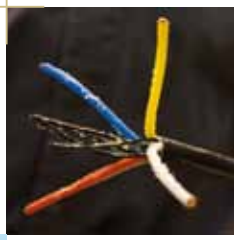
The Research Council of Norway

# Raising energy efficiency and cutting greenhouse gas emissions

## An analysis of publicly funded petroleum research

Programmes
PETROMAKS/DEMO 2000



## About the programmes
# PETROMAKS/DEMO 2000

**Large-scale Programme for the Optimal Management of Petroleum Resources (PETROMAKS)**

A major part of petroleumrelated research activities at the Research Council of Norway are consolidated under the PETROMAKS programme, which is one of seven programmes under the Research Council's Large-scale Programme initiative.

The PETROMAKS programme encompasses strategic basic research, competence-building, applied research and technology development. The programme promotes knowledge creation, industrial development and international competitiveness to enhance value creation for society based on petroleum resources.

Launched in 2004, the programme will conclude in 2013 after having allocated approximately NOK 2 billion during its programme period.

**Programme for demonstration and pilot testing in the petroleum sector (DEMO 2000)**

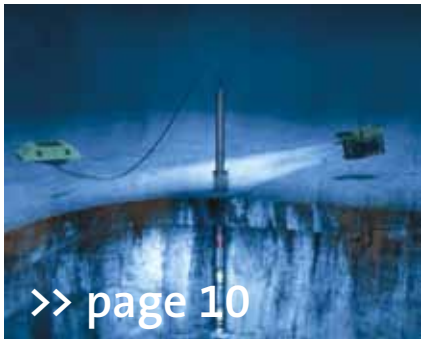
The DEMO 2000 programme provides support to pilot projects in the petroleum industry to demonstrate and qualify cost effective technology for offshore field developments on the Norwegian continental shelf.

The goal is to improve efficiency and reduce environmental impact on new and existing installations and to provide a foundation for new products and jobs.

Launched in 1999, the DEMO 2000 programme allocates approximately NOK 50 million annually.

# Contents






*Badger Explorer ASA has developed a semi-automated, energy efficient drilling robot.*


*Researchers at SINTEF are making strides in developing a subsea power supply.*


*FMC Technologies saves energy by relocating the oil/water separation process to the seabed.*

