

The Technology for the 21st century

Programme
The pilot and demonstration program – DEMO 2000



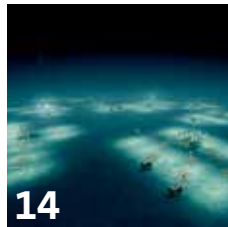
About the programme

The pilot and demonstration program – DEMO 2000

DEMO 2000 is a technology development program to improve the economics on the Norwegian Continental Shelf. The program shall secure increased export of technology from Norway. The funding is from the Norwegian Ministry of Petroleum and Energy. Grants from DEMO 2000 shall

qualify new technology that will improve efficiency, reduce costs and improve production on the NCS. DEMO 2000 shall increase the industries commitment to develop new technology and processes to the best for the society.

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DEMO 2000

The Demonstration and Qualification Programme DEMO 2000 is the product of an oil price fall. In spring 1998, the price of oil fell to just over 10 dollars a barrel. Investments in new and old fields ground to a halt. The oil companies downsized their workforces and consolidated through the merger of several companies. In Norway, this trend resulted in Saga Petroleum being swallowed up by Norsk Hydro.

The oil service industry feared that competent personnel would flee the industry and that many years' investments in new technology would be lost. Something had to be done. The industry realised that the Norwegian continental shelf had to become so competitive that new developments could be carried out and would be profitable even if the oil price remained low, at around 15 dollars a barrel. Oil service companies and the oil companies hatched a plan for developing and demonstrating new technology, and they launched the technology programme DEMO 2000. The programme soon won the support of then Minister of Petroleum and Energy Anne Enger Lahnstein and the Norwegian parliament, the Storting.

DEMO 2000 is a unique tool that is the result of the Norwegian model in which cooperation towards a common goal has a central place. The projects are based on a collaboration between the authorities, contractors and customers. It is the customers – the oil companies – that assess whether a proposed project is useful for the recovery of the petroleum resources on the Norwegian continental shelf.

The oil companies also play a key role as partners in the implementation of the projects, contributing both financial and human resources and a place where the technology can be demonstrated.

The project portfolio in DEMO 2000 mirrors the needs on the Norwegian continental shelf. The first projects prioritised subsea technology, since a large proportion of the developments that were planned on the continental shelf were based on this type of technology. However, other ground-breaking technologies were also tested with support from DEMO 2000, for example the first multilateral well. Integrated operations, automatic drilling and improved process

technology with lower energy consumption and climate gas emissions have been important priorities. The project portfolio has largely been based on the guidelines in the technology strategy set out in Oil & Gas in the 21st century (OG21).

Most of the current portfolio is concerned with more efficient drilling solutions and advanced downhole technology, both of which are necessary in order to achieve the government's and the companies' goal of increasing reserves. As of 1 August 2014, 285 projects have been awarded a total of NOK 850 million in funding. This has triggered projects worth NOK 3.5 billion and contributed to Norway being one of the few countries that has contractors/suppliers that cover the whole value chain for offshore oil recovery.

*Anders J Steensen
Programme Coordinator DEMO 2000*

From crisis to commercial success

DEMO 2000 is a product of the crisis that hit the oil industry in the late 1990s. As it has evolved, it has proven to be one of the most successful schemes ever for the oil service industry, the oil companies and society at large. Without DEMO 2000, Norway would have missed out on many commercial successes, extensive subsea developments and advanced well drilling.

The outlook was very gloomy for the Norwegian oil industry in 1998. The oil price was heading for ten dollars a barrel, and the industry feared that it might plummet to as low as five dollars a barrel. The oil companies slammed on the brakes in relation to their exploration budgets and implemented cuts in other budgets that hit the oil service industry hard. Some

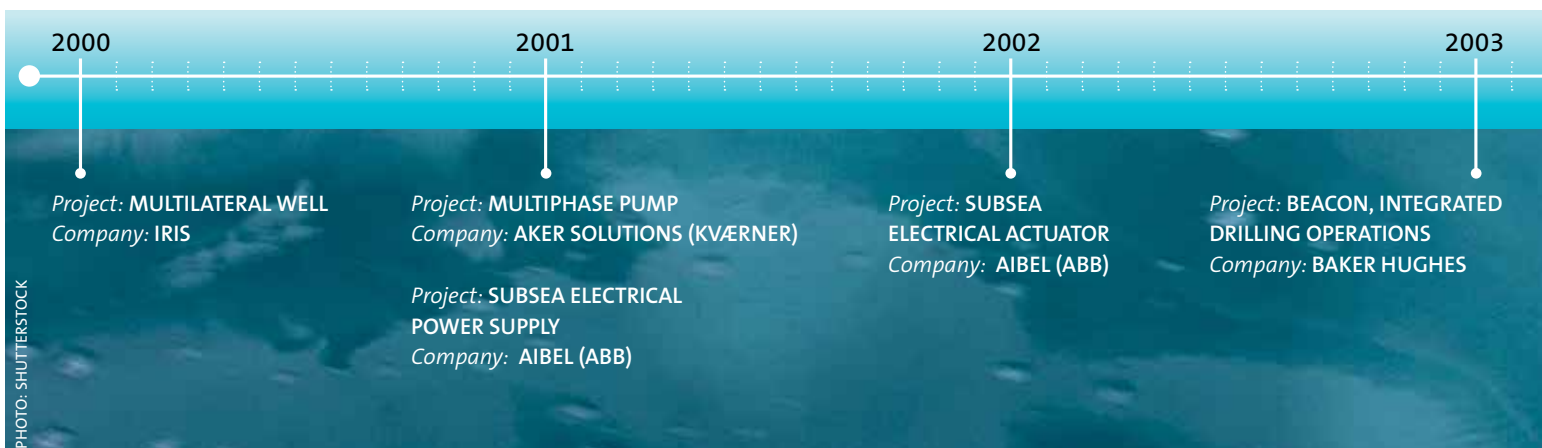
people saw possibilities, however. TBL (now the Federation of Norwegian Industries) took the initiative to form a committee of representatives of the oil service industry, research communities and the oil companies. The committee was tasked with examining how Norway could promote research-based innovation in the oil service industry. It was to build on the

good Norwegian schemes for the oil companies' investments in research and development, a policy that had given rise to strong Norwegian research communities, but without producing practical results.

Brought the best together

On the committee, which was given the name R&D Team Norway, the oil service

Timeline for DEMO 2000



industry was represented by Aker, Kværner, Umoe and ABB, and the research community by SINTEF, the Institute for Energy Technology (IFE), Rogalandsforskning and CMR, while Statoil, Hydro and Saga participated from the oil companies.

In record time, R&D Team Norway came up with a proposal for how research results could be tested in real-life situations. The initiative was named DEMO 2000 to underline that the technology was to be tested in practice by the year 2000.

DEMO 2000 was not just intended to come up with new solutions, but also

to ensure that the new technologies were properly qualified before they were introduced in practice. The backdrop was the oil companies' concerns about major cost overruns. If they were to introduce new technology, they had to be sure that it would work as intended.

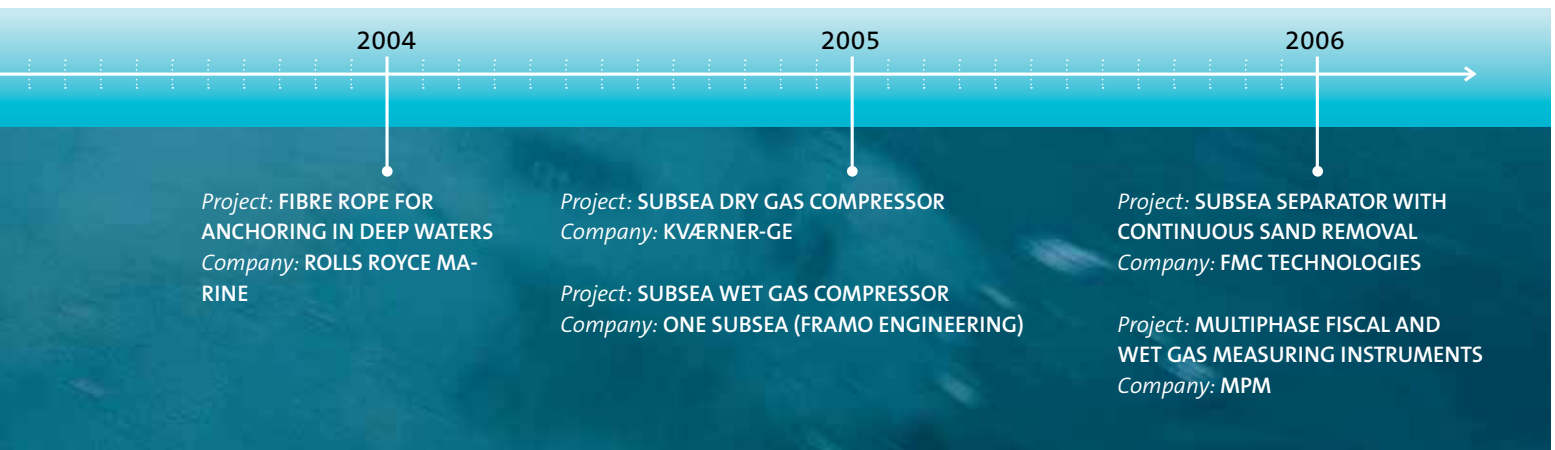
Funding in place in record time

In spring and summer 1999, the Government was looking for proposals it could include in the revised national budget that would stimulate activity on the Norwegian continental shelf. The timing of the proposal for DEMO 2000 was perfect.

With Anne Enger Lahnstein as Minister of Petroleum and Energy, DEMO 2000 was allocated NOK 100 million for its first operating year in 1999. That is probably the shortest time it has ever taken in Norway from an industry reaching agreement on a proposal until the Storting agreeing to fund it.

Calls for funding applications were administered by the Research Council of Norway. The industry was quick off the starting blocks.

'A large number of good applications were submitted, and around 40 projects were awarded support,' says Morten Wiencke,



> who was Programme Director of DEMO 2000 from 1999 until 2009. He is currently Director of Global Technology Innovation at GE Oil & Gas.

‘To be approved, a project had to demonstrate new technology and raise full funding. DEMO 2000 contributed up to 33%. The technology companies had to contribute part of the funding themselves and they had to recruit oil companies that would cover most of the investments. In other words, DEMO 2000’s role was that of matchmaker. Many of the projects that were started in 1999 have proved very important to the development of Norwegian and international oil activity,’ he says.

From scepticism to support

Testing new technology in a development project with a tight budget can easily lead to cost overruns. If production has to be

halted because problems arise, the loss of revenues is substantial. The DEMO 2000 programme has been, and still is, a support scheme that stimulates the oil companies to invest their own funds in order to take technology from the prototype stage to something that can be tested out on a field, where the oil companies are the hosts for pilots.

