 55 licensees held interest in active production licences in

2013, that number was down to 46 by 31 December 2016. With the exception of large Norwegian companies, this decline has affected all company categories during the period.

COMPANT CATEGORIES

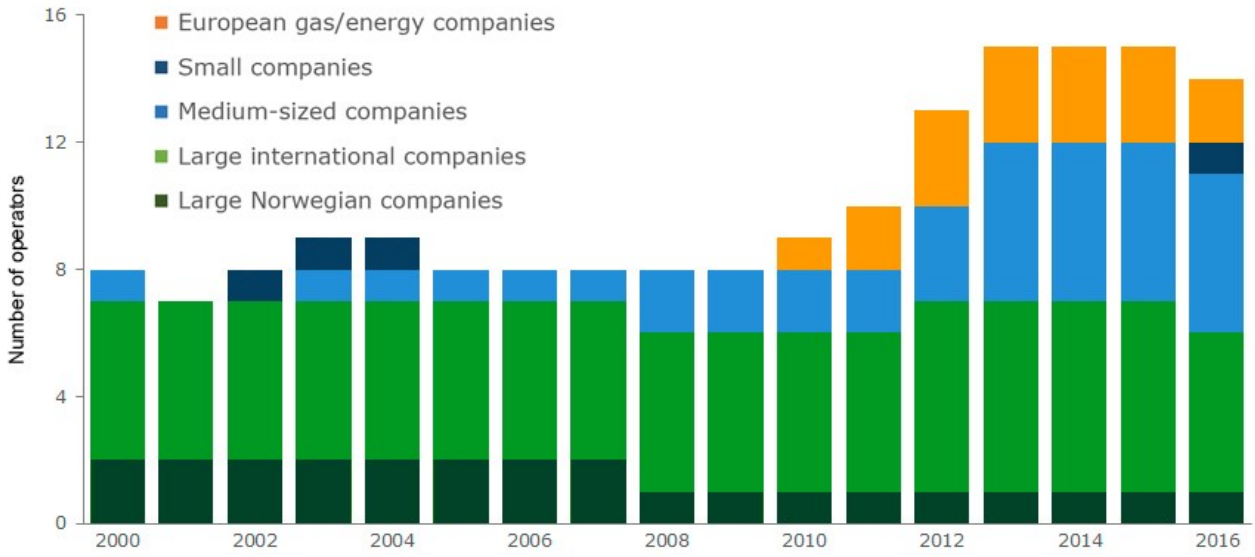
The classification of company types is presented below, with operators for producing fields in boldface. Allocation to the various categories is based on a combination of size, nationality and phase (strategy). Size is defined by the enterprise's market value on the stock exchange. The transfer of companies between different categories has been preserved historically, since they mainly change type as a result of mergers.

- Large Norwegian companies: **Statoil**, Petoro
- Large foreign companies: **Total, Eni, ConocoPhillips, ExxonMobil, Shell**, Chevron
- Medium-sized companies: **Lundin, Wintershall, Repsol, Aker BP**, Hess, Idemitsu, Maersk, Tullow, Suncor, OMV, Lotos, Capricorn, DEA, MOL, Lukoil, Rosneft
- Small companies: **Faroe**, Fortis, Concedo, Skagen44, Lime, Origo, Kufpec, Atlantic, Wellesley, CapeOmega, North E&P, Point Resources, OKEA, Petrolia, Production Energy Company
- European gas/power companies: **Centrica, Engie**, Dong, Bayerngas, PGNIG, VNG, Edison

At 31.12.2016

Operator companies for fields on stream

Substantial growth has also taken place with companies operating fields on stream. This increase occurred primarily in 2010-13. Several of the companies became production operators by developing discoveries they operated, as when Eni took Marulk through to start-up in 2012. Others acquired operator status by farming into fields on stream. Examples include Wintershall, which took over Statoil's operatorship of Brage in 2013, and Faroe Petroleum through its acquisition of the Trym and Oselvar operatorships in 2016. Most of the rise in the number of operators reflected an increase in medium-sized and European gas/power Companies.