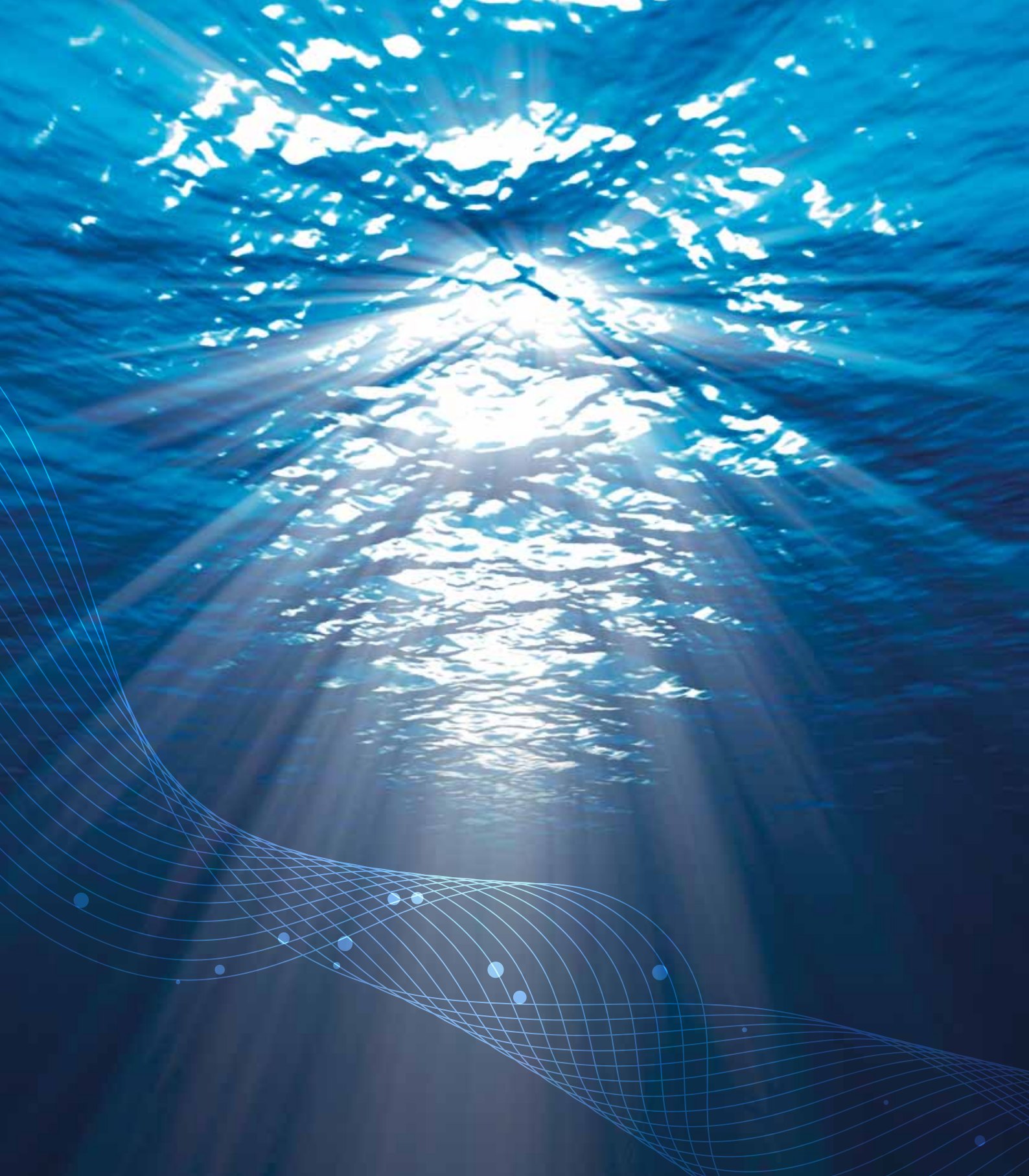


Photo: Shutterstock

# Preface

Petroleum activities comprise Norway's largest industry in terms of value creation, government revenue and export value. In 2011 several discoveries of major petroleum deposits in the Barents Sea and the North Sea have underscored the significant resource potential remaining on the Norwegian continental shelf.

Norway still has sufficient petroleum reserves to sustain substantial production and value creation for many years to come. At the same time, the world is facing tremendous challenges in terms of reducing global emissions of greenhouse gases. Norway plays an important role in this context as a stable, environmentally conscious supplier of petroleum with a long history of research and technology development.

The broad-based political agreement on climate policy[1] achieved in the Storting in 2008 states that climate must be a prime focus of publicly funded petroleum research. Each year since 2010 the Ministry of Petroleum and Energy has allocated earmarked funding for climate-related petroleum research over the national budget.

This brochure is based on an analysis study that ascertained that since 2004 the Research Council's PETROMAKS and DEMO 2000 programmes have allocated funding to more than 80 projects carried out by the research community and private industry relating to climate challenges. Once these projects have been concluded, they will have received a total of over half a billion kroner in public funding. There is no doubt that many of the measures recommended by these projects will have positive impacts on the environment. Many of these research findings can contribute to making processes more energy efficient or to directly reducing emissions of greenhouse gases.

The brochure presents a selection of these projects. A complete list of projects under the PETROMAKS and DEMO 2000 programmes which address raising energy efficiency may be found at the end of the brochure.

In the revised OG21 strategy (Oil & Gas in the 21st Century), the strategic body for the petroleum industry identifies higher energy efficiency and cleaner production as the most important strategic objectives for petroleum research in the years ahead. The target must be for Norway to remain the oil and gas province with the highest energy efficiency, lowest emissions to air, and lowest levels of hazardous emissions to sea per produced unit. The strategy recommends strengthening public funding of petroleum-related research and development (R&D) over time, and identifies the development of energy efficient technology to reduce emissions to air and sea as one of four priority technology areas.

In the course of 2013, a new large-scale petroleum research programme will succeed the PETROMAKS programme, continuing to promote activities with a clear focus on technology and knowledge development that will further reduce the petroleum industry's environmental footprint.

I trust you will find this brochure informative.

**Siri Helle Friedemann**
Director,
Department for Petroleum Research
Division for Energy, Resources and the Environment

[1] Report No. 34 (2006-2007) to the Storting on Norway's climate policy resulted in a broad-based political agreement in 2008.

# Raising energy efficiency and cutting greenhouse gas emissions

The government white paper on Norwegian climate policy (Report No. 21 to the Storting)[2] presented in April 2012 states that Norway should have one of the world's most ambitious climate policies, and that this will entail implementing new, more efficient technology. In the global context, Norway is at the forefront of energy efficient oil production.

As Norway's fields mature, increasing amounts of energy will be required to recover oil and gas deposits. The white paper points out that petroleum research can help to reduce greenhouse gas emissions through more energy efficient development and operation of oil and gas installations. Research and technology development can help to cut emissions to air both directly, for example by reducing the tonnage of carbon dioxide ($CO_2$) produced by emitting sources, and indirectly through more energy efficient production processes.

**Energy supply – electrifying the Norwegian continental shelf**

Oil and gas installations on the Norwegian continental shelf emit roughly 14 million tonnes of $CO_2$ equivalents annually. Some 75% of these emissions stem from local electricity production using natural gas turbines for offshore operations. In order to reduce these emissions, the feasibility of electrifying many offshore installations through connections to the mainland is being discussed. The mainland electricity will have to be produced using clean sources of energy if such a solution is to yield significant environmental benefits.

**More efficient use of energy through treatment of produced water and subsea separation**

No one will pay for oil with water in it. Water in the oil will also damage refinery equipment, so the water must be separated from the oil before transported to the refinery.

Water, being heavier than oil, sinks due to gravity. Enlarging the size of the water droplets makes them sink faster and separate more easily from the oil. **Coalesence,** the technology for inducing water droplets to join together into larger droplets, yields other benefits as well: there is less need for chemicals to break down the oil/water emulsions and less need to heat the oil/water mixture, which in turn raises the energy efficiency of the process.

**Examples of relevant topics/challenges:**

- Raising energy efficiency
  - >> energy supply
  - >> more efficient use of energy
  - >> reducing time required for energy intensive processes
- Reducing greenhouse gas emissions
  - >> reducing flaring
  - >> reducing emissions from power generation

[2] 2011-2012

Performing parts of the oil/water separation process on the seabed helps to make oil production more energy efficient. Reinjecting the produced water back into the oil well frees up room in the pipeline up to the platform, so less energy is spent on pumping water hundreds of metres up to the platform for separation and then down again.