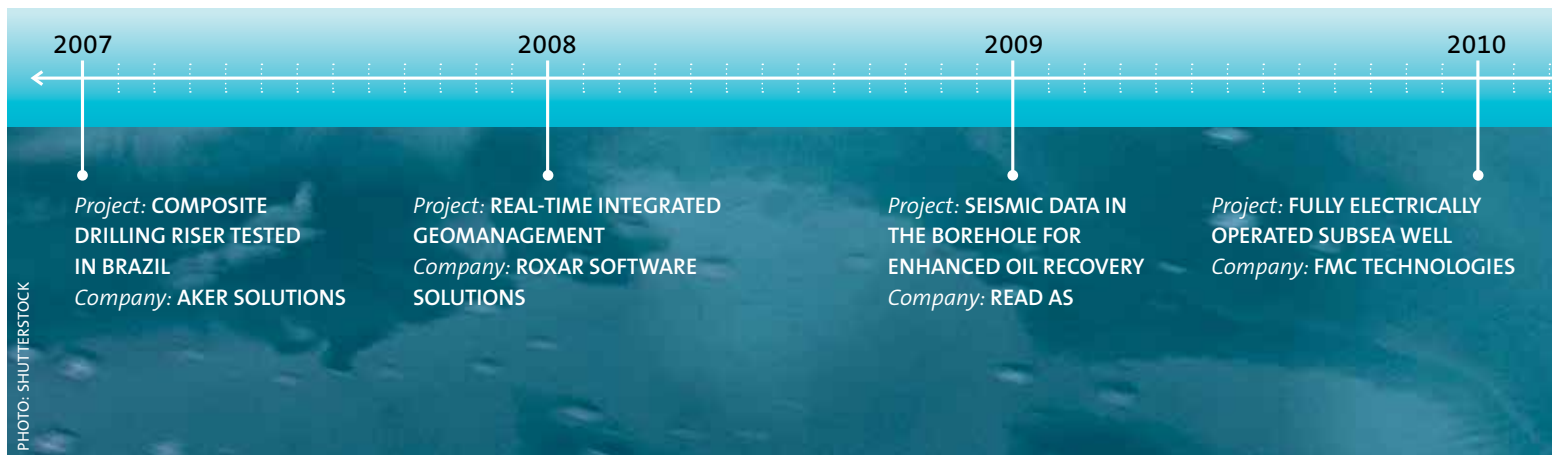
That is why it was important to make sure that the oil companies were represented on the Steering Committee for DEMO 2000 from day one. Statoil, Hydro, Shell, Elf and BP all contributed to getting DEMO 2000 up and running. Each of these companies appointed a key technology representative who could help to link the project applications to the right people in the oil companies.

‘This liaison job proved to be success factor number one for the DEMO 2000 programme. The companies that wrote the applications did not have these contacts themselves,’ says Wiencke, who did an active selling job in relation to the oil companies in the initial phase.

Biggest contributor

Wiencke emphasises that it is not the oil companies that receive support from DEMO 2000; it is these companies that contribute most to the funding. In its first ten years, DEMO 2000 contributed funding of NOK 640 million, while the total cost of the projects was NOK 2.5 billion, most of which came from the oil companies. ‘The programme gave the oil service companies effective help in qualifying their technology and thereby reducing the risk involved. Without this help, it would have been very difficult for them to sell

Timeline for DEMO 2000



new technology to the oil and gas industry,' Wiencke says.

In the second call for applications, in 2000, many applications were submitted that concerned technology for the Ormen Lange field. Hydro, which had become the operator of the field in the exploration and development phase, managed to get the partners in the licence to support the 15 DEMO 2000 projects that concerned deepwater technology and subsea solutions that could potentially prove useful on Ormen Lange.

A model for others

The Norwegian way of organising industrial collaboration on piloting and demonstration in DEMO 2000 has attracted interest from other countries.

'No matter where I travel in the oil context, whether to Houston or Kuala Lumpur,

people talk about DEMO 2000,' says Wiencke, who has been invited to many international conferences to talk about the Norwegian model, both while he was Programme Director for DEMO 2000 and in the years since.

Five years after DEMO 2000 was started, RPSEA, a similar programme in the USA, started supporting R&D and demonstration projects for the development of US gas resources in ultra-deep waters in the Gulf of Mexico and 'unconventional' gas resources, mainly onshore shale gas in the USA.

Brazil has also been inspired by the Norwegian model, and it made it a requirement that the oil companies earmark 1% of their gross turnover for R&D purposes. When the oil price rose to more than USD 100 per barrel, they realised just how much money this actually is. ●

The Statoil test loop facilities i Porsgrunn.
Photo: Anders J. Steensen



2011

Project: SUBSEA SWITCHGEAR
Company: GE VETCO GRAY SCANDINAVIA

2012

Project: CODIO PILOT
(INTEGRATED OPERATIONS)
Company: COMPUTAS AS

2013

Project: WIRELESS GAS DETECTOR
Company: GASSECURE AS

'DEMO 2000 is an arena where it is possible to establish contacts and where an oil service company with an idea can discuss it with an oil company with a need,' says Svein Bredahl. Photo: Sverre Jarild

'DEMO 2000 just as important today'

'More difficult reservoirs, greater ocean depths and more activity in the Arctic mean that it is just as important to develop technology today as when DEMO 2000 started,' says Svein Bredahl, chair of the Steering Committee for DEMO 2000. 'Not least in order to reduce costs.'

Even on the Johan Sverdrup field, which is situated in relatively shallow waters in a central location in the North Sea, it is not just a case of being able to use technology that has already been developed.

'There is always a need for new technology, both in order to recover difficult reservoirs, develop at greater ocean depths and to operate under Arctic conditions. The Arctic involves new challenges, such as icing and great distances to shore and other infrastructure. The whole industry is concerned with coming up with technology that makes it financially profitable to develop the fields,' says Svein Bredahl, CEO of Aker Solutions.

Drilling costs in particular have become very high. The wells have become longer, and more multilateral wells are being drilled. Wells and drilling often account for more than half of the costs of developing a

new field. The upside is that the oil companies can recover more from the reservoirs.

'DEMO 2000 is a programme that builds a bridge to technology that is under development but that no one is willing to introduce in practice. Getting the first user in place is the big obstacle. DEMO 2000 can contribute to qualify technology and verify that it works,' he says.

A number of technologies have been piloted and demonstrated in the 15 years that DEMO 2000 has been in existence. An estimated one billion extra barrels of oil have been brought to maturity using technologies and methods that were first tested in DEMO 2000.

Catalyst

The projects that are supported by DEMO 2000 can have maximum 25% of their costs covered. The oil service companies

and oil companies have to provide the rest of the funding. It is the oil companies that contribute most in this context.

'The 25% from the State through DEMO 2000 acts as a catalyst that both inspires others to come on board and funds and creates a joint arena for the participants. The oil companies, the oil service companies and the research institutions get together and discuss what challenges they need to get to grips with,' he says.

Competing oil service companies and oil companies sit down together at the DEMO 2000 meetings.

'This open set-up means that they share their knowledge, which is very positive in the national context. It is very much part of the culture in Norway. Foreign oil companies that operate on the Norwegian continental shelf are fascinated by



this way of working, where you share knowledge instead of hiring lawyers to safeguard your rights,' he says. 'These companies take active part in the work on DEMO 2000, and, in several cases, they have also provided us with testing opportunities outside Norway.'

Subsea success

Bredahl mentions two areas in which DEMO 2000 has been important to development:

Subsea technology, where Norwegian companies such as FMC, Aker Solutions and GE in Norway, have become world leaders in their respective fields, and drilling and wells, where many small companies have been given a chance to develop, even though the big drilling companies in Kristiansand have not been part of DEMO 2000.

Exports of products and services in the oil technology field have increased dramatically. In 1999, they were worth NOK 10 billion. In 2013, more than NOK 160 billion.

'Norway has been a laboratory for developing technology that we have subsequently been able to sell on the global market. Many of the technologies and products on the market today have been through DEMO 2000. But we cannot take credit alone. The oil companies have also developed a lot. Statoil, for example, has been very much in favour of introducing new technology,' he says.

Even more underwater activity

Bredahl believes that a lot of development remains to be done if drilling is to become more efficient and safer. And there is still a lot left to do on the seabed as regards separation, water injection and

compression now that more and more of the equipment is being moved from the platforms to the seabed. The big new challenge is ensuring a secure power supply for the subsea facilities, whether from shore or a nearby platform.

'We are completely dependent on the oil companies coming fully on board, taking initiatives and supporting suppliers with good ideas. And also guiding them in the right direction, so that developments are not just driven by engineers. DEMO 2000 is an arena where it is possible to establish contacts and where an oil service company with an idea can discuss it with an oil company with a need. More small and medium-sized enterprises have been included in DEMO 2000 in recent years, and we have helped many businesses to start up. The clusters in Stavanger, Bergen and, in part, Trondheim are hives of activity at the moment,' Bredahl says. ●

'DEMO 2000 contributes to the best possible utilisation of the laboratory that is the Norwegian continental shelf,' says Minister of Petroleum and Energy Tord Lien.
Photo: Sverre Jarild



Keeping a cool head

Also in cost-cutting times, the research community and the oil service industry still need access to ‘the big laboratory’ – the Norwegian continental shelf. Better utilisation of resources on the Norwegian continental shelf is also a good climate measure, believes Minister of Petroleum and Energy Tord Lien.

The oil industry is facing major challenges as it ventures further north, into deeper waters, endeavours to recover more from the oil and gas fields and operate in a more environmentally friendly way and use less energy. What stimulation measures is the Government planning to introduce to ensure that the oil companies get the technology they need?

‘We have very high competence in this field in Norway. It is important that this competence finds its way to the continental shelf, where it can make itself useful. It is a precondition if these high-competence groups are to continue to grow stronger in future that they are given access to the big laboratory that the Norwegian continental shelf actually is. DEMO 2000 helps to ensure that the best possible use is made of this laboratory. Such activity presupposes that there is activity out on the continental shelf, and also that we provide stimulation to ensure that the resources on fields in production are recovered and to open new areas for development.’

The Arctic and the northern Barents Sea represent even greater challenges?

‘Large parts of the Barents Sea are less demanding in terms of climate and weather than parts of the Norwegian Sea. But some of the resources are further from shore, and they involve operational and technological challenges that need to be solved. Research and development play a key role in that context.’

Reducing bureaucracy in the sector

The oil companies are very concerned at the moment about reducing drilling and well costs. And yet the costs are increasing. How can we solve this problem?

‘I am glad that OG21 gives priority to reducing costs in a number of areas. Some of the increase in well costs is due to the fact that the wells are more challenging to drill. But there is no doubt that we must continue to develop new ways of working and develop new technology. Technology is important if we are to succeed in cutting costs and thereby making more resources accessible on the continental shelf. And I must say that there is a lot of bureaucracy in the sector. That is a problem the sector itself could do something to improve.’

What does the Government plan to do to maintain the activity level?

‘Historically, cost challenges have led to increased demonstration and piloting activity – with a view to putting new technology in place that can reduce costs. I believe that the same thing will happen this time. Part of the explanation for our success on the Norwegian continental shelf is that we have managed to keep a cool head and not deviated from the long-term path, by continuing to invest in basic research and business-oriented petroleum research, and by making fields available to the industry.’

As important a climate measure as renewable energy

Is it right to spend a lot of research funding on fossil energy when it is renewable energy that will win in the long run?

‘The efficient production we see on the Norwegian continental shelf of light oil that requires little energy to refine, and the production of gas, are at least as important contributions to reducing CO₂ emissions as renewable energy in the global energy mix. It is coal that is behind the big CO₂ emissions. This means that it is fully justifiable to spend research funds on increasing the available resources and thereby the value creation on the Norwegian continental shelf, also from a climate perspective,’ says Minister Tord Lien. ●

The subsea dream has become a reality

The world's first full-scale commercial subsea processing plant will be installed on the Åsgard field next year. Qualification of the technology started with the Ormen Lange field 12 years ago, with good help from DEMO 2000.





In the mid-1980s, people started to dream of recovering oil and gas from the seabed and pumping it to shore, without there being any platforms on the surface. The motivation for this was primarily that larger amounts could be recovered from the reservoirs and that it would be cheaper.

In the late 1990s, Norwegian oil service companies started in earnest to develop processing plants for use on the seabed. Already in 1989, Kværner (now Aker Solutions) started developing the world's first subsea facility for keeping up the pressure in the pipelines. Esso, Saga, Statoil and the Research Council of Norway all supported the project.

