The Research Council of Norway

PETROMAKS – Examples from petroleum research in Norway 2008

Large programme

Optimal Management of Petroleum Resources – PETROMAKS

Large-scale Programmes

The RCN initiative to meet national research priorities

About the Programme

Optimal Management of petroleum resources – PETROMAKS

PETROMAKS is the umbrella for most of the petroleum-oriented research supported by the Research Council of Norway.
The programme covers both long-term basic research and applied research, resulting in the development of new competence as well as innovation.This is the largest single programme run by the RCN. Insofar as possible, the programme will implement the strategy drawn up by the Norwegian petroleum industry's strategic body OG21 (Oil and Gas in the 21st Century).

Large-scale programmes are an important tool at the Research Council towards realisation of prioritised central research policy. They shall provide enhanced knowledge in the long-term national sense, with an eye towards stimulated innovation and increased added-value or generate knowledge that contribute to solving prioritised social challenges.

Content

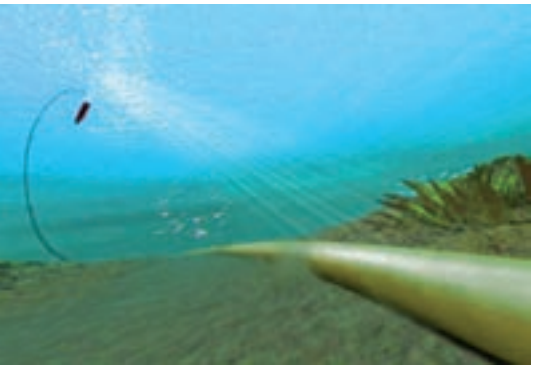
PETROMAKS – A large programme for optimal management of petroleum resources

The Research Council of Norway (RCN) has an annual budget of almost NOK 6 billion and plays a central role in Norwegian research. The mandate of the Council is to promote and support basic and applied research in all areas of science, technology, medicine and the humanities. Important goals include raising the general level of the understanding of research in society as a whole and supporting innovation in all sectors and branches of industry.

With the introduction of PETROMAKS in 2004, the Norwegian government gave a signal that strong public support of petroleum R&D was necessary. With this backing, the Research Council of Norway has an annual budget in 2009 of NOK 360 mill for the petroleum R&D. The budget for PETROMAKS is approximately NOK 200 mill. PETROMAKS will assist in implementation of the strategies and plans laid down by the government strategy initiative OG21 (Oil and Gas in the 21st century).

Thematic areas for research and innovation in PETROMAKS are in harmony with the OG21's targeted thematic technology areas:

- Environmental technology for the future
- Exploration technology and reservoir characterisation
- Enhanced recovery
- Cost effective drilling and intervention
- Integrated operations and real time reservoir management
- Subsea processing and transportation
- Deep water and subsea production technology
- Gas technologies
- HSE



PETROMAKS focuses on basic and applied research and technological development. An active, growing industrial cluster is needed to maintain the petroleum sector at a sustainable level. The supply and service industry are given special attention since globalization and worldwide participation are vital to maintaining Norway's leading position. Support from the PETROMAKS programme therefore involves forging alliances, creating networks, and facilitating different types of cooperation with the world's foremost science and technology institutions.

The Norwegian Continental Shelf is characterized as a mature oil province, although the northern part remains largely immature in terms of exploration and development. A substantial amount of the world's undiscovered petroleum resources are expected to be found in this area. The Barents sea is an area of great potential, current developments there include Norway's Snøhvit field, and the planned Russian development of the Shtokman field. Therefore PETROMAKS seeks to address R&D challenges of operations in such demanding and environmentally sensitive areas.

www.forskningsradet.no/petromaks
www.PETROMAKS.no

At the bottom of the sea

The offices of Seabed Rig AS are planted firmly on the ground among a series of furniture chains and electrical stores at its new premises in Forus Business Park. The company aims to move drilling operations from the oilrigs to the seabed and has developed a robotised platform that will make the drilling process less expensive and more environmentally friendly.

Seabed Rig AS has spent three years developing a solution to simplify the drilling process. They are now working on a robotised, remote controlled drilling platform that will be placed 3,000 metres down on the seabed. The platform is a modular system that encapsulates the drilling rig on the seabed with the help of an installation ship on the ocean surface. The entire process is remote controlled from the ship. Repairs can also be carried out remotely, removing the need to send staff down manually.
Costs will be significantly reduced as the process will not involve drilling rigs. Using robot technology will also make the drilling process more environmentally friendly and less hazardous.

One step further
The first components of the rig are ready and the prototype of a full-scale, automated and encapsulated iron roughneck was exhibited outdoors at ONS 2008 (the annual Offshore Northern Seas conference and exhibition) in Stavanger.

It is the very first component in the drilling process and the first of five critical components that are ready. The other results from phase 1 were presented at ONS's Innovation Park stand. Phase 2 will be completed in 2010 and the prototype will be tested at IRIS (the International Research Institute of Stavanger).
"There's a long road ahead before the technology can be commercialised," comments Lars Raunholt, CEO of Seabed Rig AS. The next stage is to begin testing and further development of the remaining components. The project will cost around NOK 50 million and will finance testing on land before the system is tried out in the water.
"The robotised drilling will be as safe as traditional drilling methods," emphasises Raunholt.

Transatlantic collaboration
"We were delighted with the response at this year's ONS. It is crucial to make contacts and to present ourselves in the right circles," says Raunholt. Seabed Rig AS is already collaborating with a professor of Robotics at Stanford University in California.

"We must continue developing our solutions for remote controlling and robot technology. That's why we are sending one of the IRIS researchers who has worked with us on placement to Stanford next year. This is a collaborative project where students from the University of Stavanger, Stanford and NTNU (the Norwegian University for Science and Technology) will use Seabed Rig as a case study and look for new solutions. "Our" students are being supported by the Research Council of Norway's PETROMAKS programme and will give us valuable knowledge in this field of study."

Financing from several sources
Financing for the next phase of the project is underway.
"StatoilHydro has invested NOK 15 million in the next phase of the project and we have had confirmation from the DEMO 2000 programme that it will commit NOK 5.94 million. It is very satisfying that we have managed to take the step from the PETROMAKS programme to DEMO 2000," says Lars Raunholt. The support from the Research Council also conveys important signals externally. We are expecting almost NOK 10 million from SkatteFUNN (the Norwegian tax deduction scheme for R&D expenses) and Innovation Norway. The remainder of the costs will be funded by the company itself.