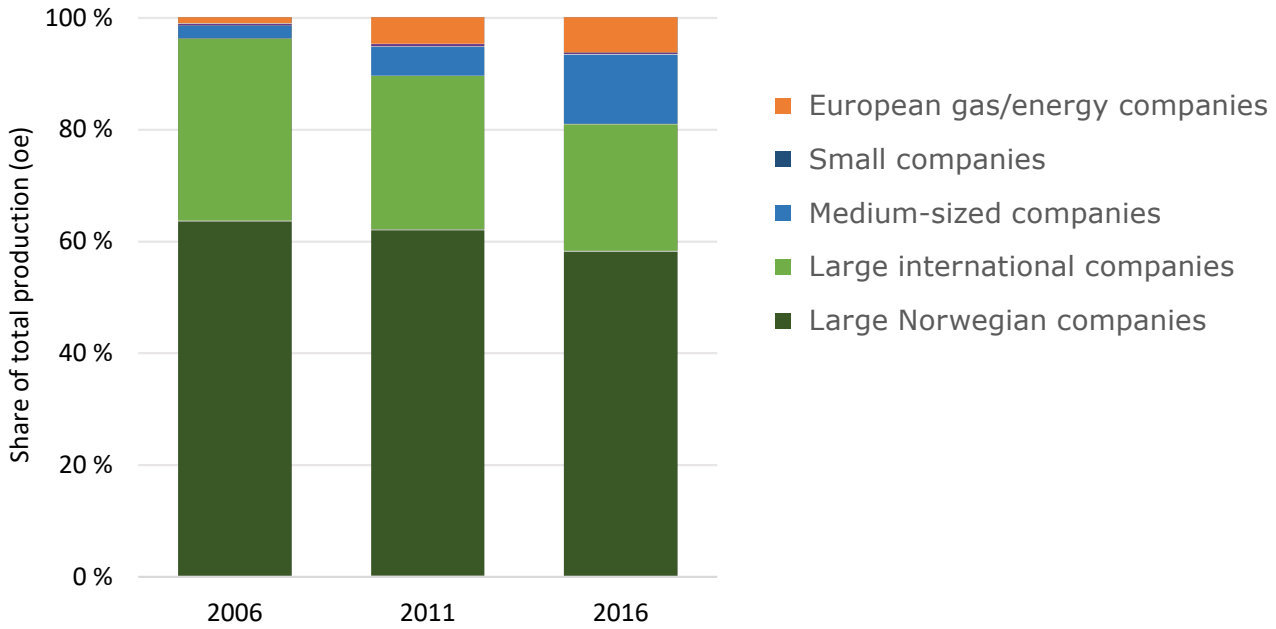


After a period when a number of new production operators emerged, the picture has been more stable in recent years.

After a period of substantial growth, the overall trend for the composition of production operators has been one of limited change over the past couple of years. A slight reduction in the number of operators for fields on stream nevertheless occurred in 2016, which supports the impression that some consolidation of companies in the production phase is under way. Examples were seen when Shell acquired BG and when Det Norske and BP merged to form Aker BP. Despite the relative stability in the number of production operators, constant revisions are taking place in the composition of company types. The purchase of ExxonMobil's operated interests by Point Resources provides a recent example of a player picture in constant change. This transaction is currently under consideration by the government

Production by company category

Although a number of new players have entered the NCS, the big companies still account for the bulk of output. However, production is breaking down ever more evenly between the various company categories. The share of medium-sized companies, in particularly, has increased sharply over the past decade.



A clear trend has existed towards a growing variety of companies over time (distribution of annual production, based on company holdings in operated and partner-operated production licences).