Gave us a head start

'Some people believe that we started far too early. I believe that this gave us a head start that resulted in a pilot on Ormen Lange, where we could demonstrate the results. Subsea technology is still in its infancy, but it is starting to really generate earnings now,' says Kjell Olav Stinessen, Chief Engineer in Subsea Power & Process at Aker Solutions. Stinessen has taken part in the development right from the start with Kværner.

In the early 2000s, qualification started of technologies that led to Ormen Lange being realised. In 2001, DEMO 2000 awarded support for two large demonstration projects in which subsea compression was tested in big tanks.

After the DEMO 2000 projects, Shell, Eni, Statoil (then Norsk Hydro Oil & Gas) and Aker Solutions further developed the technology in a concerted effort. A 12.5-megawatt compressor was designed but not built.

◀ The oil companies want more production, processing and transport to take place on the seabed. Illustration: Aker Solutions.

The Ormen Lange pilot

Statoil continued the development work and started a qualification project for critical components. Aker Solutions and other oil service companies were invited to carry out studies. In 2006, Aker Solutions was awarded the contract for the pilot installation of a compressor station for Ormen Lange subsea.

It became one of Norway's biggest ever industrial development projects. Around 50 components had to be developed and qualified for use under water. The delivery has still not been completed.

In 2015, Statoil will install two subsea compression trains on the Åsgard field, a big contract for Aker Solutions and the world's first commercial full-scale delivery.

'It has been an incredible journey. When we started in Kværner, we were five employees and we didn't have any products. We are now at the cutting edge of subsea technology, we have 9,000 people working for us, if we include contract employees, and we have all the products required for subsea processing,' says Stinessen.

Good prospects for the Norwegian oil service industry

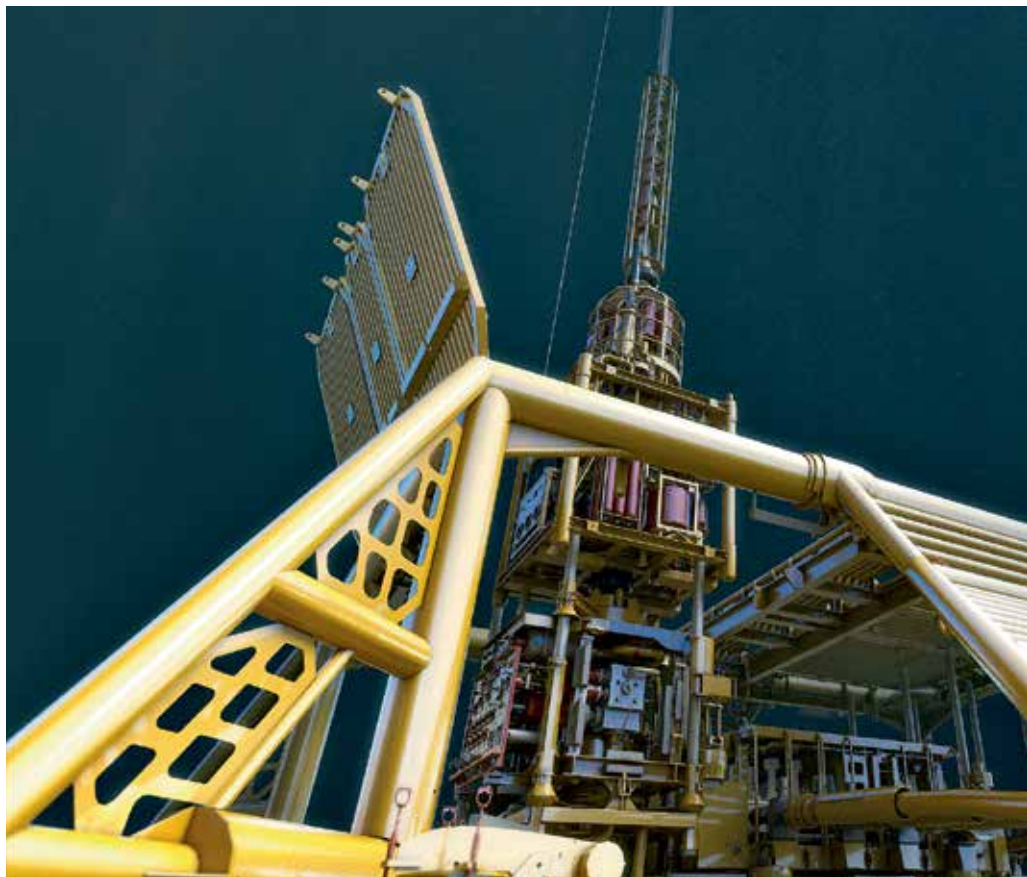
Norwegian suppliers are now world leaders in multi-phase pumps, and at the cutting edge in relation to subsea compression and subsea pumps. The oil companies want to move compression to the seabed on more and more offshore fields. Stinessen sees big opportunities for Norwegian subsea deliveries to Brazil, India, Malaysia and Australia in the years ahead. ●



The oil service companies need test fields where they can test new subsea technology. Photo: FMC Technology



‘FMC Technology has received good support from DEMO 2000,’ says Rasmus Sunde.
Photo: Sverre Jarild



> Benefits greatly from support programmes

The North Sea is a big technology laboratory where the oil service industry is responsible for a lot of the technological development. For FMC Subsea, DEMO 2000 has played an important role in enabling it to grow internationally from its origins on the Norwegian continental shelf.

‘The DEMO 2000 programme has given us an opportunity to take part in some technology developments that we would not have been able to do on our own, at the same time as we have developed an international strategy. Field development used to be the driving force, now it is subsea technology,’ says Rasmus Sunde, CEO of FMC Subsea.

Need test fields

A lot of the development aimed at solving pressing technology challenges has been done directly by the companies, without public funding. The oil service companies see potential markets for new technological solutions, and they are driving development. But they are dependent on the oil companies giving them access to testing.

‘It is extremely important that there is a customer or operator with a petroleum field where we can carry out testing and

gain experience,’ Sunde underlines. FMC Subsea has worked closely with Statoil on finding solutions to major technological challenges. These technologies have then been exported worldwide.

Made technology boost possible

DEMO 2000 made an important contribution to development and testing when oil prices were low and cost-cutting was required.

‘DEMO 2000 is not just important financially, but also in order to ensure that the petroleum clusters in Norway pull in the same direction. It benefits the whole cluster when the civil service and the authorities lead the way. After 25 years in the industry, I have learnt to respect the petroleum clusters,’ says Sunde.

FMC Technologies became involved in subsea technology from the outset,



almost 30 years ago. With a market share of approximately 40%, the company is now the world's leading supplier of subsea technology, with 4,000 employees in Norway. It has grown by around 23% a year for the past four years.

High level of activity in Africa

FMC Subsea is currently most active in Africa, with field developments in Angola, Nigeria and Ghana, among other places. Norway is still an important market for the company, however. A large proportion of the Norwegian production already takes place using subsea wells. Statoil is currently the second biggest company in the world measured by the number of subsea wells in production, after Petrobras.

'I am optimistic about the Norwegian market, and I believe that subsea technology is cost-competitive here,' says Sunde. ●

Simulator making multiphase flow more economical

The oil companies are saving millions by using a simulator developed in Norway to control production from wells in the best possible way.

LedaFlow is a decision support tool for use when oil, water and gas are transported in the same pipes, what is called multiphase flow. The tool has been developed under the leadership of Kongsberg Oil & Gas Technologies. The advantage of this innovative tool is that it produces more accurate results and has better functionality than corresponding tools.

Important distribution job

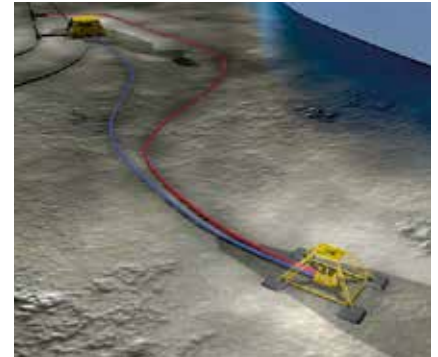
Total E&P Norge AS in Stavanger uses an online version that is integrated with the production support system for the Skirne/Atla fields.

The system is also used to monitor the well flows from the different operators' wells, so that it is clear how much each operator has delivered. These flows are collected in a joint pipeline. The simulator is responsible for annual savings of NOK 10–15 million in this project alone.

Several interested companies

'Total has been a good partner in the development of the simulator. We now have several customers that want to use the simulator tool online in real time,' says

Layout for LedaFlow on the Atla field.
Illustration: Kongsberg Oil & Gas Technologies



Arne Aas, Global Department Manager for Real-Time Production Assurance at Kongsberg Oil & Gas Technologies.

It was Sintef, ConocoPhillips and Total that started developing LedaFlow in 2001. The goal was to develop a tool that would produce a more accurate result that is closer to the physical reality and reduces the design margins.

Kongsberg Oil & Gas came on board as a commercial partner in 2009 and became a co-owner together with Total, ConocoPhillips and Sintef in January 2014.

Greater accuracy

LedaFlow is more accurate and includes more details in its simulations than its competitors. Among other things, it carries out separate temperature calculations for gas, oil and water and what is known as slug calculation:

At low flow speeds, oil and water are transported in waves in the pipeline. When the waves fill the cross-section of the pipe, fluid slugs arise. The simulator is capable of predicting when they arise and where in the pipeline the fluid accumulates. ●



> Successful investment in multiphase compression

Next year, the first commercial installation of subsea multiphase compressors from OneSubsea will start on the Gullfaks field. Their development started in Bergen as far back as the 1980s.

'It is incredible that a small company based in Western Norway can compete with the big, international compressor manufacturers,' says Nils Arne Sølvik, Vice President of Emerging Technologies at OneSubsea, for-

merly Framo Engineering. Sølvik has been involved in much of the development.

The founder of the company, Frank Mohn, predicted already in the 1980s that something was going to happen in the subsea area, and the company invested in compressors that could maintain the pressure.

From ships to oil

Several concepts were considered, and contra-rotating compressors were chosen. The idea came from contra-rotating pumps that were used to move large amounts of ballast water on ships in a short space of time.

The idea was that the compression work should be carried out as close to the res-

ervoir as possible. This would allow the wet gas to be transported to and arrive at the receiving plant at the highest possible pressure. The compressor had to be robust and withstand different types of fluids, particles and other elements in the well flow.

Shell came on board in the early 1990s, and a 400-kilowatt compressor was installed directly in the well stream on a field in the Netherlands.

Little interest

As the 1990s progressed, the compressor's capacity and effect increased significantly. The oil companies' response was weak, however. There was a real danger that the





◀ Siemens's goal is that it will be possible to use the power supply equipment down to depths of 3,000 metres and to transmit power over great distances. Illustration: Siemens

concept would end up in a museum as an oddity in the history of the oil industry.

The DEMO 2000 programme started up around the same time. Together with Shell and Statoil, Framo Engineering was awarded funding from the programme.

'Demo 2000 proved to be a real shot in the arm that saved the further development of wet gas technology at Framo,' Sølviik emphasises.

A lot of time was spent on further developing the compressor over the next few years. A new hydraulic system was put in place, and the capacity was increased four to five-fold. When Statoil's Gullfaks programme started in 2008 and technology was to be qualified, a dedicated hydrocarbon test cycle was built at OneSubsea in Fusa.

Landed big contract with Statoil

The tests were successful. Now, 30 years later, OneSubsea has an EPC contract with Statoil worth NOK 800 million for the installation of compressors on the Gullfaks field in 2015.