The road to the Northern Areas
"We are optimistic and look forward to the first commercial seabed drilling operations in 2013," says Raunholt. We are one of a very small number of groups in the world working with this technology. We will therefore build up a solid engineering group locally in Stavanger and become the best in the world in seabed drilling technology. Looking further forward, our concept is perfectly suited for the Northern Areas."
Having the entire drilling process on the seabed eliminates the need for large surface rigs and problems with ice and severe weather conditions. In the distant future, all drilling installations will be controlled from onshore facilities.
"Just as safely, much less expensively and with no spills," concludes a future-oriented CEO.

Facts:
The PETROMAKS programme supports research projects over the entire research landscape, from basic research at universities to innovation and applied industrial research.

The DEMO 2000 programme aims to test and pilot innovative Norwegian products for the petroleum industry. It will support suppliers of new technology, enabling them to test their products with the oil companies. This is a common obstacle encountered by smaller enterprises in particular. Despite having an exciting and innovative product or solution that has been developed as a result of extensive research, it can be very difficult to attract the major companies on the Norwegian Continental Shelf to test out the technologies in the oil fields.

"It is therefore very encouraging that successful projects in the PETROMAKS programme are supported by DEMO 2000 and are taking the next step, with testing and hopefully commercialisation of the results," says PETROMAKS adviser Tarjei Nødtvedt Malme. From a total of 29 new projects that are starting up through the DEMO 2000 programme this year, 11 were supported by the PETROMAKS programme at an earlier stage.

3D model of the robotised, remote controlled drilling platform.
Photo: Seabed Rig AS

The first components of the rig are ready and the prototype of a full-scale, automated and encapsulated iron roughneck was exhibited outdoors at ONS 2008.

Robots at Alnabru

Robots could make unprofitable oil fields profitable. New concepts are now being tested at ABB's laboratory at Alnabru, backed by the Research Council of Norway.

Researcher Charlotte Skourop of ABB with the robot at Alnabru.

Extended lifetime

A robotic arm with a camera swings round in a warehouse in the Alnabru area of Oslo. Here, among the bathroom tile and flooring outlets, is something that could mark the beginning of Norway's oil future.
Researchers from ABB, StatoilHydro and Aker Solutions aim to use robots to extend the lifetime of Norway's oil fields.
"Robots can eliminate the need for people on the oil platforms. They can perform camera inspections, check that equipment is working and carry out maintenance work," says Charlotte Skourop of ABB.
The robot inside the laboratory is operated from a large control desk.

"In a few weeks we will try and control the robot from the office," says Skourup, gesturing enthusiastically. ABB has assigned one of its best researchers to this project. In 2004, Skourup was named as one of the 100 leading researchers in the world under 35 by the MIT periodical Technology Review.
The robot research is part of the TAIL IO project, an R&D collaboration consortium led by StatoilHydro and ABB.
One of the overriding aims is to increase the daily production of our industrial partner StatoilHydro's field by 5 per cent, and cut costs by 30 per cent – a production increase that almost all of the companies on the Norwegian Continental Shelf (NCS) use as the basis for their investment in Integrated Operations (IO).

A brave new world

"IO primarily involves supporting more efficient operation of an oil or gas platform. Operational information is supplied to land-based experts and trouble-shooting can begin sooner, allowing equipment/systems to be up and running again more quickly in the case of problems. Another considerable saving in terms of both time and money is of course that the experts do not need to be deployed offshore," says Svein Vatland, who is leading the entire TAIL IO project.

Optimism about the future is running high for what IO could mean for the NCS. The Norwegian Oil Industry Association (OLF) believes that IO will generate NOK 250 billion in increased revenues. Certain industry experts claim that the gas explosion on the Snorre A platform in 2004 could have been avoided with the help of IO. The incident would have been discovered sooner and operations shut down well before the explosion occurred. This would have avoided the subsequent lengthy closure of the field.

IO has already produced significant operational savings on several fields, including Ekofisk, Brage and Statfjord.

New platform solutions

The test rig at ABB's laboratory will demonstrate whether the robot technology can shape the platforms of the future. These will be based on modules, almost like Lego bricks, that can be moved and repaired as often as required.
"Large, unmanned platforms are cheaper to run. Everything is moving towards subsea now, but if platform solutions can be made cheaper, they could become competitive. After all, we get more out of the fields from platform solutions today," says Vatland.
"The optimal solution would be that robots would carry out everyday operations, inspections and maintenance on oil and gas installations both onshore and offshore," he continues.

Challenges ahead

Robots have been used for decades in the car and computer industries, while the oil industry has lagged behind. A number of challenges can therefore be anticipated before this conservative industry becomes convinced of the robots' potential.
"We must be certain that the robots will work in a marine environment and be able to cope with the extreme conditions they will be exposed to on an offshore installation. The challenge is to get all the small pieces in place and to fit together. We must also demonstrate and test concepts for robot knowledge, human-robot interaction and collaboration between the different robots," says Skourup.
The robot project is regarded as a high risk venture by the researchers, but they are optimists.
"If we succeed – I mean *when* we succeed – we will be helping to extend the lifetime of the NCS," says Svein Vatland.

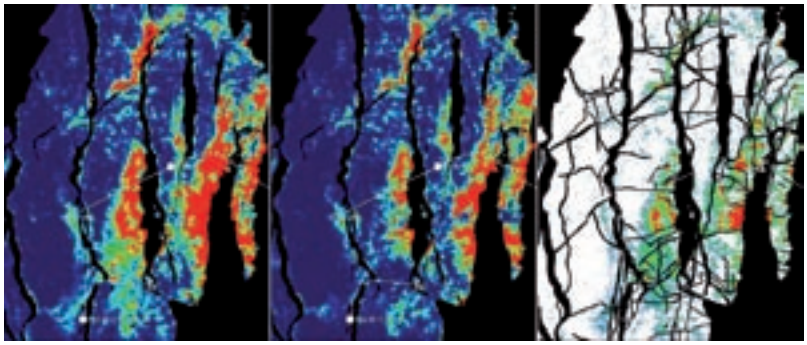
Facts:
TAIL IO includes seven individual projects:

1) Condition and performance monitoring
2) Turnarounds and shutdowns
3) Wireless communication
4) Collaborative visualisation
5) Mobile ICT infrastructure
6) Robotics technology
7) Common integration architecture

The project is a collaboration between ABB, StatoilHydro, SKF, IBM and Aker Solutions, with the Research Council of Norway's PETROMAKS programme as co-financier.