**Reducing time required for energy intensive processes**

An indirect way to achieve cuts in emissions to air is by making processes more efficient so they can be carried out more quickly; spending less time on the same operation means reduced emissions to air. Cutting the time needed for energy intensive processes may involve, for instance, shortening the time spent perfoming a drilling operation, rigless drilling or using a seabed-placed drilling unit.

**Reducing flaring**

Flaring is the practice of burning off excess flammable gas and oil from petroleum recovery. This is both a waste of resources and a significant environmental strain in the form of large emissions of $CO_2$. Flaring should thus be kept to a minimum. However, flaring does provide a safe way to vent gas and fluid if a fatal error should occur in the production process. Therefore, a small pilot flame is kept burning from the flare stack at production platforms.

A better optimised process of recovering oil and gas will translate into fewer facility malfunctions and will thus reduce flaring by limiting petroleum installation shutdowns.

**Reducing emissions from power generation**

Power generation using natural gas and diesel fuel is the primary source of $CO_2$ emissions on the Norwegian continental shelf. Raising energy efficiency and phasing out the turbines used to generate power are key environmentally friendly measures for saving energy and cutting emissions.

Photo: Badger Explorer ASA

He Zhao, a Ph.D. student under the Remote Gas project and now a post-doctoral fellow in the Low Emission LNG project at SINTEF Energy Research, is examining droplet formation in the laboratory.
(Photo: SINTEF Energy Research AS)

# Projects opening up new possibilities

The Research Council's Department for Petroleum Research has carried out an analysis study to identify petroleum research projects that have the potential to improve energy efficiency and/or reduce emissions to air should the new technology and research findings be implemented.

The study is based on close dialogue with the project managers of more than 80 projects funded under the Research Council's PETROMAKS and DEMO 2000 programmes. The analysis shows there is great potential in many of the projects for raising energy efficiency and cutting emissions to air. This potential can be realised by implementing new technology in several areas.

The findings show that across a variety of project types and scientific disciplines, 81% of the projects have the potential to raise energy efficiency, while 67% have the potential to reduce emissions to air. In addition, nearly half the project managers responded that their projects also have potential for other environmental benefits such as lower emissions to sea and less use of chemicals. This suggests that new technology in general contributes to both raising energy efficiency and cutting greenhouse gas emissions.

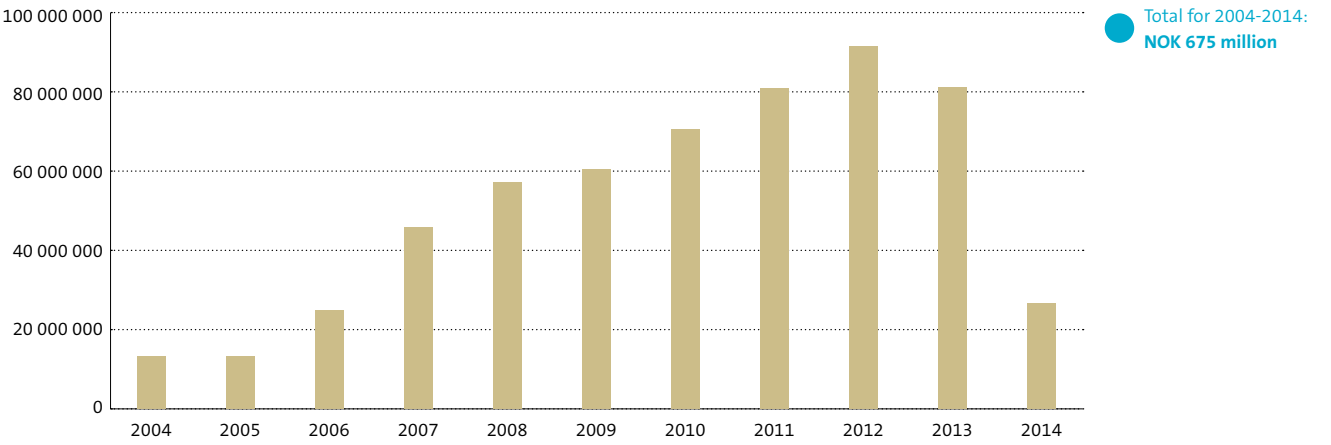
Feedback from more than 80 project managers indicates that a large proportion of the projects represent potential to both raise energy efficiency and reduce greenhouse gas emissions. Please note that since most projects offer possibilities for multiple environmental benefits, the number of projects under each topic adds up to more than the total number of responses.

The two petroleum-related programmes have allocated NOK 675 million to projects relating to raising energy efficiency in the petroleum sector and/or cutting the industry's emissions to air. Most of the projects fall under the technology areas *subsea processing and transportation* and *cost-effective drilling and intervention*.

At the end of this brochure is a list of the projects under the PETROMAKS and DEMO 2000 programmes whose activities, according to project managers' responses, can contribute directly or indirectly to raising energy efficiency and/or cutting greenhouse gas emissions.

| The project managers' own classification of environmental potential | Number | Percentage |
|---|---|---|
| Energy efficiency | 72 | 81 |
| Less emission to air | 60 | 67 |
| Electrification | 13 | 15 |
| Other | 43 | 48 |
| Total number of responses | 89 | |

**Public funding allocated to petroleum research with potential for raising energy efficiency and/or cutting greenhouse gas emissions**




**Research on environmentally friendly utilisation of petroleum resources**
Many of the projects in the petroleum programmes' portfolios aim to develop technologies for raising the energy efficiency of oil and gas production on the Norwegian continental shelf.