'The delivery means a lot to us. We are now included when the big oil companies plan the further development of big subsea gas processing plants all over the world. All the big companies know who we are now,' says Sølviik. ●

◀ Compressor rig from OneSubsea in dry dock. A big delivery for Gullfaks will take place next year. Photo: OneSubsea

Electrifying the subsea factory

A dependable power supply for equipment on the seabed is crucial to successful subsea development. Siemens is almost ready for a DEMO 2000-supported test of its power supply system in water.

So far, power supply systems have been located on floating rigs, with point-to-point cables running down to each individual motor on the seabed. The limitations as regards weight, room, the number of cables, the length of the cables and the output that can be transferred mean that this kind of solution is not good enough for a subsea factory.

In Subsea Power Grid, the transformer, the drive and the switchgear have all been moved down to the seabed, with just one main cable running down to them. 'There are already subsea transformers. The truly innovative elements are the subsea switchgear and subsea drive. That hasn't been done before, except in an Ormen Lange pilot,' says Anngjerd Pley in Siemens, who is project manager for the DEMO 2000 project.

Thorough testing

Since it is expensive and difficult to repair equipment located on the seabed, dependability is paramount. Each individual part has to undergo a comprehensive qualification programme. It is crucial to find components that can withstand the fluid, the external pressure and the

temperatures at depths of 3,000 metres. Siemens has built a comprehensive test laboratory in Trondheim for this purpose.

Prototypes of drives, transformers and switchgears are tested, first in water in the factory at the old Dora submarine base in Trondheim. The system integration test is supported by DEMO 2000.

'We plan to run the equipment in the submarine base's dry dock in order to gain operating experience in water. The oil companies have made it very clear that they are not willing to try the equipment until it has been tested in water,' Pley says.

Chevron, Exxon Mobil, Petrobras and Statoil are partners in the project.

'DEMO 2000 is an arena where you are seen. The programme is known for supporting sound projects. It confers a hallmark of quality and makes it easier to discuss further support with partners,' Pley emphasises. ●



◀ 'DEMO 2000 puts a quality stamp on the projects,' says project manager Anngjerd Pley in Siemens. Photo: Siemens



INCREASED
OIL RECOVERY

Using tracers to monitor production wells

Operators need to have as accurate a picture as possible of what is going on down in the wells in order to optimise production. This has previously been a problem, but a Trondheim-based company came up with a solution that is being embraced by the oil and gas industry.

Development started at Sintef in 2003. Resman AS was formed two years later. In July the next year, the company had its first trial installation in a well on Statoil's URD field, with funding support from DEMO 2000.

'The funding was very important in the early phase in relation to getting a test well so soon after the start-up of the company, just a year after it was formed. That is unique in the oil industry. After the first installation, where we proved the technology, it was much easier to get wells number two and three,' says Torger Skillingstad, CEO of Resman.

Found in more than 180 wells

Today, the sensors are used by 33 oil companies worldwide in more than 180 production wells. More than 70% of sales are international sales, and the company has sales offices in Stavanger, Aberdeen, Houston, Rio de Janeiro and Abu Dhabi.

The company's turnover has increased by well over 50% per year in the last few years, and it is expected to grow at the same rate in the next three years. It had a turnover of NOK 119 million in 2013. The company has 61 employees.

Sends out flows of molecules

Resman has developed and patented unique chemical molecules that are used as tracers. The tracer molecules are embedded in a special type of plastic and installed in cavities in the steel pipes that are used to reinforce the production wells.

There are two types of molecules in the plastic rods. One type is released when it comes into contact with oil, while the other is released in contact with water. The sensors are installed in different zones in the wells.

The molecules flow up to the platform on the surface, where samples are taken. The samples are analysed in a laboratory. This allows the operators to identify the

location of water breakthrough and get a picture of how much of the different liquids comes from the different well zones.

'It is a kind of wireless monitoring of what goes on in the well, with no risk for the operators,' says Skillingstad.

Cheaper and safer

Resman's technology provides continuous information from different reservoirs and wells. The plastic rods that contain the tracers do not damage the well either. The alternative is to stop production and lower sensors that are connected to an electric cable down into the well. Production is then restarted while the sensors move downwards and collect data. This is an expensive, risky and time-consuming way of monitoring wells.

'The costs can quickly reach NOK 100 million in a subsea well, so the operators do not want to do it in that way anymore,' says Skillingstad. ●



> Producing special water for enhanced oil recovery

Seabox has developed equipment that can produce clean water on the seabed for injection wells at reduced cost. The water can be specially adapted to different reservoirs' properties to further enhance recovery.

Water injection in the oil reservoirs is a common method for enhancing recovery. With today's methods, the water is produced up on the platforms, leading to high operating expenses and a lot of maintenance. By treating the water on the seabed, Seabox will help to get as much as possible from the reservoirs in a more cost-effective way.

Tailored injection water

Subsea Water Intake and Treatment (SWIT) treats the seawater down on the seabed, removes particles and can add chemicals to the water before it continues to the injection pumps. By tailoring the properties of the water, it can be made more suitable for extracting oil from the reservoirs. The equipment was tested in the Oslofjord for six months in 2013 in a DEMO 2000-funded project that yielded good results. The water was analysed

by the Norwegian Institute for Water Research (NIVA) in Drøbak.

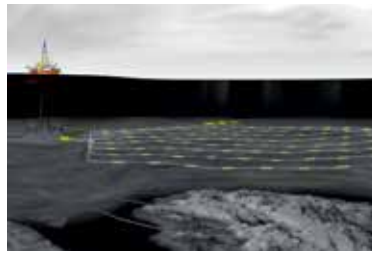
'It went very well. The SWIT technology, combined with membranes, worked as expected, and no changes in performance were observed during the six months. We now have confirmation that this is a technical solution that functions reliably over a prolonged period and that is capable of producing whatever water quality you want,' says Øyvind Espeland, COO of Seabox.

ExxonMobil came in as a partner towards the end of the Oslofjord project.

Removes elements from the water
Sulphates are food for sulphate-reducing bacteria that generate H₂S and make reservoirs go sour. They can also lead to the precipitation of solids in the form of particles, known as scaling, which can reduce permeability, clog filters and production pipes and create problems for pumps and other equipment. Both sulphates and salt are removed when the water passes through the membrane filter.

Salt affects the reservoirs' wetting properties. By influencing these reservoir properties, oil recovery can be increased by 2 to 30 percentage points. It is thereby





◀ The cables with seismic sensors cover the whole reservoir.
Photo: Octio

a very important element in relation to enhanced recovery.

The water quality can be monitored and the process controlled via the internet at any time and from anywhere in the world. During the test in the Oslofjord, the process was controlled by Seabox in Stavanger.

Heading towards commercialisation

The next step in the process is to place the equipment on the seabed in a project aimed at producing a commercial facility through an agreement with a company that wishes to use this type of solution.

Introducing new technology takes time in the oil industry. The consequences of incorrect assessments can be great, and oil companies therefore spend a long time on decision-making processes.

‘The technology qualification alone can take over a year. In addition, this is a technology that must be included in new development projects, which also take many years to realise. For us, it is important to secure funding at an early stage. DEMO 2000 is unique in relation to developing new technology and it helps to get projects off the ground,’ says Espeland. ●

◀ Injection water can be treated on the seabed.
Illustration: Seabox

Detecting micro earthquakes

The Bergen-based company Octio has developed a 4D seismic method that helps the oil companies to have a full overview of what happens when they inject water, gas or drill cuttings into the reservoir. A pilot plant is being tested on the Oseberg field.

Four-dimensional (4D) seismic data means that the data collection is repeated over and over again at pre-set intervals. This enables the oil companies to monitor developments over time.

Octio’s system consists of a network of seismic sensors on the seabed that ‘listen’ to activity in the bedrock. When the seismic sensors are on the seabed instead of being towed behind a seismic vessel, the operators receive more accurate data, and minor changes such as microcracks can be detected sooner.

Cuttings are often disposed of by injecting them back into the reservoir. The injection causes the rock to crack, which can be registered as microseismic activity. If these cracks occur in the wrong areas, they can quickly cause big leakages. By using equipment that continuously monitors the development of microcracks, such leakages can be avoided.

Given opportunity offshore

Octio has tested the system in a fjord using its own funds. Through DEMO 2000, the company was also given an opportunity to test the system offshore in the Seismic Waste Injection Monitoring (SWIM) project, with financial support from Statoil and the Research Council of Norway.

‘It was difficult for us to finance such a test. Even though we were certain that the technology worked and had commercial potential, we had to prove it to the oil companies. Without the DEMO 2000 project, we would probably not have got any further,’ says Leon Løvheim, CTO of Octio.

The plan was that the system would monitor injection in a new well on the Oseberg field from summer 2013, but the drilling was postponed for a year. In the meantime, Octio is collecting data and analysing noise and other activities in the area. For example, an earthquake in Sogndal was clearly registered on the seabed, and the perforation of pipes in nearby production wells is clearly shown.

More sensors

Once the network has been placed on the seabed, other types of sensors can be connected to it, for example to measure oceanographic data or chemical and biological data. In a new DEMO 2000 project, Octio will test wireless subsea communication in the sensor network. Since the communication is based on international standards, different types of sensors can easily be connected to the network. ●



PHOTO: STATOIL

The Norwegian continental shelf an important arena for testing new technology

LARS HØIER OF STATOIL believes that the team effort by the big companies, smaller technology companies and the authorities has resulted in a number of interesting technologies.

How has DEMO 2000 benefited Norwegian and international offshore oil activity?

'DEMO 2000 has been, and still is, an important means of getting offshore pilots implemented, among other things in key areas such as enhanced recovery, drilling and wells, and subsea. The programme has accelerated technology testing, with subsequent broad implementation of several of these technologies.'

Where do you see the biggest technological challenges in the next 15 years?

'The complexity of the remaining resources and reserves is increasing, and the size of many of the discoveries is decreasing. Technology that results in cost-efficient solutions for field development, the use of existing infrastructure and drilling and well technology will be decisive. Statoil's ambition is to achieve an average recovery rate of 60% on fields we operate ourselves on the Norwegian continental shelf. That will require a

technological boost where Norwegian and international expertise cooperate closely.'

What needs to be done to ensure that the Norwegian oil service industry remains competitive?

'In addition to exports of oil and gas, the petroleum-related service industry is Norway's most important export industry. That is why it is vital to future competitiveness that the Norwegian continental shelf continues to be an important arena for testing new technology, ensuring that innovative power is maintained through close collaboration between the authorities, the academic community, the oil service industry and the oil companies.'

What do you believe is the reason for the great interest the industry has shown in DEMO 2000?

'It is particularly demanding for small technology companies to raise capital for costly demonstrations and piloting of new technology. The great interest taken by the industry shows that the team effort by the big companies, smaller technology companies and the authorities has worked and resulted in a number of interesting technologies.' ●



PHOTO: NORSK INDUSTRI

The contribution from the public purse should be doubled

STEIN LIER HANSEN OF THE FEDERATION OF NORWEGIAN INDUSTRIES believes that DEMO 2000 has been, and still is, an attractive programme for testing new technologies in practice, producing many spin-offs and adding value.

How has DEMO 2000 benefited Norwegian and international offshore oil activity?

'DEMO 2000 has played a decisive role in testing and documenting the functioning and applicability of many technological solutions and products that are currently sold and used on the Norwegian continental shelf. The links between technology suppliers in Norway and big international oil companies that operate on the Norwegian continental shelf and in other regions have also been an important success factor for the internationalisation of the Norwegian oil service industry.'

Where do you see the biggest technological challenges in the next 15 years?

'In the years ahead, it is important that Norwegian expert environments become even better in areas where we are already among the best in the world, such as technologies for activity in the Arctic, safe, environmentally friendly and energy-friendly solutions, subsea technology, drilling technology and, not least, solutions for enhanced recovery.'