5 post-doc and 5 PhD students are affiliated with the Tail IO project.

Total budget is NOK 220 million over three years.



Monitoring of oil production with 4D seismic
In the three seismic images we see from left to right the oil – saturation in the reservoir (in warm colours) at production start, the oil - saturation in the reservoir after nine years of production and finally the difference in oil – saturation as a result of nine years production. Based on this information reservoir – compartments with remaining oil can be identified and targeted with new wells like C-36 .

Seismic giant founded on research and innovation

Around 75 percent of the world's seismic fleets have Norway as their home base. Use of time-lapse three dimensional seismic (or 4D seismic) is considered to be perhaps the single most important technology for increasing extraction from existing oil fields. Much of the groundwork for this technology originated in a small Norwegian research group in the 1970s.

Something had to be done

Seismic had been used in oil exploration since the 1920s, but at that time it was in just two dimensions, one vertical and one horizontal. A long cable with receivers was dragged behind a boat, while simulated sound waves made by an air gun were sent down into the depths and reflected up from the reservoirs. This method gave limited information about the subsoil.

"There was therefore motivation to come up with a better solution," says Lars Sønneland, research director of Schlumberger Norway and one of the original driving forces behind the Norwegian seismic company, Geco AS.

"Our competitors had been using smaller supply boats for many years. These boats lacked control in the ocean and produced poor quality data. The Norwegian maritime industry, with its larger fleets, had long-standing experience of coping with difficult weather conditions. We therefore started using these boats when we needed more power and control in the sea to pull several seismic cables and produce a three dimensional picture of the subsoil," says Helge Brandsæter, former head of seismic processing at Geco AS.

Brandsæter studied physics and cybernetics at the University of Oslo and wrote his thesis on seismic data collection.

"We weren't the first to use this technique, but we were the first to commercialise the technology," says Brandsæter.

Foundations for success

Perhaps the most important factor that enabled the small group in Norway to flourish was what Sønneland calls the "North Sea laboratory".

"Statoil, Hydro and Saga Petroleum were all prepared to take risks and support us. This allowed us to carry out realistic field testing at an early stage. Close and effective dialogue with the oil companies also gave us valuable feedback about the nature of their requirements for technological development," says Sønneland.

A second and also very important factor for the rapid success of the group was having an effective organisation. Successful cooperation in a flat structure with a board that was prepared to provide support and try out new ideas was crucial. Decision processes were short from the initial idea to implementation.

"We had a considerable advantage over our American competitors in this respect. They had to go through extended processes at high levels in the company," says Anders Farestveit, one of the early visionaries in Geco AS.

Cooperation with the Research Council

Although the above mentioned factors were the most important for the pioneering work in this area, the Research Council of Norway also came in as partner later on.

"This public support was absolutely crucial. We were a small company, a dwarf in comparison with the large multinational companies," says Sønneland. Geco AS ran the pioneering work in all areas under the seismic umbrella; collection, processing and interpretation. 3D seismic produces enormous volumes of data, which created considerable challenges in the industry at the time. The Research Council supported key projects that worked on the interpretation of the data. Geco AS therefore became the first company in the world to develop a commercial seismic interpretation software, Charisma. In 1983, the automated interpretation station was presented at the Oslo Concert Hall as part of EAGE's annual conference.

"We had to hide the equipment behind a curtain so that our main competitors could not get a look at the technology," reminisces Farestveit. Charisma later became part of Schlumberger's GeoFrame, an integrated reservoir characterisation system.

"We basically began from scratch. The security that the Research Council's financial support gave us was particularly important for the work in developing the interpretation systems," says Lars Sønneland.

Norway today

In 2003, BP installed the world's first permanent 4D system on the Valhall field. It is estimated that the system could add around NOK 10 billion of value over the field's lifetime. This is possible because the system can produce three dimensional pictures of the reservoirs that are laid over each other and give the engineers a clear impression of where the challenges lie in the reservoir. There is also significant production of seismic equipment in Norway today, including seismic streamers and winch systems. The value of this production is estimated at around NOK 1.5 billion per year.

The Research Council's largest programme, PETROMAKS, provided support to 18 different seismic projects in 2007.

Facts:

Seismic: Use of sound waves to produce a picture of the subsoil in one or more dimensions

Seismic processing: Manipulation of seismic data to obtain user friendly pictures and information about the rock formation

4D seismic: Electromagnetic energy is sent down to the ground. Water and oil have very different electrical conductivities, which affect the amount of energy that is reflected back from the reservoir to the measurement instruments. By using advanced data technology, a picture of the reservoir can be created that shows whether you have found water or oil.

Ormen Lange: Norway's second largest gas field that is estimated to contain around 400 billion cubic meters of recoverable gas.

Supplying electricity under water

New field developments out at sea still require electricity. Researchers at SINTEF are helping find new ways of providing this power.

Subsea power
The oil companies on the Norwegian Continental Shelf (NCS) are now developing most of the fields using subsea installations. These installations require a great deal of power.

"With increasingly large electric installations on the seabed, there is more demand for power, meaning that the supply voltage will be increased. It is therefore necessary to develop new components that can supply power at the appropriate voltage. The operating companies need to know that these components are reliable and will operate for the required lifetime even under the extreme conditions they will be subjected to on the seabed," says Anngjerd Pleym, Research Director of SINTEF.

Decisive factor
One of the main challenges with underwater solutions is to achieve secure subsea compression.
"Electricity for compression on the seabed can be a decisive factor when developing new fields," Pleym confirms. One of the most significant future challenges will be the Ormen Lange installation. The pressure in the reservoir is high now, but when the pressure falls, gas compression will be needed. This will necessitate huge energy supplies. The question is whether the supply facility will be on floating platforms or down on the seabed.
"Time will tell whether the facility will be located on the seabed, but our research will help in developing this type of solution. There will be significant advantages in placing this type of facility on the seabed and the companies will save billions of kroner with such a solution," says Pleym.