Download data

Players in the exploration phase

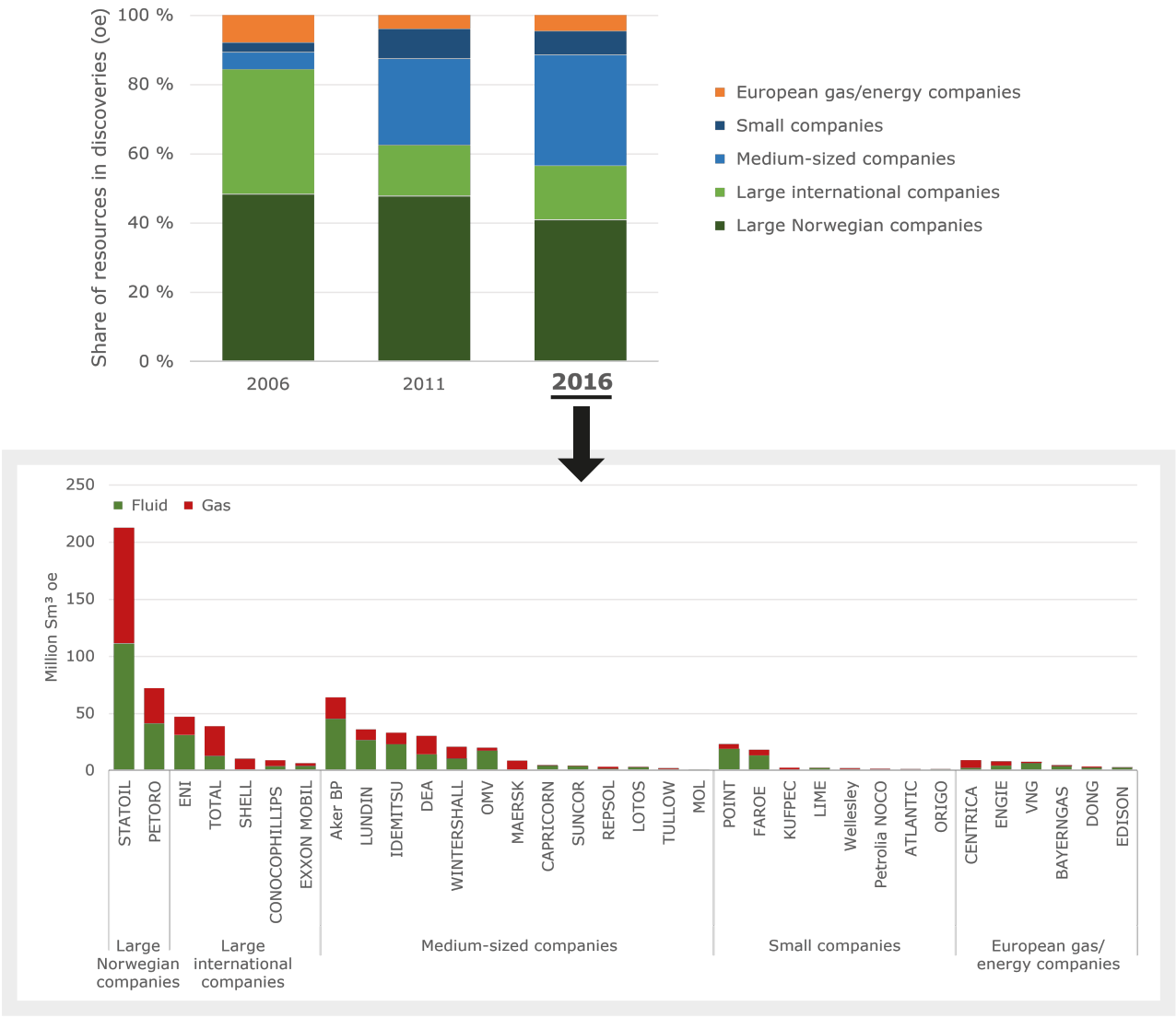
The growth in new companies has been particularly marked in the exploration phase. This has yielded a high level of activity, increased competition and a greater diversity of ideas. The 2016 resource report for exploration shows that the new players have generated activity, competition and different ideas, and thereby contributed to new discoveries and substantial value for society. This development emerges clearly when resources in the discovery portfolio are broken down by the various company categories:

- the large companies accounted for 84 per cent of the portfolio in 2006
- that share was reduced to 56 per cent by 31 December 2016.

Medium-sized companies hold about a third of the resources in today's discovery portfolio. In light of that development, a further increase in their share of output is likely as more discoveries are matured to Production.

Company resources in discoveries

The overview below is based on company interests in operated and partner-operated production licences.



Resources in the discovery portfolio have become ever more evenly divided between the various company categories over the past decade.

Download data

In addition to Statoil and Petoro, licensees with the biggest interests in resources in discoveries include Aker BP, Eni, Total and Lundin