We need to be best – because we aren't cheapest

BENTE NYLAND FROM THE NORWEGIAN PETROLEUM DIRECTORATE hopes that **we will keep up the pressure on development and testing of new technology so that we continue to be at the cutting edge internationally.**

How has DEMO 2000 benefited Norwegian and international offshore oil activity?

'DEMO 2000 has contributed to faster testing of new technology, for the benefit of both the operator companies and the manufacturers who have developed and commercialised new technology. As important as the money, however, is the hallmark of quality that is conferred by having a project approved. Receiving funding from DEMO 2000 leads to acceptance and focus when the technology is to be tested.'

Where do you see the biggest technological challenges in the next 15 years?

'Enhanced recovery from fields in operation is important to the Norwegian Petroleum Directorate. There are major technological challenges involved, particularly in connection with testing and developing injection methods and developing cheaper and more efficient drilling and

well technology. In relation to seismic surveys, the challenges lie in improving the 'image quality' of substrata and improving 4D seismic data, which is an important technology for reservoir monitoring and optimal recovery. Cost developments are a challenge internationally, but perhaps especially challenging on the Norwegian continental shelf.'

What needs to be done to ensure that the Norwegian oil service industry remains competitive?

'We need to keep up the pressure on development and testing of new technology so that we continue to be at the cutting edge internationally. It is important that we are best – because we aren't cheapest!'

What do you believe is the reason for the great interest the industry has shown in DEMO 2000?

'Here, I would like to emphasise the importance of the hallmark of quality that participation in DEMO 2000 confers. The money is not insignificant, but it is nonetheless a fairly small part of the total budget of the projects. When DEMO 2000 believes in a project, that is often what opens the door to other sources of funding.' ●

What needs to be done to ensure that the Norwegian oil service industry remains competitive?

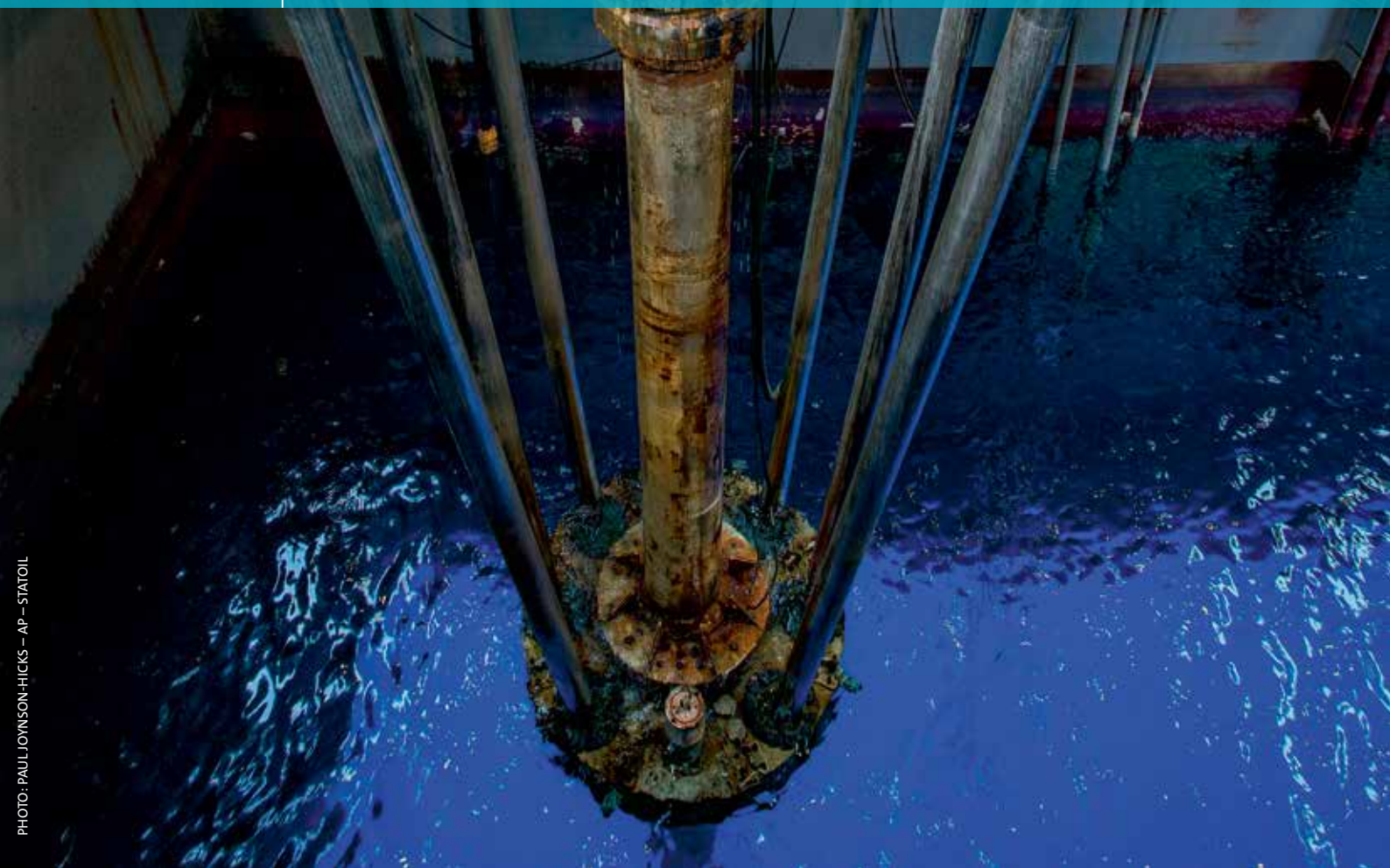
The Norwegian oil service industry will be competitive if we continue to stimulate the development of cost-efficient technical solutions and work processes, and focus on a high degree of automation of production and operations, while at the same time putting the brakes on wage growth in relation to our trading partners.'

What do you believe is the reason for the great interest the industry has shown in DEMO 2000?

'DEMO 2000 has been, and still is, an attractive programme for testing new technologies in practice. This is not just because of the financial support offered, but also the fact that technologies are linked up to users, for example oil companies, and that the oil companies take co-ownership of testing and piloting, both technically and financially. In my opinion, the contribution from the public purse should be at least doubled, given the spin-off effects and the historic 'vale creation' many of the technologies that have been through the programme have generated.' ●



DRILLING AND WELLS



The multilaterals success story started in Stavanger

Many oil and gas fields are now developed using multilateral wells. The first and so far only test well in Norway for this technology was drilled in Stavanger with support from DEMO 2000. It is now the standard method for developing oil and gas fields.

The test rig Ullrigg at Ullandhaug in Stavanger has played a key role in the development of this technology. The first drilling took place in 2000, in a project initiated by Halliburton and IRIS research centre, which was called Rogalandsforskning at the time.

Multilateral wells are wells that follow the same track down to the reservoir and then spit into several branches or sidetracks. It is thus possible to produce from several pockets or different areas of the same reservoir at a much lower cost than using

individually drilled wells. The operator companies are thereby able to effectively increase both the drainage area, the production ceiling and the total production from new and existing fields on the continental shelf.

Showed the oil industry that it was possible

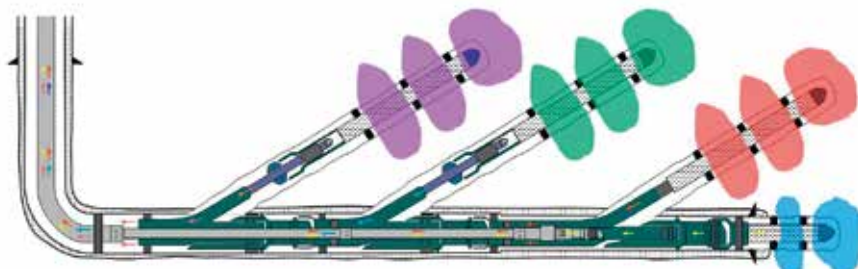
'The Ullrigg project was important because it showed that Halliburton could create multilateral junctions using its drilling technology, and it made the

industry aware of the technology,' says Sigmund Stokka, Research Director at IRIS.

'Our experience from Ullrigg formed a large part of the basis for the pressure-tight well junctions that Halliburton developed later,' says Gorm Liland of Halliburton.

A successful demonstration

The initiative for multilateral drilling came from Halliburton, which realised that oil recovery was not efficient enough, took too long and was too expensive.



◀ A multilateral junction from Halliburton with zonal control of many multilateral wells, as it is today. Illustration: Halliburton

‘Ullrigg has been important in relation to the development of drilling technology,’ says Project Director Sigmund Stokka of IRIS. Photo: Sverre Jarild

> This led to Halliburton and IRIS, with Saga Petroleum, Statoil and the Norwegian Petroleum Directorate also participating, starting a project to qualify multilateral technology. Several products and methods were qualified, and the oil companies and DEMO 2000 provided broad support in two rounds.

‘The result was very successful. We demonstrated the installation and testing of two well junctions, as well as new cementing methods,’ says Senior Advisor Jostein Sørbø at IRIS, who led the project.

Troll was the turning point

The first company to use multilateral wells in the Norwegian sector was ConocoPhillips, but it was the Troll oil field that became the biggest driving force behind use of the technology. The oil in the field lies 1,500 metres below the seabed in 12 to 14-metre thin layers with thin sand formations between them.

Together with horizontal drilling, multilateral wells played a decisive role in making it financially feasible to develop the oil zone in the field. At the end of 2000, a pressure-tight well junction, where a lot of the technology was identical to that used on Ullrigg, was installed on the Troll field.

Since the successful test well, more than 130 multilateral wells have been drilled on the Troll field alone. All new wells on the field are planned as multilaterals. Today, horizontal wells are drilled that are up to five kilometres long per node.



Multilateral wells are now part of the plans for many new field developments worldwide.

‘Many new fields are dependent on cost-reduction measures. This kind of technology can be a great help in making them financially feasible,’ Gorm Liland points out.

Many wanted in on the act

‘The support from DEMO 2000 was essential in relation to getting the project off the ground. The funding award made it easier to establish a dialogue with the operator companies. It started with a normal allocation of costs, but the budget increased as

more oil companies joined the project and added funding,’ says Sigmund Stokka.

Among those who came on board were BP Exploration, Phillips Petroleum, Norske Shell, Agip, Chevron and Hydro (through Saga).

The support played a decisive role in Halliburton’s head office giving its Norwegian branch approve to devote resources to the project. The project was one of the biggest that the company had carried out in Norway, and it formed the basis for the Norwegian branch of Halliburton becoming the most important in the company as regards multilateral technology. ●

Continuous drilling will result in big savings

In February 2015, a full-scale pilot rig will be ready to demonstrate fully robotic, continuous well drilling at IRIS in Stavanger. The technology is expected to reduce drilling time by 35–50%.

Continuous Motion Rig (CMR) is a drilling method that makes it possible to carry out non-stop drilling. It is West Drilling Products that has invented and patented the technology. With support from DEMO 2000, the company is now building a full-scale drilling rig.

The reason for the big time-savings is that the drilling process takes place continuous-

ly, without having to stop to connect the pipes that make up the drill string as the drill bit digs deeper and deeper. The result is that the drilling process goes much faster. There are also fewer well problems.

Slower drilling operations

For the past 20 years, operators have focused on automating the drilling process. Paradoxically, this has led to the drilling process becoming less efficient. The tripping speed, for example, i.e. how fast the pipes are pulled up from the well, has been reduced from 1,800 metres an hour to 400–600 metres an hour. The drilling operations thereby take much longer, which costs a lot of money.