Plastic buckets are not water tight
"Even a plastic bucket is not entirely water tight. Moisture seeps through the material under high pressure conditions and over long periods of time," says Einar Fasting of SINTEF. The SINTEF researchers have therefore begun a series of experiments to find impermeable insulation materials for subsea power.

"We are combining materials such as nano particles in plastic materials. Our aim is to improve the impermeability of the material," says Pleym.
The main focus for the projects will be knowledge building.
"We are building vital competence in this subject area and educating talented graduate researchers. This way, we will help to develop Norwegian know-how in subsea power supply. The researchers are trained to be able to solve basic problems and develop the necessary knowledge for developing and testing subsea equipment," says Pleym.

Competitive advantage and environment
With increasingly tough competition for licences and development projects, the project could make a difference internationally.
"The project could give Norwegian companies a competitive advantage internationally, providing them with attractive technology," says Pleym. She is also pleased that competitor supplier companies have joined forces and are supporting the project.

The energy project is also an example of how petroleum research can make important contributions to alternative energy solutions.

"A cable is a cable, whether it is used to supply electricity to a platform or from an offshore wind turbine to land. The research can therefore be useful for offshore wind energy as well as electrification of offshore oil installations," says Fasting enthusiastically.

Model testing in Orkanger fjord.
Photo: Atle Lenes

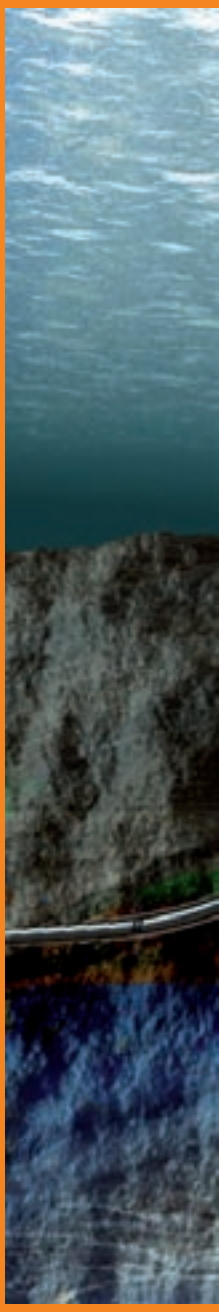
Facts about the project:
The PETROMAKS programme is supporting three research projects in subsea power supply. The total budget for the three projects is around NOK 75 million, including industry financing. Operator companies and supplier companies are participating in the projects through financing and supplying relevant know-how. The key areas of activity will include identification of critical components, characterisation of new insulation materials and new methods and equipment for condition monitoring.

The three projects are:
– Electrical Power Systems for Subsea Processing and Transportation of Oil and Gas
– Feasible Power Electronics for Demanding Deepwater Application
– Electrical Insulation Materials and Insulation Systems for Subsea High Voltage Power Equipment

Lifetime testing of cables under pressure and voltage. In the laboratory tests are carried to see how long the cables can withstand damp conditions under a certain pressure and voltage.
Photo: Hallvard Farmo.

The researchers who never gave up

It all began with a bright idea, but it took decades before this particular research adventure would become a reality, generating revenues in the NOK 100s of millions – and it cost blood, sweat and tears.



A bright idea
Professor Erling Hammer had an idea at the end of the 1970s. His aim was to measure the volume of water in oil. He made enquiries at the oil companies and the response was clear: What is the point? We separate the oil and water. The oil companies were also sceptical that this was actually technically possible. Hammer therefore approached NTNF, one of the forerunners of the Research Council of Norway, for initial funding.
"NTNF's support was tremendously important at that time," says Mr Hammer, retired professor of physics at the University of Bergen.

So why were multiphase meters important to the oil companies? In the late 1970s, the oil industry did not have control over production volumes: did an oil well produce mostly water or oil?
Oil is obviously a lucrative product whereas water just ends up back in the ocean. In those days, to find out how much oil they were producing, oil companies had to wait for the results of the separation process of the two phases. With multiphase meters, however, such results are obtained continuously. The oil fields would be able to produce at optimal levels and recover more oil.

Sceptical experts
Internationally, expert groups were sceptical. "What you're doing in Norway is just nonsense," declared an arrogant English professor to Erling Hammer at one seminar. An international race was under way to be the first to produce a multiphase meter, and few had faith in the Norwegian researchers. Although Hammer and his colleagues believed they were close to discovering something big, more opposition was waiting. After two years of support from NTNF, the funding stopped – and the message was clear: "Now you have to find an industrial partner.".

Market collapse
The concept was eventually presented at ONS in 1984 (the annual Offshore Northern Seas conference in Stavanger). By this time the oil industry was falling over itself with interest in the technology. BP and Saga invested a total of NOK 18 million in the project. The intention was to measure the composition of the mixture flowing through the oil pipes, or develop what's known as a fraction meter (phase 1).
This was duly achieved, but then the market collapsed.

"There was no market interest for this type of meter. The oil companies needed a flow meter as well as a multiphase meter," says Eivind Dykesteen from technology company Roxar. However, the researchers still had faith in the idea and started phase 2 of the development; a multiphase flow meter. They contacted a number of Norwegian companies that would be able to commercialise the end product.