>> Implementing bottoming-cycle steam turbines on gas turbines on the Norwegian continental shelf would cut 2.65 million tonnes of $CO_2$ emissions per year – the equivalent of over a million motor vehicles.

Implementing new, environmentally friendly technology will boost the efficiency of power production and lower energy consumption, thereby reducing $CO_2$ emissions.

Raising the energy efficiency of power production is one of the top environmentally friendly priorities for saving energy and cutting emissions. This may be done, for example, by examining how to most efficiently utilise available waste heat at offshore platforms.

Project findings indicate that:

>> Energy savings of up to 35% may be possible by implementing bottoming-cycle steam turbines on the platforms' gas turbines.

>> Optimising electricity production at existing oil platforms has the potential to cut energy consumption by 15-20%.

**Research carried out at universities, university colleges and independent research institutes**
Among the projects carried out by research groups, it is particularly those in the area of subsea processing and transportation that have led to the development of technology that can raise energy efficiency and reduce greenhouse gas emissions to air. Although the primary objective of these projects may have been technology development for other specific purposes such as separation technology, they have made important contributions to developing technology with major potential to benefit the environment.

The projects receiving funding from the Research Council address a wide array of topics and promote advances in many areas.

Findings from projects in the portfolio include the following:

>> Electrocoalescence studies indicate that raising the efficiency of oil/water separation at an oil production facility can reduce the power requirement for this operation by over 50%.

>> Phasing out fields with topside installations and developing new fields with subsea installations can, in some cases, reduce greenhouse gas emissions by 50%.

>> Using low-friction materials in pipelines can reduce in-line pressure drops and provide more energy efficient transport of multiphase fluids. It can also reduce the number of compressors needed along the pipeline.

>> In the long run, halving emissions from inefficient gas turbines on the Norwegian continental shelf would reduce greenhouse gas emissions equal to the annual emissions from 2.5 million petrol-powered vehicles in Norway.

>> Electrification of the Norwegian continental shelf could substantially cut local emissions from platforms and floating production units, particularly emissions from inefficient gas turbines.

**Research carried out by the industry**
Research carried out by the petroleum industry itself indicates that advances in drilling and well technology hold the greatest potential for benefitting the environment. Raising energy efficiency is not the primary objective of these projects, but rather the result of development and innovations targeting other ends.

The analysis shows that although the contributions of each individual project may be modest, collectively and together with other innovations they have major potential for bringing about real change in the petroleum industry. The potential for raising energy efficiency and cutting greenhouse gas emissions can primarily be realised by implementing technology in a number of technology areas such as robotisation, automation and faster drilling.

Feedback from the project managers indicates that good progress is being made on developing new and improved methods for drilling greater distances and more efficiently than is possible with conventional methods.
Other findings include:

>> New oval-hole drilling technology can reduce friction by 10% compared to conventional round well paths.

>> Loading oil from a floating platform directly to tankers could reduce emissions of volatile organic compounds (VOC) by more than 50%. This would spare the environment 750 000 tonnes of $CO_2$ equivalents annually – as much as the emissions from 400 000 motor vehicles in Norway.

>> New technology for drilling from floating rigs can reduce fuel consumption by 30%.

>> More knowledge about drilling and well models in the planning and operational phases could improve well construction and cut $CO_2$ emissions by 10%.

>> A newly designed pump for produced water should raise efficiency by at least 10% compared to conventional pumps, due to better separation and hence less droplet breakup.

Photo: Badger Explorer ASA

# Digging like a badger to cut emissions

The Badger Explorer is a semi-automated drilling robot with a standard drill bit on the front end, rotated by an electric motor. Cuttings are transported to the tail end of the device and compacted against the walls of the borehole so that the robot digs through the formation like a badger.

▶ The Badger Explorer collects formation data during the drilling operation. The data collected is transmitted via the power cable to a communications device and relayed to the operations centre on shore. Operating the drill requires 10 kW of power. The device can be remotely controlled and monitored, eliminating the need for deploying personnel offshore.

Upon commercial launch, the Badger Explorer will:

›› Consume substantially less energy than conventional drilling rigs. The need for helicopter transport and support vessels will be dramatically reduced, further lowering energy requirements associated with drilling operations.

›› Supplant the use of drilling mud and associated chemicals in drilling activities, thus eliminating these materials as a source of pollution.

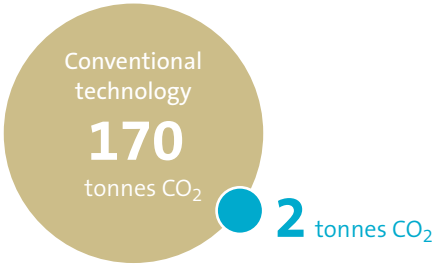
Assuming that a diesel generator were to power the device, drilling a 1 000-metre deep well with the Badger Explorer would require 2 500 litres of diesel fuel, resulting in 680 kg of $CO_2$ emissions. Drilling a 3 000-metre deep well would generate just over two tonnes of $CO_2$.

The figures for equivalent operations with conventional drilling technology amount to diesel-fuel consumption of approximately 530 tonnes, resulting in around 170 tonnes of $CO_2$ emissions. In comparison, the Badger Explorer would be 85 times more efficient in terms of energy consumption.

www.bxpl.com

Photo: Badger Explorer ASA

**$CO_2$ emissions**



# Extending the reach of horizontal drilling

The entrepreneurial company Reelwell AS has come up with a new technology for extended reach drilling with great potential for increasing recovery and value creation from oil and gas fields while sharpening focus on safety and the environment.