‘The reason is that the automation has focused on HSE issues, not the interplay of machinery. People cannot deal with that many operations simultaneously. Nor can

they do something exactly the same way time after time,’ says Odd B Skjærseth, managing director and founder of West Drilling Products.

Continuous Motion Rig is expected to achieve a tripping speed of 3,600 metres an hour and to remove a number of well problems. That means much greater efficiency.

‘With day rates of 60,000 dollars for drilling rigs, there are big savings to be made on finishing drilling sooner,’ Skjærseth points out.

DEMO 2000 a catalyst

The building of the pilot rig, which will be located near the test rig Ullrigg at Ullandhaug in Stavanger, is on schedule. New, robotic machinery will be developed for the rig. Five robot machines will work together on 27 axes.

Statoil, ConocoPhillips, Shell and ABB are the industrial partners in the project, and DEMO 2000 and Innovation Norway are also providing support.

‘The support from the Research Council of Norway, Innovation Norway and the partners has made the project possible. The DEMO 2000 programme has acted as a catalyst for bringing professional partners on board, and user participation is crucial in relation to both the development of the rig and the commercialisation phase,’ Skjærseth says. ●



◀ This is how the continuous motion rig will appear.
 Ill: West Group

> Lower well costs and a higher recovery rate

Enhanced Drilling has developed drilling technology that reduces well costs and can contribute to a higher recovery rate. A successful test was completed on the Troll field in April.

‘If we are to succeed in cutting costs on the Norwegian continental shelf, we need to reduce the well costs, which account for around 50% of the costs on seabed-operated fields,’ says Børre Fossli, VP Technology in Enhanced Drilling.

Since the drilling rig market is international, there is little that can be done to influence the cost of renting rigs. There is therefore only one thing that helps, believes Fossli:

‘We need to reduce the time it takes to drill and complete wells. Enhanced Drilling has technology that contributes to that. This is extremely important, especially for Norway, since it has so many subsea fields.’

Will increase the recovery rate

The company is also working on increasing the recovery rate from subsea fields, which have an average recovery rate that is 18% lower than fields with fixed installations.

‘A special type of technology is needed to recover more resources from subsea fields.

If the recovery rate can be increased to the same level, this will mean hundreds of billions of additional kroner for the treasury. We are talking about added value totaling NOK 1,500 billion, or half the present Government Pension Fund,’ Fossli says.

Enhanced Drilling has developed technology for both pressure-balanced drilling from mobile rigs, called EC-Drill, and the recovery of drilling mud on floating rigs without using risers, called Riserless Mud Recovery. Both these concepts are based on subsea pumps and control systems for operating the pumps.

The system means that the operators can work in a narrow pressure window between pore pressure and fracture pressure. The technology will thereby make it possible to recover resources from deep reservoirs that have been regarded as too costly to recover, as well as enabling more efficient drilling on mature fields.

Two parallel development paths

Enhanced Drilling is the result of a merger of the companies Ocean Riser Systems (ORS) and AGR Subsea (AGR Drilling Services Holding). Before the merger, both companies carried out several DEMO 2000 projects. ORS started worked on a Troll Pilot in 2008 and was awarded support by Innovation Norway in 2010, although it proved difficult to fully finance the project. In parallel, AGR was working on another DEMO 2000 project (CMP multi-gradient drilling), whose progress was dependent on a field test.



The equipment tested on Troll opens for exploration from reservoirs that so far has not been economical feasible. Photo: Enhanced Drilling

The two companies were merged in 2012 to form AGR Enhanced Drilling, and the two projects were merged as part of Troll Pilot. The project could now be fully financed with support from DEMO 2000, Innovation Norway and Statoil. The two projects were completed in May, and the company recently changed its name to Enhanced Drilling.

Many interested companies

Following the successful Troll test, Fossli hopes that the technology will be widely implemented on the Norwegian continental shelf.

‘Pressure-balanced drilling from floating rigs has been lacking in the Norwegian sector. Now, we have proved that the technology works. It means safer, and more efficient drilling and lower well costs. The whole oil industry has been following Troll Pilot, and now their enthusiasm has been triggered. Several oil companies have registered interest,’ Fossli says. ●

A drilling robot can cut costs to a tenth

Badger Explorer is an environmentally friendly drilling robot that bores its way underground without the help of drilling rigs or intervention vessels, while collecting data at the same time. It will mean enormous savings.

Badger Explorer is also the name of the Stavanger-based company that is developing this ground-breaking drilling method, which the oil companies describe as a game changer. The robot has measuring instruments that can detect oil and gas on its way underground.

Sigmund Stokka, Research Director at IRIS in Stavanger, came up with the idea in 1999. Work on developing a prototype started in 2005, with ExxonMobil, Shell and Statoil as partners and with support from Petromaks.

DEMO 2000 project in its final phase

In the second and current development phase, the oil companies Chevron and Wintershall have come on board as partners, replacing Shell. The DEMO 2000-supported demonstration project is now in its final phase.

‘The support from the Research Council of Norway is invaluable, both financially and in relation to winning over the partners. We

would not be where we are today without this support. The staff at the Research Council of Norway are also positive and helpful, and they make excellent sparring partners,’ says Steinar Bakke, Managing Director of Badger Explorer.

Finished in three years

In late summer this year, it will be verified whether the equipment meets the oil companies’ requirements specifications. Initially, Badger Explorer should be able to drill 100 metres.

In the next phase, a new three-year project will start where new requirements apply, among other things as regards how deep and how quickly the tool will be capable of drilling. A full-scale test will be carried out during this project period.

The company’s long-term goal is to be able to drill exploration wells down to a depth of 3,000 metres at an average speed of two metres an hour.

Huge potential

Badger’s development and operating costs of NOK 40–50 million are justified given the company’s long-term earning potential and expected savings on exploration for customers. The potential savings in terms of time and costs for the oil companies are huge. Once Badger enters the commercial phase, a delivery will be priced at between 10 and 20 million dollars.

The project partners have right of first refusal to buy the equipment once the development of Badger Explorer is com-

pleted. The company Badger Explorer will sell packages comprising equipment, crew and services to the oil companies.

A long pipe

Badger Explorer comes in the form of a 30-metre-long pipe with a diameter of 15 cm. It has a mechanical drill bit that is powered by an electric motor at one end. The three main parts of the drilling robot will involve developing completely new technology: the drilling takes place in a new way, since the drill cuttings are transported inside the robot, and it is the drill cuttings that seal the borehole behind the tool.

The power supply for the robot is placed on the seabed. It is supplied through a cable that is coiled inside the robot and is fed out as the robot digs deeper.

Since the crushed rock formations after the drilling, the drill cuttings, are compressed to a plug behind the robot, it buries itself and is therefore only intended for one-time use. The drill cuttings remain in the well and have no environmental impact. ●



Badger Explorer has been test run in a DEMO 2000-supported demonstration project. Here is the 30-metre-long drilling robot at the workshop in Stavanger. Photo: Badger Explorer

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◀ A robotic rig prototype has been developed and built with the help of funding from DEMO 2000. Photo: Robotic Drilling Systems



▲ A robotic rig prototype has been developed and built with the help of funding from DEMO 2000. Photo: Robotic Drilling Systems

Drill floor robot fast approaching commercialisation

The Sandnes company Robotic Drilling Systems AS is developing an unmanned, fully robotic drill floor system that can reduce drilling costs by 30%.

The company's goal is to achieve a faster, fully robotic drill floor process. Today, such processes are partly automated, but not robotic. This means that people have to rig up a lot of special tools, which is very time-consuming.

'Robotisation increases reliability and flexibility, which means that operations can be easily changed. The robotic machinery in our system works together seamlessly, and you do not need to carry out manual operations,' says Lars Raunholt, general manager of Robotic Drilling Systems.

Prototype in 2010

The company has spent NOK 300 million

on development since it started ten years ago. DEMO 2000 has given it support several times, among other things for a full-scale prototype rig in 2010.

'That was an important milestone that proved that the system worked. Without DEMO 2000, we would not be where we are today. It was the factor that triggered investment support from the three oil companies that are our sponsors,' Raunholt says.

Comprehensive testing at the workshop in Sandnes is now right around the corner. This will be followed by testing at full capacity on Ullrigg, a full-scale test rig in Stavanger.

The robot control system consists of three key products: a drilling robot that handles the pipes that go down the borehole, a robotic device that screws the pipes together (called an 'iron roughneck' in industry jargon), an elevator from which the pipes are suspended and a control system that steers the whole system. The robots are operated electronically and work together. The whole system is connected to other

systems to make up a complete drilling package.

The robots are coming

The aim is that the system will reduce drilling costs by 30% and result in significantly shorter drilling time.

'Robotisation is a buzzword in the oil industry. It's coming, and it could give the whole oil and gas industry a boost. Everyone will have robotic drilling operations in 10 to 20 years,' Raunholt maintains.

That means that Robotic Drilling Systems has the potential to be a billion dollar business. The market for drilling operations is worth at least NOK 30 billion a year.

The actual drilling robot is in the process of commercialisation at the moment. A function test was carried out in December 2013. The rest of the system is heading for commercialisation, and an offshore pilot is scheduled for 2017. ●

INTEGRATED OPERATIONS



Boundless cooperation has big advantages

ConocoPhillips has changed how it communicates in its integrated operating model. The company has erased the boundaries between its own employees, drilling operators, contractors and big suppliers onshore and offshore.

ConocoPhillips is a pioneer in integrated operations, where onshore personnel cooperate with people out on the platforms. The company has participated in several DEMO 2000 projects in this area. Nearly ten years ago, the company opened its first drilling operations centre in Tananger. Now, several floors at the company's Norwegian headquarters have been converted to accommodate integrated operations.

'We have changed the way we communicate and are now changing our philosophy from integrated operations to cooperation. We are creating a kind of internal Facebook, where relevant information is shared with the right people,' says Ole Lindefjeld, Research Manager at ConocoPhillips.

Many advantages

The goal of the cooperation model is to create the best solutions with a view to achieving better, safer and more optimal operations. ConocoPhillips's operating model has contributed to better planning,

increased operating efficiency, less need for temporary production shutdowns, lower transport costs and lower CO2 emissions.

The company has erased the boundaries between its own employees, drilling operators, contractors and big suppliers onshore and offshore. Modern communication equipment means that data from the offshore installations can be made available onshore in real time, despite the great physical distances involved. Cooperation takes place across disciplines, entities and locations throughout the organisation.

Big changes in working methods

Initially, a large operations centre was fitted out, with giant screens on the walls and a lot of people gathered in one place. Now, a lot has changed.

'The transition to the new working method is more of a mental process than a technological one. We work in a different way in small groups of three or four

people, and we use ordinary computer screens. The work stations are grouped for different work processes, such as HSE, well operations etc. The model includes very many functions,' explains Lindefjeld.

Several departments have now been converted to integrated operations. Cellular offices have been replaced by open-plan offices. The layout was designed to suit the company's work processes, such as platform operations, drilling and well maintenance, maintenance, modification projects and development projects. The company now has more than 20 such cooperation centres.

One of the issues is the huge amount of data that is transferred to shore from the Ekofisk field via fibre-optic cables.

'It is a question of finding out and separating what is important, and responding in the right way. We have done a lot of research into utilising the potential of our centres,' says Lindefjeld.





◀ 'The transition to the new working method is more of a mental process than a technological one,' says Research Manager Ole Lindefjeld of ConocoPhillips. Photo: Sverre Jarild

➤ **More attractive workplace**

ConocoPhillips has changed the way it communicates and given its employees the tools they need for this. There will always be some apprehension when new processes are introduced, but Lindefjeld underlines that the staff have been positive.