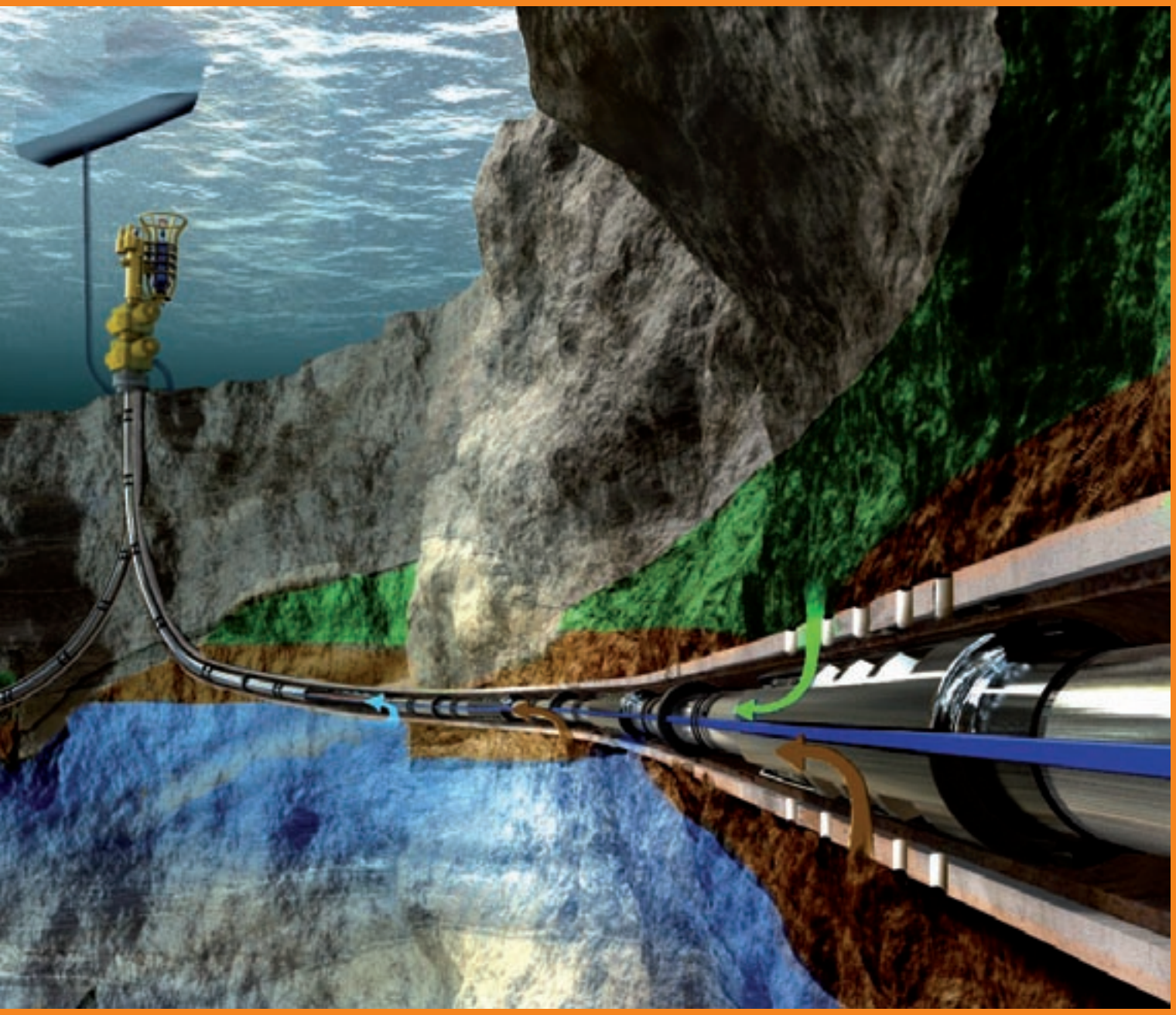
"But none of the Norwegian companies were interested. The "Not invented here" syndrome was too strong," says Erling Hammer. Instead, the Christian Michelsen Institute in Bergen founded its own company, Fluenta, to work on the technology.

Success at last
By 1992, they had developed a flow meter. Things were progressing smoothly in general, but new adjustments were required. The Norwegian Continental Shelf (NCS) began to mature over the course of the 1990s and increasing amounts of water were being produced.

"The method didn't work with such high levels of produced water. So we had to start yet another new project (phase 3)," says Dykesteen.

When it the last of the obstacles appeared to have been overcome, the technology was launched in 1996 – 15 years after the initial idea had been conceived. However, there were numerous teething problems.

"There were serious problems with the meters on the installations and these were not solved until a year later. Fluenta was in danger of going under and we had many disappointed investors. However, in 1999, the technology took off and in 2001 Roxar bought Fluenta. Roxar was formed from the merger of the competitor company Multifluid and Smedvig Technologies. Its value



The latest research breakthrough: Multiphase meters will be placed down in the wells.

multiplied and the long years of research finally began to produce results. Today, the multiphase department of Roxar generates revenues of NOK 500 million. Paradoxically enough, it was the Norwegian companies who had won the international competition to be the first to create a multiphase meter.

Also measures fish

The added value of multiphase meters is enormous, and has contributed to several developments on the NCS.

"Multiphase meters have become important in subsea development. One third of subsea wells now use them. This has changed development plans and improved production from the fields on the NCS though increased control," says Dykesteen.

The technology has also led to a number of spin-off effects:

The same technology used in the multiphase meters is now used to measure fish. The Bergen research group has also trained hundreds of physicists in the measurement technology. These individuals now work in research and in Norwegian industry.

But what did the oil companies get in return for supporting the project?

"They have gained directly in the form of profits and indirectly they have achieved substantial savings through less expensive development plans. They also benefit on a daily basis from increased production due to better control over the production process," says Dykesteen.

What is the next step?

"We need multiphase meters down in the wells," says Dykesteen, who is well aware that the oil companies to an increasing extent would like better control over which zones in the reservoir are producing water and which are producing oil.

A long-term view is vital

"The initial funding was decisive. No one wanted to take on such a project apart from NTNF. I don't think that CMR would have got very far with the concept without funding from the Research Council," says Hammer and continues:

"But it is also important not to spoon-feed by handing out money year after year."

Further support from the Research Council in the 1990s was also significant.

"Grants from the KAPOF programme were vital for Fluenta to start the industrialisation of the product," says Dykesteen.

Infrared eyes keeping watch in the north

At the far end of the harbour area of Trondheim sits the small research company Aptomar, looking out over the sea. Its experts are developing the latest in safety and surveillance technology for limiting accidental oil spills. Using infrared cameras, oil and gas extraction will become safer, including in the Northern Areas.

Aptomar uses advanced data systems technology, radar and IR cameras to give accurate positional information to ships and other installations, in addition to the thickness and spread of possible oil spills. Coordination of all the information in real-time will make clean-up and damage limitation safer and more efficient.

Environmental challenges in the north

As the petroleum industry moves increasingly further north, it will also encounter new challenges. Cold, darkness, icebergs, icing and long distances from emergency services and infrastructure all demand improved working methods. Industry will require new technology in most areas. Of particular importance is to develop better technology and increased know-how in preparedness and oil spill control and mitigation, to avoid potential oil spills that can cause significant damage to wildlife and nature along the coast.