▶ Reelwell's developments have made it possible to drill significantly longer horizontal wells than current conventional technology allows. By extending the horizontal reach from existing offshore installations, the company's technology can help to increase the resource base and make it economically feasible to tap into marginal reservoirs in the vicinity of the installation.

The drilling technology may also be employed from land to reach offshore fields in areas near the coastline. This method eliminates the risk of catastrophic blowouts at sea – always an important consideration, but especially critical in the Arctic and other areas with a vulnerable natural environment, or reservoirs below lakes or populated areas.

www.reelwell.no

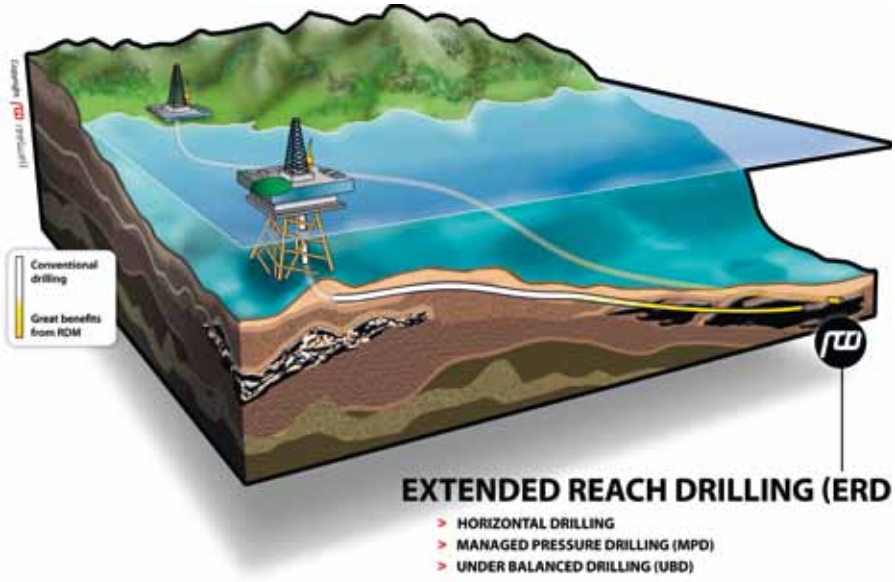



Illustration: Reelwell AS

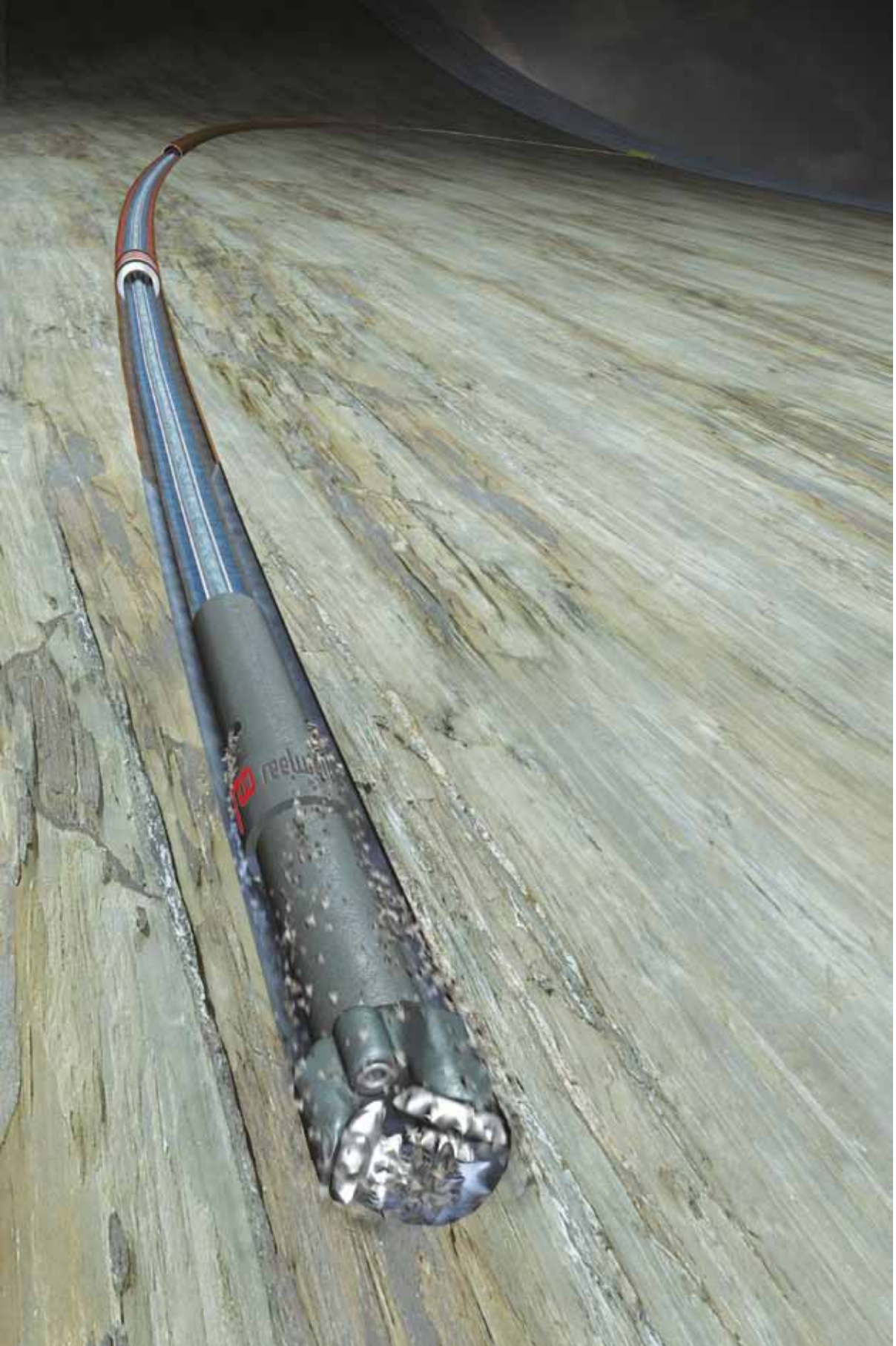


Illustration: Reelwell AS


AkerSolutions
OSCV 03

Photo: Rolls-Royce Marine AS

# Light rope to replace heavy wire

Rolls-Royce Marine AS is contributing to replacing the use of steel wire with fibre rope when installing subsea facilities. Unlike steel wire, fibre rope is nearly weightless in water.

▶ Using fibre rope as a substitute for steel wire during deepwater lifting operations decreases the power requirements of the crane, the winch and the vessel during operation. For the installation of large-scale seabed production systems off the coastline of Brazil, it has been common practice to employ drilling rigs throughout the entire process. Deploying boats equipped with a Rolls-Royce lifting system allows fibre rope to be used during certain stages of the process, cutting installation time by more than half.

In 18 months of production time, 100 installations have been carried out with the vessel *Skandi Santos,* operated by Aker Solutions.

Lighter equipment and shorter operations have reduced emissions to air substantially.

www.rolls-royce.com/marine

Photo: Rolls-Royce Marine AS

Photo: SINTEF/Thor Nielsen

# Generating electricity under water

Oil companies operating on the Norwegian continental shelf are now looking into the possibilities for making their next oilfield a subsea facility. Such installations require a great amount of electricity from a highly reliable source. Researchers at the independent research foundation SINTEF are poised to help with new solutions.

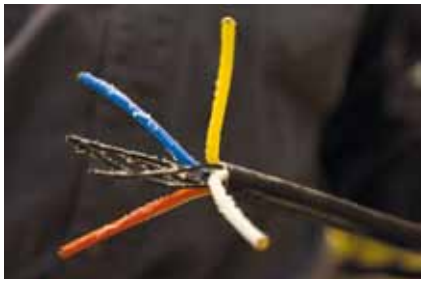


Photo: SINTEF/Thor Nielsen

▶ As the size of electrical installations on the seabed steadily grows, so does the need for high-voltage electricity. This need drives the development of new components able to provide an energy supply with adequate voltage levels. The operating companies must be assured that these components meet reliability requirements and have an acceptable lifetime, withstanding exposure to the seabed's extreme conditions.