'The change has been gradual. Once the staff start working together in groups in the new way, there is no going back to the old, more isolated way of working.'

Lindefjeld also points out that the operating model is also attracting younger employees. They see it as an attractive place to work because people are integrated in a completely different way than before.

Important marketing effect

The Research Manager believes that DEMO 2000 is very important in relation to creating interest in and marketing projects.

'Projects start with an idea. In DEMO 2000, an expert panel evaluates the quality of the projects and rates them in relation to several parameters. Projects that are not relevant are rejected, and it is highly probable that approved projects will be realised. This makes it easier for the oil companies to become involved in the projects,' he says. ●



IT tools making drilling operations more efficient

The Oslo-based company Computas has developed a sophisticated, interactive decision-support system for drilling operations based on integrated operations. The commercialisation phase has now started.

The oil and gas industry has introduced integrated operations, where information and communication technology is used to establish closer cooperation between the offshore and onshore organisations and across disciplines. This has resulted in better operations, lower costs, a higher level of safety and increased value creation.

The IT company Computas saw a need to fill the gap between technology and organisation, however, and it started developing the decision-support system CODIO (Collaborative Decision-making in Integrated Operations) for drilling operations. The system is intended to reduce non-productive time and improve performance in the field of health, safety and the environment.

◀ Cooperation usually takes place via ordinary computer screens.
Photo: Sverre Jarild

‘Integrated operations bring together people from different disciplines in collaboration rooms, but the decision-making process is largely unchanged. We have developed an IT system that compiles relevant information and includes decision-making models that can be used to analyse the outcome of alternative decisions,’ says Roar Fjellheim, Director of Business Development in Computas.

Soon ready for the market

Drilling operations require large amounts of data to be swiftly and accurately processed in order to ensure that the right decisions are made. The drilling teams must monitor data, interpret trends and analyse and diagnose situations.

CODIO supports cooperation between the discipline groups involved. The system helps the drilling teams to filter and exchange information, arrive at a common understanding of the situation and agree on an action plan.

The system was developed for ConocoPhillips Norway. Now, Computas has set up a branch office in Stavanger in order to win new customers, and the commercialisation of CODIO is well under way.

Started six years ago

After integrated operations became a hot topic on the Norwegian continental shelf, the company started a development partnership with ConocoPhillips Norway in 2008. Odfjell Drilling, Halliburton, the

research centre IRIS and the universities of Stavanger and Oslo came on board afterwards.

The basis for the system architecture was developed in a three-year Petromaks project. Two laboratory-scale prototypes were developed: decision-support during potential blow-outs, and geomangement, i.e. the adjustment of drilling paths. In 2011–2013, a demonstration project was carried out at ConocoPhillips in Tananger. It was supported by DEMO 2000.

‘Here, the computer tool was adapted to the real world. In reality, that meant a great deal of new development also had to be done during the demonstration phase. DEMO 2000 was thereby not just a means of bringing oil companies on board and getting the project off the ground; it also gave us freedom to invest in new methods,’ explains Fjellheim.

Next: condition-based maintenance

This year, a new DEMO 2000 project was started in which Eni Norge is a partner in addition to ConocoPhillips. CODIO is being further developed for use in another area of application, namely condition-based maintenance.

‘Time-based maintenance is expensive. We aim to ensure more rational planning of maintenance based on data about the condition of the machinery that are sent onshore from the platforms,’ says Fjellheim. ●

PRODUCTION AND TRANSPORT



Technological leap for separators

The company InnSep in Trondheim has developed an innovative gas and liquid separator that is light and space-saving. It will soon be tested by Statoil.

Little has happened in separation technology in the last century, but a big technological leap is now about to take place. A prototype from InnSep that is up to 50% more compact than traditional separators will be tested by Statoil under high pressure early next year.

If the test is successful, a new DEMO 2000 project will start in the first quarter 2015. The separator will then be tested in full scale under real conditions with hydrocarbons, either at Statoil's K-Lab at Kårstø or on a platform.

Support schemes lead to progress

'This is a good example of a technological development that is the result of all the funding schemes that are available in Norway. Without funding from programmes like DEMO 2000, the project would have been closed down and the technology would never have seen the light of day,' says Sondre K Jacobsen, CEO of InnSep.

Development started in 2008 at the Norwegian University of Science and Technology (NTNU). When married couple Maria Fernandino and Carlos Alberto Dorao started working on separators at the university, they discovered that there was little innovative thinking being done in the area.

This resulted in a new idea that involved using wire-mesh as a centrifuge in the separator. This means that the separator can be much more compact, lighter and less costly. The innovative aspect is that the gas is led towards a rotating wire-mesh that removes liquid from the gas stream.

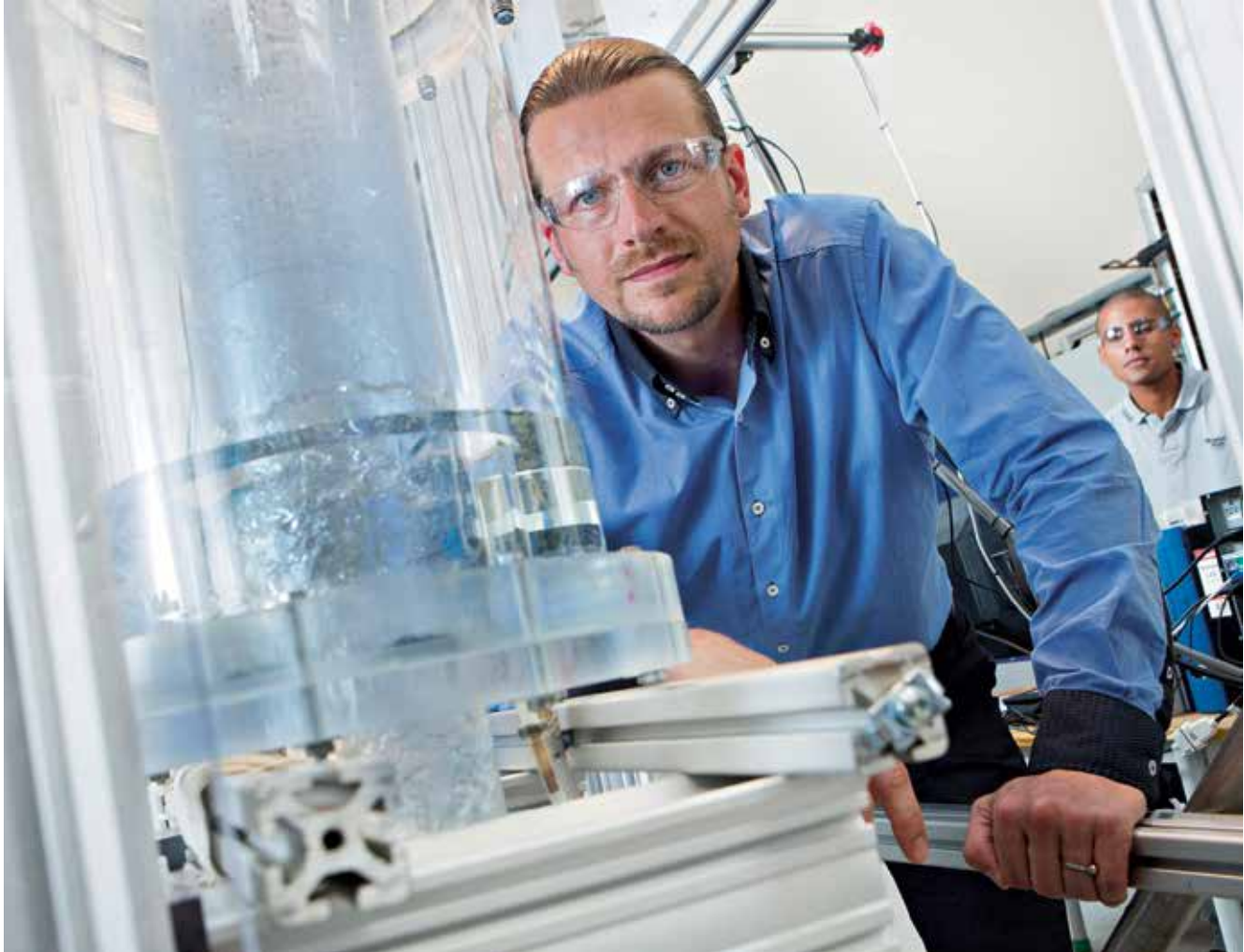
Funding from several sources

Three years later, work started on building a high-pressure prototype with financial support from NTNU Discovery. The project later received funding from the Research Council of Norway's MAROFF



The new separators are much more compact than the traditional gravity based separators.
Photo: Sverre Jarild





Sondre K Jacobsen says that the new separators save a lot of space and weight on the platforms. Photo: Sverre Jarild

> programme, which focuses on the application of technology for cleaning exhaust gases on ships, and a start-up grant from Innovation Norway.

In 2012, successful tests were carried out of the first prototype using natural gas and liquid hydrocarbons at 60 bar pressure in the USA.

Extensive technological qualification

The USA test was the reason why Statoil became involved in a DEMO 2000 project in which the equipment will be qualified. The goal is to run a separator that is 50% smaller through Statoil's seven qualification steps for new technology.

'If the qualification goes well, we will move on to the commercial phase, which

involves both the retrofitting and new installation of our separators for gas and liquid without particles,' says Jacobsen.

The global market potential is huge. Offshore platforms have several compressors whose job is to pump dry gas onwards. Each of them needs a separator that removes the liquid from the gas. ●

MPM develops and builds its multiphase meters at industrial premises in Forus in Stavanger. Photo: Emile Ahley/MPM



Norwegian multiphase meter a great success

In just a few years, MPM in Stavanger has gone from having a good idea to selling multiphase meters for almost NOK 600 million a year.

In 2003, Arnfinn Wee tested an idea in his kitchen at home in Oslo. It involved creating more accurate and reliable multiphase meters. A few simple experiments confirmed that the idea could work. In the same year, the company MPM AS was formed in Forus in Stavanger by Wee and Hans Olav Hide. Since then, the company has grown rapidly and it currently has 180 employees.

‘We started from scratch. Given how conservative the industry we are targeting is, it is pretty amazing how quickly things have gone and how far we have come,’ says Hide, CEO of the company.

Used medical technology

The oil companies need accurate real-time

measurements of how much oil and gas is delivered from the production wells. This is both in order to manage and optimise recovery from the fields and in order to decide the distribution of oil and gas produced between the different owners of the fields.

This is where multiphase meters come in. These instruments measure the content of oil, gas and water in the well flow. ‘Arnfinn Wee saw that there was a need in the market for more accurate and reliable multiphase meters. He came up with the idea of using tomography from the medical field and microwave technique from 3G mobile telephony in the instruments,’ explains Hide.

Established contact with the oil companies early on

We handled the technology, while Hide focused on the finances. The company worked hard to get the oil companies on board at an early stage. The marketing work started long before there was a product to sell, apart from on paper. MPM went for a threefold funding model for development, where one part was

public funding, one part came from the oil companies and one part in the form of investment capital in the company. That is why it was very important to get the oil companies on board at an early stage.

Early-phase public funding

Innovation Norway and the industrial R&D contracts scheme (IFU) contributed funding in the start-up phase. In 2005–2006, DEMO 2000 supported a project to test the first prototype. The oil companies ConocoPhillips, Eni, Shell, Statoil and Total participated as project partners.

It is actually very difficult for a company to raise funding for the development of new technology.

‘It was fantastic to receive public funding at such an early stage. The funding was important both because we needed the capital and because it was easier to get the oil companies on board once they saw that others believed in the product. Now, the Norwegian authorities will get back many times what they contributed in the form of tax from the company and the employees,’ says Hide. ●

ENVIRONMENT



All information in one place

Arctic Web contains information about everything from environmental conditions and fisheries to exploration drilling, as well as other activities in the area.