In addition to the Norwegian Continental Shelf (NCS), there is also considerable activity among our other friends in the north. In Canada, activity is increasing and new fields have opened in its northernmost area on the Beaufort Sea. On the Russian side, the well known Stockman field is planning further development. For the Norwegian petroleum industry – both oil companies and suppliers – with their good environmental reputation, these developments provide opportunities for exporting technology and know-how in a world of intensifying environmental demands.

New technology in Trondheim

"The background of the project was a combination of summer jobs and studies at the Department of Engineering Cybernetics at NTNU (the Norwegian University of Science and Technology)," says an enthusiastic Lars Solberg, CEO of Aptomar.

"The initial idea was a stabilised search light for boats, but after working closely with consumer groups we saw other applications for the basic technology. The result of this was the safety and navigation system, SECurus. The project will develop the SECurus system into the best available tool for managing risk before, during and after an accidental oil spill. The tool will increase the efficiency of the clean-up operations; it will provide operational management on land and at sea with prompt decision-making information; and will give the operator company and the authorities information in real-time. On a practical level, the system will map the extent and variation in the thickness of the oil spill from the ship using infrared cameras. The system must be robust and be able to function under the specific conditions in the north – cold, dark and foggy with large waves.

The information about the thickness of the oil spill will be transferred automatically to a digital map in real-time, so that the operational management can direct the recovery resources where they will be of most use, for example, towards the thickest part of the oil spill.

"We are the only company in this market niche. The key functionality of our SECurus system is in the sensor platform and the user interface," explains Solberg.

Financing

Aptomar now has a number of large, industrial partners in the project, including StatoilHydro and Eni, both of which have existing operations in the Barents Sea. NOFO (the Norwegian Clean Seas Association for Operator Companies) and Simon Møkster Shipping are also participating in the project. Industrial sponsors are investing NOK 4 million throughout the project's lifetime and the PETROMAKS programme is contributing NOK 3.5 million.

"Both of the operator companies are focused on solving the key challenges facing all operator companies in the north; cold, darkness and proximity to coastal areas. StatoilHydro and ENI see the SECurus system as the next generation tool for handling crisis situations such as accidental oil spills and to protect life, health and the environment," says a proud Solberg.

The aim is to complete the project by the end of 2009 and for the technology to be operational shortly after. Aptomar can already see a significant international market for this type of technology and is working on this at the same time.

The new technology should be able to function just as effectively in both dark and rough seas as it does in calm, daylight conditions.

Facts:

Environmental technology in PETROMAKS:
Since the start of the project in 2004, the PETROMAKS programme has steadily increased its portfolio of projects in environmental technology. Environmental technology covers projects focusing on new technology and competence within preparedness and oil pollution control, risk management and reducing both sea and air pollution under normal operations. The PETROMAKS programme currently supports nine environmental technology projects to a total value of NOK 50 million. This has led to an approximately comparable investment amount from industry.

Company on the offensive with research as its weapon

Since 1987 the Research Council of Norway has supported around 23 of READ's research projects, through a range of programmes. Four of these projects are still active today.

"READ's successes would not have been possible without public sector support," says Tor Hilton, head of seismic at READ. Hilton says that as a student he was able to work on research projects with the late Professor Durk J. Doornbos, supported by the Research Council. "The first projects supported by the Research Council at the end of the 1980s laid the foundations for what we are doing now," he continues.
Since 1987, the Research Council has supported around 23 of READ's research projects, through various programmes. Four of these projects are still active today.

What does READ do?
One of the most crucial characteristics of an oil field is permeability. Permeability determines whether the oil can flow out and up to the surface or if it will be permanently trapped in the reservoir. One area that READ has distinguished itself in is finding, mapping and interpreting small structures in the reservoir that can have an enormous impact on the reservoir's ability to produce oil and gas. These mystical reservoir properties are called anisotropy and can be mapped using technology called borehole seismic.

Collaboration with the Research Council
Much of company's focus around the mid-1990s was on areas that were largely uncharted territory at the time. Hilton identifies two projects from 1994 in particular that received solid support from the Research Council. These projects would prove to be extremely important for the company, as READ is now one of the world's leading companies in "anisotropic processing", a skill in great demand from the oil companies. READ has a more than 50 per cent market share worldwide in this specific area of borehole seismic and has received the top rank in international benchmarks several times.
"We are the only company that can compete with the three key players in borehole seismic," emphasises Hilton, referring to Schlumberger, Baker and Halliburton.

International activity
Times have not always been prosperous, however, even for READ. During the industry downturn at the beginning of the decade, it was the company's international network of customers that led it through low oil prices and bleak economic forecasts. Hilton says that it was international companies such as Chevron, Shell and Total that helped them develop an international customer base, and that the company had little help from Norwegian enterprises.

READ now operates in around 30 countries. In 2005, it increased its activities in China and is looking at important development opportunities in North American and West Africa. In the Gulf of Mexico, READ has undertaken the largest 3D VSP contract for BP, and now has global contracts for borehole seismic with several major international oil companies.

Modern seismic data processing can give extremely detailed 3D pictures of the subsurface.

Long term research, vital for the future
An important, but often frustrating characteristic of research is that it is difficult to measure its short term benefits and therefore justify the funding and costs that accumulate as it progresses. Moreover, you don't always get the results that you are expecting. However, this doesn't mean that the research was in vain. The acquired knowledge can be used in the future.
"The basis for "seismic-while-drilling" that is being commercialised now for example, was actually developed 13 years ago when we received support from the Research Council for some early projects in that area," explains Hilton.

Of the other projects that the Research Council has supported in the last few years, Hilton points out two DEMO 2000 projects that involved implementation and demonstration of 3D and 4C seismic processing. "This project gave us a considerable boost and we are now working further on the technology that we developed," says Hilton proudly.

Norwegian partners
READ also collaborates closely with other Norwegian organisations. Its project with NORSAR focuses on interpretation and analysis of microseismic waves in bedrock created during oil production. It is thought that increased understanding of this phenomenon will improve both risk analysis during drilling and production optimisation. This could be an important contributor to continued production in the North Sea's increasingly ageing fields. The PETROMAKS programme is a key investor in the project and along with Total is providing most of the funding.

"There is an increasing market for this internationally. We need to be innovative and get a head start on the other groups," says Hilton.