**Plastic buckets are not watertight**

Even a plastic bucket is not watertight. Under high pressure, moisture penetrates the plastic and along material seams over time. Researchers at SINTEF have initiated a number of experiments with the aim of finding good solutions, for example, for high-voltage subsea cables.

The researchers' efforts to develop a subsea power supply have also led to the development of an electric power technology capable of operating under seabed water pressures down to a depth of 3 000 metres.

In addition, the researchers have developed new analytical methods and models making it possible to analyse complex electrical power plants with high precision.

**Helping to design alternative energy solutions**

These research projects clearly demonstrate that petroleum research can make a valuable contribution to designing alternative offshore energy solutions. The research results will also be very valuable in other marine activities, such as offshore wind power production and the electrification of offshore installations.

Challenges relating to cable technology closely resemble those faced in these areas of application. Compact seabed systems can help to reduce the amount of materials used, lower production-related emissions, and cut the installations' environmental costs.

www.sintef.no/home

# Faster drilling cuts emissions

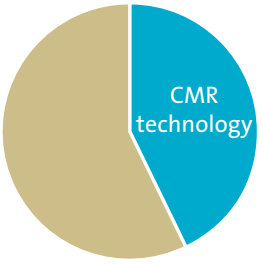
WeST Drilling Products AS has developed the Continuous Motion Rig (CMR), a revolutionary new drilling method with the potential to cut drilling costs in half while reducing emissions accordingly.

▶ The CMR method cuts the time required for a drilling vessel to remain on-site during operations by 40-45%, reducing energy requirements over conventional drilling practices by a corresponding amount.

CMR drilling is carried out without acceleration/deceleration when running drill string or casing in and out of the hole, translating into total energy savings of 55-60%. CMR technology contributes substantially in terms of raising energy efficiency and reducing emissions to air.

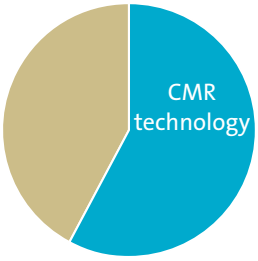
www.westgroup.no

**Time savings**




**40 - 45 %** Time savings

**Energy savings**




**55 - 60 %** Energy savings

▲ A CMR drilling installation shown on a modern Maersk “Jack Up” drilling rig.
(Illustration: WeST Drilling Products AS)

▶ The CMR triple will cut both drilling costs and emissions in half.
(Illustration: WeST Drilling Products AS)

# Rapid robots

Most operations on the drill floor are carried out using hydraulic systems. The company Robotic Drilling Systems AS is clearing the way for electric robots to take over these tasks, cutting time spent on operations and reducing environmental impact.