The idea for a geoportal for the Arctic was conceived on Bjørnøya island in 2006. A group of people were weather-bound on the island and passed their time discussing new ideas. Back home, they established a pre-project whose goal was to demonstrate that it was possible from an ICT perspective to create a joint portal for a number of different sources. DEMO 2000 awarded support, and in 2007, the pre-project proved that the portal was possible.

The oil companies quickly saw savings in time and resources they could make when all the information they needed could be found in one place. Seven oil companies therefore made a concerted effort to develop the portal and secure financing for its operation.

176 topics

At arcticweb.com, you can search for and find information about a specific area. A search robot continuously searches for new information in the databases of 16 official sources, so that users always get updated information about the environment, fisheries and other marine activities in the area in question. To make the portal easier to use, the

data are divided into 176 topics. The data are stratified and linked to the map of the area.

Relaunch

The portal was launched in 2010. Acona Wellpro of Tromsø was responsible for the design and content, while Kadme of Stavanger developed the ICT solution. Acona withdrew from the operation of Arctic Web in 2012 and Aker Solutions in Tromsø took over. An updated version will be launched in the course of 2014 with a number of new data sources, including data about risk and emergency preparedness.

‘Here at Aker Solutions, we see this as an important tool if you are looking for information about a specific area, for example in connection with seismic data surveys, exploration drilling or early-phase development of fields,’ says Kjell-Are Vassmyr, Regional Manager for Aker Solutions in Northern Norway. He was one of the driving forces behind Arctic Web and previously worked for Acona.

The portal started with the Arctic, but it now covers the entire Norwegian continental shelf. ●

The new oil trawl has properties that take oil spill response one step further. Photo: NorLense



Trawling for oil spills

NorLense’s newly developed boom equipment can recover oil in demanding wind and wave conditions, and it also recovers oil that has been broken down into droplets and pressed down into the sea. The new solution, involving an oil trawl, solves several of these challenges.

‘The oil trawl inflates automatically, and there is no need for deck space since the trawl is deployed directly from a container/reel. The whole oil trawl can be operated by one person on their own,’ says Hugo Svendsen, R&D Manager of NorLense. The boom equipment has undergone thorough testing, both in test tanks and at sea.

Because the oil is collected in a bag that floats in the sea, vessels without tanks or other storage space can also help with the cleaning up after an oil spill. The bag is towed to shore for emptying, or it can be moored and collected later. The most important partners in the R&D work are Reninor and the Norwegian University of Science and Technology (NTNU). Financial support is allocated through the Research Council of Norway’s Petromaks, DEMO 2000 and SkatteFUNN programmes. ●

Only Norway and the USA have complete oil service clusters

The Norwegian oil service industry leads the world in many areas, thanks to the development of innovative technology. We must make sure that we maintain this position,' emphasises Runar Rugtvedt, Head of Oil and Gas at the Federation of Norwegian Industries.

When the Norwegian oil adventure started, we were dependent on foreign technology, but now Norwegian technology is leading the way in many areas.

'Today, Norway is the only country apart from the USA with a complete oil service cluster. The UK used to have one, but it has fallen behind. We have experienced good growth in the last ten years, and we now have the top oil service clusters in the world in drilling, advanced vessels and subsea technology,' says Runar Rugtvedt.

He points out that many DEMO 2000 projects have played an important role in developing new technology.

Technological pioneering industry

Norway is a pioneer in the export of oil and gas over long distances. Some of the technology that was developed to produce oil and gas has been of decisive importance.

'Without multi-phase technology, for example, neither the Ormen Lange field nor the Melkøya plant would have been developed,' says Rugtvedt.

He points out that the Norwegian continental shelf is more of a technology driver than many other continental shelves.

'We must continue to stay one step ahead, cultivate the areas where we are good and test new technology. If not, we will just cement the technology and lose ground,' he believes.

Vital support programme

The Federation of Norwegian Industries has been a strong supporter of DEMO 2000 from the outset. Rugtvedt regards it as a highly successful programme in terms of its ability to generate many large and small technological innovations.

'The programme has a pretty crucial role in relation to carrying out piloting and

testing; a real shot in the arm. And it helps the oil service industry to establish contact with oil companies that can use the technology,' Rugtvedt says.

He believes that the funding should be more robust and at a higher level, however. Today, it is mostly small and medium-sized projects that can receive support. Big expensive projects would have taken too great a share of the funds at the programme's disposal.

'DEMO 2000 will be at least as important going forward and it should give priority to more costly projects relating to, for example, enhanced recovery,' he says.

Pilot plant contributing to great value creation

In order to be competitive, Norwegian companies must be good at technology and cost-efficient solutions. That is important to both the oil companies and the oil service industry.



‘Norway is a technological giant in offshore oil and gas. There is also a big market for enhanced recovery and optimisation. We can drill faster and more efficiently and recover more from the fields. In the past three or four years, new technology has taught us more about the bedrock, so that we know a lot more about what the fields contain. This means that the discovery rate is higher than before,’ says Rugtvedt.

He urges the oil companies to allow new technology to be tested out on the fields, even though they are concerned with keeping up their production level and having high uptime. Statoil and other oil companies have made huge investments and are involved in demanding and expensive developments, at the same time as the production of oil is decreasing. The overall financial situation has thereby become more demanding, and the companies are reviewing their global portfolios to see where they can cut costs. The oil service industry has really felt the effects of this.

Big investments

In 2013 and 2014, investments on the Norwegian continental shelf will reach a peak level of approximately NOK 200 billion a year. A levelling out and possible decline in investments is expected in the next few years. The Johan Sverdrup developments will generate substantial activity up until 2020. Rugtvedt hopes that Norwegian suppliers will be awarded contracts for deliveries, so that Norwegian expertise and capacity are fully utilised.

There are currently 78 fields in operation on the Norwegian continental shelf, and in a few years, the number will increase to 85–90.

‘Many of these fields will continue production for many decades to come and there will be a need for operation, maintenance, modernisation, modification and automation. We must also take part in the increasing globalisation and seize the opportunities that exist to sell technology to other parts of the world,’ says Rugtvedt. ●

Most important value creator and employer

A total of 250,000 people are directly or indirectly employed in the oil and gas industry in Norway. As many as 25–30,000 work for the oil companies, while the rest mainly work in the oil service industry.

The Norwegian petroleum industry has a turnover of NOK 460 billion a year, NOK 186 billion of which is related to international sales and exports of technology, products and services.

In 2013 and 2014, the annual investments amounted to approximately NOK 200 billion, which includes new-builds, exploration costs and major modifications.

Source: The Federation of Norwegian Industries

Executive summary DEMO 2000

The DEMO 2000 programme is the Research Council of Norway's initiative for the demonstration and piloting of new equipment and systems aimed at increasing the competitiveness and efficiency on the Norwegian continental shelf.

The programme was established 1999 with the objective to ensure that key competence and expertise remain and are augmented within the Norwegian supplier industry for the offshore petroleum market.

The DEMO 2000 programme has been extremely successful. Many of the projects which were granted funding in the early years have become industry standard. Among them are projects on integrated

operations, multilateral wells, subsea processing and lately, subsea multiphase pumping and subsea compressing of wet gas.

The Oil and gas in the 21st century (OG21) technology strategy constitutes the guidelines for the programme. The technology projects that receive funding must contribute to fulfilling the Government's goals for the development of the Norwegian continental shelf.

Today the main projects supported by the programme are within the drilling and well area. The costs of drilling and wells have more than doubled in the last ten years. Consequently, many drilling projects do not meet the economical requirements

and are therefore not implemented. Thus, more petroleum sources will remain unexploited even if the global need for more energy is evident.

In a more demanding industry setting where easily exploited oil resources are becoming increasingly rare, the need for developing new technology is ever more important. The DEMO 2000 programme will play a central role in the challenge to meet the need for energy for the decades and generations to come.

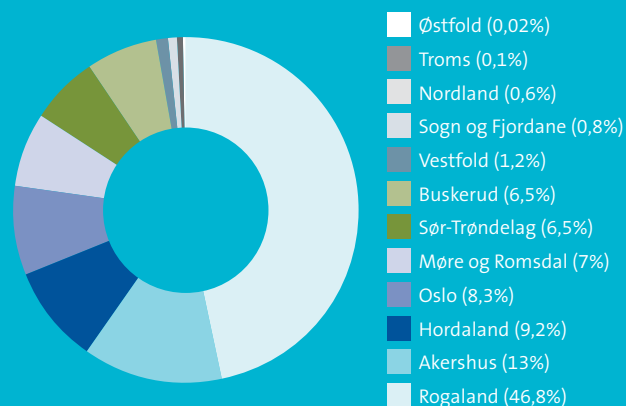
*Anders J. Steensen
Programme Coordinator
the DEMO 2000 programme*

Figures and facts about DEMO 2000

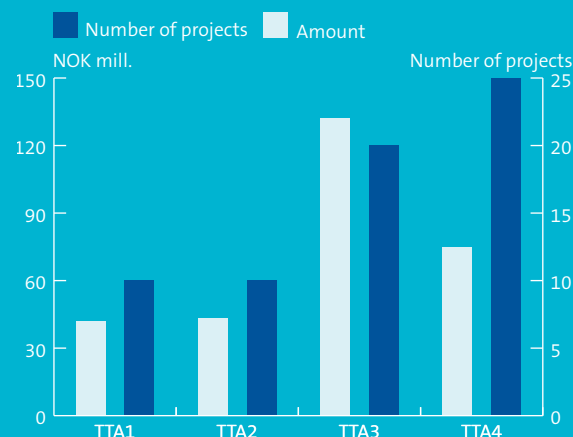
Commercial successes resulting from the first DEMO 2000 projects

- > *Framo*: Subsea compressor.
- > *Kværner*: Multiphase pump.
- > *FMC*: Subsea separator with continuous sand removal.
- > *Reelwell*: Riserless drilling.
- > *Kværner and Nuovo Pignone (GE enterprise)*: Subsea compressor.
- > *AGR Subsea*: Drilling concept where the drilling mud circulates and eliminates the need for a riser.
- > *Aker*: Booster pump.
- > *Resman*: Method that identifies the risk of water breakthrough in a well.
- > *Seabox*: Filter system for seawater injection.
- > *Odin*: Winch system for the use of fibre ropes for anchoring heavy installations in deep waters.
- > *Ziebel*: Fibre-optic well logging.
- > *Cubility*: Closed system for the removal of drilling mud.
- > *Aibel*: System where electrostatic fields remove the remaining amount of hydrocarbons from the produced water.
- > *Systems in Motion (now Kongsberg Oil and Gas)*: 3D visualisation technology that requires so little data power that it can be used on a laptop computer.
- > *Optoplan (now Weatherford)*: Fibre-optic solution for downhole sensing.
- > *Petrotech (now Halliburton)*: Solutions for downhole metering and testing that eliminate the need for flaring.
- > *FMC*: Well maintenance from a light construction vessel instead of a drillship (Riserless Light Well Intervention – RLWI).

Breakdown of DEMO 2000 funding since 2005, by county



Allocations from DEMO 2000 in the last five years, by target area



- TTA1** Energy-efficient and environmentally sustainable technologies
- TTA2** Exploration and increased recovery
- TTA3** Cost-efficient drilling and intervention
- TTA4** Future technologies for production, processing and transportation



The Research Council of Norway

Drammensveien 288

P.O.Box 564

N0-1327 Lysaker

Telephone: +47 22 03 70 00

Telefax: +47 22 03 70 01

post@forskningsradet.no

www.forskningsradet.no

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