Facts:
Permeability: A rock's ability to let fluid flow through it.

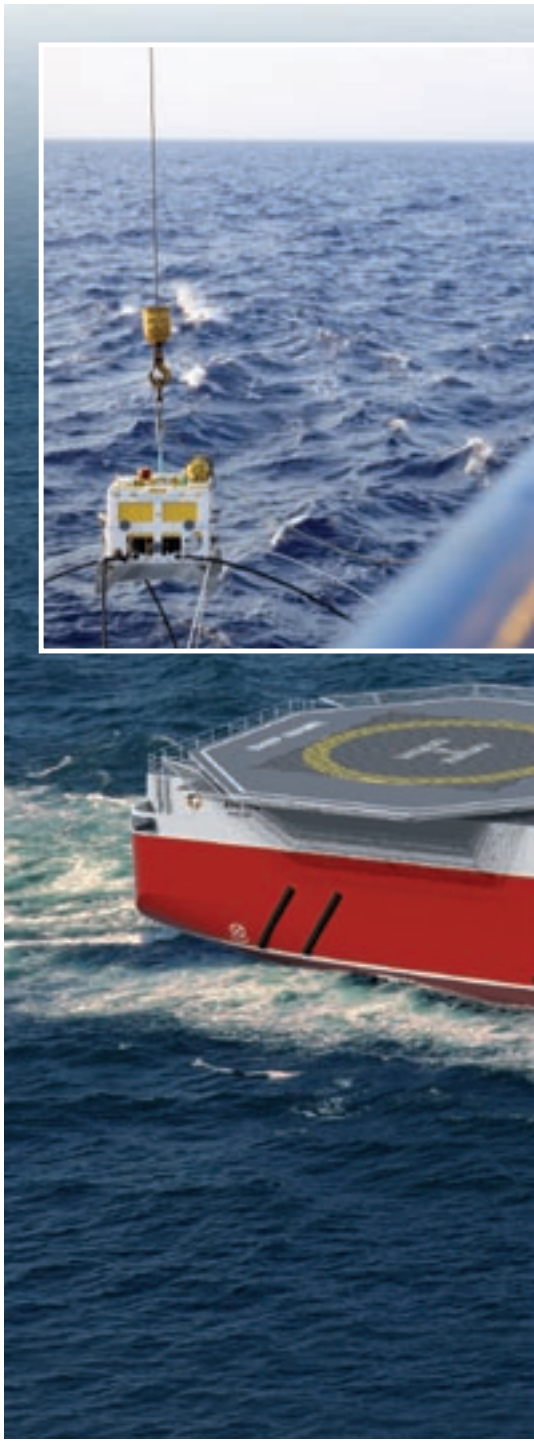
Anisotropy: A characteristic of many rock types that affects its properties so that they become dependent on which direction you observe the rock from.

Borehole seismic: Use of sound waves to produce a picture of the rock formation in one or more dimensions.

Seismic processing: Advanced computational treatment of seismic data to obtain user friendly pictures and information about the rock formation.

Long-term oil research produced new exploration technology

With a new and unique search technology, Norway is leading the world in oil exploration. Research and development over a 20 year period has played a crucial part.



In 2007, geophysics company EMGS was valued at NOK 5 billion on the Oslo Stock Exchange. The company's revolutionary technology, seabed logging, involves sending electromagnetic waves down into the subsurface, thereby helping oil companies establish whether there is oil or water in the reservoir. The seeds of this technology were planted over 20 years ago

Sowing the seeds

"Plants have a circadian rhythm that follows a 24-28 hour cycle. The leaves move up and down like clockwork. We disrupted this cycle using Electromagnetic (EM) waves," says Technical Director Svein Ellingsrud. He is talking about post-doc research into electromagnetic radiation in plants that he completed almost 20 years ago. Little did he know that this knowledge would form the basis for one of this decade's biggest Norwegian R&D successes.

Terje Eidesmo, CEO of EMGS, has a PhD in plant physics, while Fan Nian Kong, another of the key individuals behind the research at the Norwegian Geotechnical Institute (NGI), gained valuable expertise during his post-doctoral research in environmental technology. Common to them all was support from NTNF, the forerunner of the Research Council of Norway.

Pioneering project

Fan Nian Kong remained at NGI where he became involved in the POSLOG project, supported by the drilling technology programme at NTNF. The project aimed to use EM waves to help guide a drill head during the drilling process. After 20 years, it was concluded that the project itself was unsuccessful; however, the knowledge gained from the research would prove invaluable.

"It gave us the basis of our expertise. No one knew anything about using EM for this type of challenge before this work was done," says researcher Harald Westerdahl, who was also involved in the project. NGI subsequently became the most important research resource in EM technology for an inquisitive and experimental Statoil.
Parallel efforts were also made throughout the process to protect the technology and methods with patents.

Einstein's technology

In autumn 1997, Statoil researchers Ellingsrud and Eidesmo were in the USA. On their trip, they heard about a researcher by the unlikely name of Einstein, who had developed a powerful source of magnetic radiation.

On the flight back to Norway, Ellingsrud and Eidesmo asked themselves, "Could we possibly use this kind of source to search for oil?" This question triggered the whole idea of using EM radiation in this way and the researchers embarked on a project in collaboration with NGI to see if it really was possible.

With NGI, they carried out modelling studies in the autumn of 1997 and early part of 1998 and discovered that thin hydrocarbon layers could produce a measurable effect if the correct geometry, emitters and receivers were used.
"Statoil had excess funds available and wanted to do something ambitious with it. Spare money can lead to valuable advances," says Westerdahl.

The Statoil researchers became increasingly convinced about the technology. They tested it using eight king sized waterbed mattresses filled with fresh water – simulating an oil reservoir – which were submerged in a salt water pool. The EM technology produced results from the mattresses and new challenges awaited. Statoil's specially made mattress also became the world's biggest waterbed. "The Guinness Book of Records doesn't have anything bigger," says Ellingsrud.

Recipe for success

In 2000, the technology was tested off the coast of Angola, with positive results, and in 2002, the researchers showed that they could "see" the gas in the Ormen Lange field using the technology. "That was a very special moment for us," says Ellingsrud. They founded the company EMGS and a majority share were later sold to Warburg Pincus Private Equity for several hundred million kroner. With an almost 4 percent

The Atlantic Guardian crew performs 24/7 survey operations in Southeast Asia. Photo: emgs

emgs' current fleet of survey vessels. Photo: emgs

share holding, NGI received some NOK 15 million. The technology proved itself useful to the oil companies in the exploration process and has been used in the discovery of, among others, the Linerle prospect in the Norwegian Sea.