Photo: Robotic Drilling Systems AS

▶ An electric robot will consume less energy than hydraulic systems. A hydraulic pump runs continuously, whether the system is in use or not. Energy is also lost when converting mechanical energy to hydraulic energy in addition to the losses incurred via valves, pipes, regulators and other components in the hydraulic system.

The use of electric robots eliminates this energy loss while facilitating planning and a greater degree of standardisation in operations. The objective of Robotic Drilling Systems' project is to develop robots that can perform tasks 30% more quickly while consuming significantly less energy than conventional technology.

www.rds.no/home

Photo: Robotic Drilling Systems AS

Photo: FMC Technologies, Inc.

# Separating oil and water on the seabed

One challenge facing oil production activities on the Norwegian continental shelf is the steadily increasing amount of water collected from maturing reservoirs. Water has to be removed before the oil can be transported to shore for refining into petrol, paraffin and other essential products.

▶ Current separation facilities are almost exclusively located at the ocean surface, meaning that a great deal of energy is used to transport the oil and water several hundred metres up to the surface and then to transport the water down again. A more effective solution would be to remove the water before transporting the oil and gas to the surface. For certain projects, separating out the water on the seabed could save a great deal of energy.

FMC Technologies, Inc. is developing new techniques for subsea separation of oil, water and gas. The new technology will make subsea constructions a more feasible and attractive alternative for many more petroleum field facilities, including deepwater sites.

Compact seabed facilities make exclusive use of electric motors to run equipment such as compressors and pumps. No exhaust is emitted on site and no energy is needed for transport or for personnel facilities.

www.fmctechnologies.com

Photo: FMC Technologies, Inc.

# Smooth pipes have less pressure loss

When transporting liquids and gases over long distances through a pipeline, it is essential to maintain internal pressure.

Photo: Colourbox

▶ Uneven pipeline surfaces are one factor causing pressure loss. Surface anomalies can arise from corrosion, droplets, or deposits of wax or other solid materials. Compressors are commonly placed at regular intervals along the pipeline in order to maintain adequate pressure and to ensure flow.

The SMOOTHPIPE project is a collaboration between SINTEF Materials and Chemistry, the Norwegian University of Science and Technology (NTNU) and a number of industry partners. The objective of the research project is to examine how the use of various coatings on the internal pipe surface can limit pressure loss in multiphase fluids. An effective coating will result in a smoother pipe surface by preventing corrosion and decrease the accumulation of deposits. This will improve energy efficiency by reducing the number of compressors needed along long pipelines.

www.sintef.no/home/Materials-and-Chemistry/

# Projects included in the analysis

Key

- Energy efficiency
- Fewer emissions to air
- Electrification
- Other

Project managers were asked to complete a qualitative and quantitative analysis of their respective project's potential for raising energy efficiency and/or cutting emissions to air. More than 80 project managers confirmed that their project has potential for yielding environmental benefits, either through more energy efficient processes or reduced emissions of greenhouse gases.

**Projects relating to raising energy efficiency – the PETROMAKS programme**

| Project no. | Project Owner | Project title | | | | |
|---|---|---|---|---|---|---|
| 143992 | Norwegian University of Science and Technology (NTNU) | High Pressure Gas Separation (HiPGaS) | ✓ | ✓ | | |
| 146710 | SINTEF Energy Research | Eletrocoalescence – Droplet-droplet interaction and coalescence in electric fields and turbulent flow – experiments and modelling | ✓ | ✓ | | ✓ |
| 156662 | Statoil ASA – Trondheim | Compact LNG Heat Exchangers | ✓ | ✓ | | |
| 163253 | Badger Explorer ASA | Badger Explorer Prototype | ✓ | ✓ | | ✓ |
| 168159 | SINTEF Petroleum Research | Prediction of deposition and transport of sand in sand-liquid flows (STRONG) | ✓ | | | ✓ |
| 168274 | Statoil ASA | Compressed Energy Technology | | ✓ | | |
| 168284 | Remora AS | Model Test – HiLoad LNG Regas Terminal | | ✓ | | |
| 169293 | Seabox AS | SWIT – Subsea water injection and treatment | ✓ | | | |
| 169381 | Robotic Drilling Systems AS | Feasibility Study regarding a Subsea Drilling Module | ✓ | ✓ | ✓ | |
| 169429 | Institute for Energy Technology (IFE) | Optimisation of Glycol Loop Design and Operation | ✓ | | | ✓ |
| 169439 | Axon Norway AS | Drilling optimization in Real Time | ✓ | ✓ | | ✓ |
| 169466 | SINTEF Energy Research | Electrocoalescence – Criteria for an efficient process in real crude oil systems | ✓ | ✓ | | ✓ |
| 169477 | NTNU Department of Chemical Engineering | High Pressure Gas Liquid Separation | ✓ | ✓ | | |
| 174036 | Eureka Pumps AS | Underwater ElectroMagnetic Sensorsystem | ✓ | ✓ | ✓ | ✓ |
| 175918 | SINTEF Materials and Chemistry | Reducing the Environmental Impact of Acid Gas Cleaning Technology | ✓ | | | ✓ |
| 175968 | University of Bergen | $CO_2$ Injection For Stimulated Production Of Natural Gas | | ✓ | | |