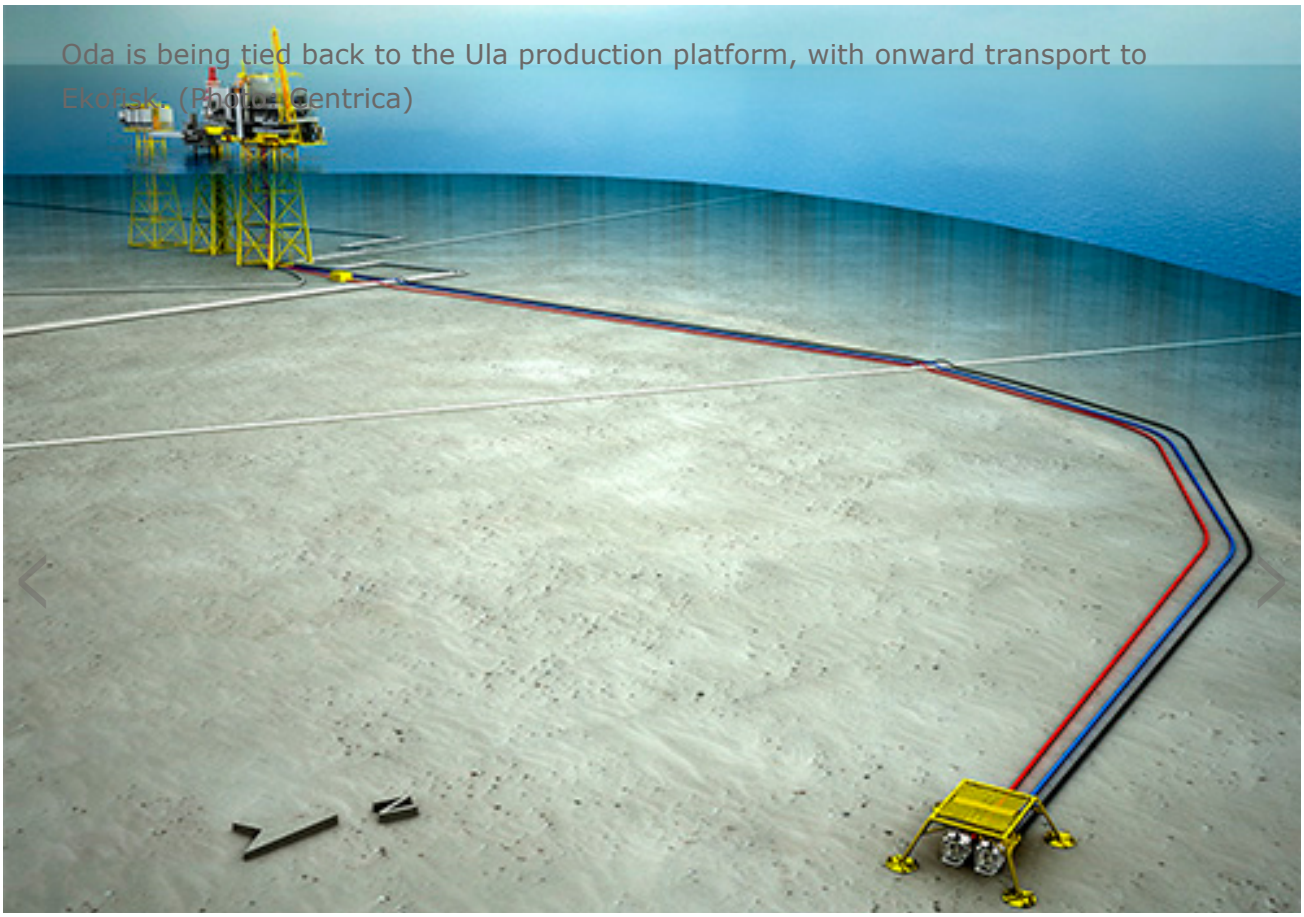
New players created added value

As new players account for a steadily growing share of activity on the NCS, it is important that they show the ability and willingness to develop projects which secure long-term value creation. Many cases exist of new players who succeed in maturing development projects to production.

- Wintershall submitted its first plan for operation and development (PDO) in 2015 as operator for Maria.

- Centrica is pursuing its first development as an operator on the NCS after submitting a PDO for Oda in 2016.
- DEA submitted its first PDO as an operator for Dvalin in 2016

Maria, Oda and Dvalin are examples which demonstrate that new field operators are important contributors to value creation on the NCS.



Oda is being tied back to the Ula production platform, with onward transport to Ekofisk. (Photo: Centrica)

Players learn from each other

As further companies enter the NCS, experience transfer between the players becomes steadily more important. New players can learn from companies with a long history in Norway's petroleum sector, while many are also able to contribute valuable experience and expertise from other oil and gas provinces.

The NPD’s role as a driving force and supervisor establishes parameters for contributing to experience transfer between players. Close follow-up provides insights which can also be utilised in the dialogue with others.

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