But what was the formula for success?
"A good idea, a market and sufficient capital, combined with a founding group with complementary expertise," says Ellingsrud. He adds, "...and never giving up. You have to be determined to fight on. We faced a lot of resistance and bumps in the road, including convincing a very conservative oil industry."

Further improvements
EMGS has paved the way for a number of other EM companies and research groups.

"They have seen our success and are jumping aboard. All of this has happened because of us. We have built up an enormous market," says Ellingsrud.

EMGS and NGI intend to develop the technology further. There are still problems with certain types of reservoir. For example, EM technology showed no results in the Nucula discovery in the Barents Sea, even through Hydro found oil there. EMGS is therefore heavily invested in continually improving its technology.
"We have 40 researchers working on R&D," says Ellingsrud.

EMGS is currently supported by the Research Council's PETROMAKS programme.

EMGS Facts:

Seismic: Seismic: Sound waves are sent down into the subsurface and reflected back when they strike different rock types. Seismic has very limited ability to "see" whether oil or water has been found.
EM waves: Electromagnetic energy
EM technology's main principle: Electromagnetic energy is sent down into the subsurface. Water and oil have significantly different electrical conductivity and this affects the amount of energy that is reflected back from the reservoir to the measuring equipment. Using advanced data technology, it is possible to form a picture of the reservoir that shows whether oil or water has been found. Ormen Lange: Norway's second largest gas field that is estimated to contain around 400 billion cubic metres of recoverable natural gas.

The PETROMAKS programme – Summary of 2008

Fellowship holder seminar on Norwegian oil and gas related research
The PETROMAKS research programme arranged a special seminar for the programme's fellowship holders on 24–25 April. The event was held at the University of Oslo and was attended by almost half of the 230 currently funded PhD and post-doc candidates.

The PETROMAKS programme has arranged several seminars over the past few years, but this was the first time that an event had been held exclusively for fellowship holders. The PhD and post-doc candidates supported by PETROMAKS programme funds were given two half-days to present their work and to discuss their contributions to Norwegian oil and gas related research.

One of the seminar's objectives was to increase awareness of the roles of individual fellowship holders. Why is "your" research important in a national and global perspective? Several representatives from industry, academia and the Research Council's programme gave plenary lectures and shared their experience and knowledge.

PETROMAKS – Russia seminar
On 17–18 June, the PETROMAKS programme arranged the third Norwegian-Russian seminar on Arctic technology in St. Petersburg. The seminar was held in collaboration with the Russian Academy of Science (RAS).

A total of 64 Russians and 53 Norwegians participated in two days of plenary discussions and thematic workshops. This year's event was split into three areas and focused on Arctic challenges within environmental technology, geology and field development.

This series of seminars is part of a long term strategy for increasing research cooperation between Norwegian and Russian organisations with a focus on the common challenges facing both countries in the north.

Seminar follow-up:
The PETROMAKS programme hopes that the seminar will contribute to increased cooperation and more projects. On this basis, international cooperation was specifically identified in the call for new project applications with a deadline of 15 October.

The PETROMAKS programme received several applications in the areas of environmental technology, geology and field development with Norwegian-Russian cooperation.

The programme administrators are now planning the next Russian seminar which will be held in Oslo on the 17–18th of June 2009.

ONS 2008 – Innovation Park
Innovation Park was part of ONS 2008 (the annual Offshore Northern Seas conference and exhibition) in Stavanger. It is a collaborative project between ONS, the Research Council, Innovation Norway and Ipark (Stavanger Innovation Park, formerly the Rogaland Science Park). 21 enterprises from the four partners' portfolios were invited to present their innovative projects and products in a green and creative setting.

Ola Vestavik from ReelWell AS emphasised the value of being able to showcase themselves at such an event and how important the project funds from the Research Council are for a small, innovative company in its start-up phase.

The companies on display included everything from brand new and small SMEs to more established enterprises.

"I am delighted that at this year's ONS we have been able to showcase some of the exciting and innovative projects that the Research Council supports," said Siri Helle Friedemann, Programme director of the PETROMAKS programme.

The stand was strategically placed beside StatoilHydro, Petoro and the Government stand. This gave the Innovation Park participants the chance to make valuable contacts and attract particular attention from important guests.

Seminar on Integrated Operations
The PETROMAKS programme has follow-up responsibility for one of the 14 Norwegian Centres for Research-based Innovation (SFIs) – the Center for Integrated Operations in the Petroleum Industry (IO Center). On

PETROMAKS was responsible for Innovation Park at ONS 2008 together with Innovation Norway, ONS and IPark.

9 September 2008, a day seminar was arranged with IO Center for representatives from the oil industry, supplier industry and R&D institutions.

Adviser Tor Petter Johnsen presented the Integrated Operations (IO) projects in the PETROMAKS portfolio and discussed the autumn call for new project applications for the programme. Presentations were also given by a number of large research initiatives within IO.

"We are delighted with the seminar and the wide participation it attracted," said Tor Petter Johnsen.
"In addition to being an arena for exchanging information on research in the area, there was also room for discussion of strategic challenges in the future".

News from the administration

– Programme director Siri Helle Friedemann has been named as jury chair for the ONS 2010 Innovation Awards.

– The programme board in PETROMAKS gave 30 new projects funding for research on the board meeting December 18th. PETROMAKS received 117 applications on October 15th 2008.
The programme decided to grant 60 MNOK for 2009 for new projects, this amounts to 248 MNOK over the lifetime of the projects .

– The PETROMAKS programme board, which has been in place since the programme's inception in 2004, will hold its final meeting on 18 December 2008. A new board will then be appointed and begin its term of office from January 2009.

Programme director in PETROMAKS, Siri Helle Friedemann.

About this publication
In this brochure you can read about some of the exiting projects in the PETROMAKS portefolio. The articles are written by advisers Reidar Müller, Tarjei Nødtvedt Malme, Christine Meling Christensen and Kari Druglimo-Nygaard in the PETROMAKS programme, the Research Council of Norway.

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