>>

| | | | | | | |
|---|---|---|---|---|---|---|
| 175997 | Typhonix AS | Development and testing of a new low shear valve concept | ✓ | ✓ | | ✓ |
| 176018 | International Research Institute of Stavanger (IRIS) | E-centre laboratories for automated drilling processes | ✓ | | | ✓ |
| 176024 | SINTEF Energy Research | Electric power systems for subsea processing and transportation of oil and gas | ✓ | ✓ | ✓ | ✓ |
| 176025 | SINTEF Energy Research | Feasible power electronics for demanding subsea applications | ✓ | ✓ | ✓ | ✓ |
| 176134 | SINTEF Energy Research | Electrical Insulation Materials and Insulation Systems for Subsea High Voltage Power Equipment | ✓ | ✓ | ✓ | ✓ |
| 176137 | Institute for Energy Technology (IFE) | Liquefaction of Unprocessed Well-Stream | ✓ | | | |
| 176611 | SICOM AS | SmartPipe – Self diagnostic pipelines and risers for future integrated process management | | | | ✓ |
| 179790 | Seabed Rig AS | Development of Seabed Drilling Rig, Phase 1 | ✓ | ✓ | ✓ | |
| 180038 | SINTEF Materials and Chemistry | SMOOTHPIPE: Applied Surface Technology for Multiphase Pipelines | ✓ | ✓ | | |
| 187320 | Seabed Rig AS | Development of Seabed Drilling Rig, Co-operation with Universities | ✓ | ✓ | ✓ | |
| 187389 | SINTEF Materials and Chemistry | Arctic Materials – Materials technology for safe and cost-effective exploration and operation under arctic conditions | ✓ | ✓ | | ✓ |
| 187391 | International Research Institute of Stavanger (IRIS) | Water Weakening of Chalk – Physical and Chemical Processes | ✓ | | | ✓ |
| 188981 | eDrilling Systems AS | eDrilling Qualification and Demonstration | ✓ | ✓ | | |
| 192950 | eDrilling Systems AS | Complex Operations Control | ✓ | ✓ | | |
| 192967 | SINTEF Materials and Chemistry | Deep water repair welding and hot tapping | ✓ | ✓ | | ✓ |
| 192974 | Typhonix AS | Development of a subsea Typhoon Valve | ✓ | | | ✓ |
| 193062 | SINTEF Energy Research | Enabling low-emission LNG systems – Fundamentals for multilevel modeling | ✓ | ✓ | | |
| 193108 | SINTEF ICT | High Temperature Power Electronic Packaging | ✓ | | | |
| 193134 | Norwegian University of Science and Technology (NTNU) | Improved imaging, mapping and monitoring of hydrocarbon reservoirs | | ✓ | | |
| 200455 | SINTEF Materials and Chemistry | Acid Gas Removal with no damaging Effect on the Environment in offshore applications | ✓ | ✓ | | |
| 200492 | RESMAN AS | Future wireless well monitoring system using environmentally friendly tracers for permanent monitoring of well influx | ✓ | ✓ | | ✓ |
| 200500 | Badger Explorer ASA | Drilling in a Closed Cavity near Pore Pressure | ✓ | ✓ | | ✓ |
| 200548 | Smartmotor AS | Innovative efficient and survivable electric drive systems for subsea and downhole applications | ✓ | | ✓ | ✓ |
| 200553 | Schlumberger Norge AS | Environmental technology for the future – Automated EPCON CFU system | ✓ | | | |
| 200593 | SINTEF Petroleum Research | Non-circular wellbores – a new dimension in well construction | ✓ | ✓ | | |
| 200600 | International Research Institute of Stavanger (IRIS) | Optimizing Water Chemistry for Enhanced Oil Recovery | ✓ | | | ✓ |

| | | | | | | |
|---|---|---|---|---|---|---|
| 200624 | Institute for Energy Technology (IFE) | Shut-in and Restart of Waxy Crude Pipelines: Software Module Development | | | | |
| 200665 | Hole in One Producer AS | Hole in One Producer Prototype | | | | |
| 200714 | Wireless Instrumentation Systems AS | Wireless communication and power generation for Downhole Wireless Retrofit Instrumentation | | | | |
| 203284 | Iris-Software AS | Automated drilling fluid processing | | | | |
| 203310 | SINTEF Energy Research | Energy efficiency in offshore oil and gas production | | | | |
| 203404 | Teknova AS | Optimization of electrical energy production in offshore installations | | | | |
| 200548 | SmartMotor AS | Innovative efficient and survivable electric drive systems for subsea and downhole applications | | | | |
| 206976 | SINTEF Energy Research | Fundamental understanding of electrocoalescence in heavy crude oils | | | | |
| 206989 | SINTEF Materials and Chemistry | High Pressure Gas Liquid Separation – II | | | | |
| 207537 | Institute for Energy Technology (IFE) | Improved Glycol Loop Operation | | | | |
| 207538 | Norwegian University of Science and Technology (NTNU) | Increased energy savings in water/oil separation through advanced fundamental emulsion paradigms | | | | |
| 207661 | International Research Institute of Stavanger (IRIS) | Water weakening of chalk at realistic reservoir conditions | | | | |
| 208526 | Iris-Software AS | Energy Efficiency of Field Development: IOR, System Analysis and Risk Evaluation | | | | |
| 208677 | Typhonix AS | Low shear centrifugal pump for produced water applications | | | | |
| 210432 | Norwegian University of Science and Technology (NTNU) | Intelligent Drilling – Automated Underbalanced Drilling Operations | | | | |
| 215584 | SINTEF Energy Research | Pressure Tolerant Power Electronics for Subsea Oil and Gas Exploitation | | | | |
| **Responses** | **58** | **Category subtotals** | **53** | **38** | **10** | **28** |

## Projects relating to raising energy efficiency – the DEMO 2000 programme

| Project no. | Project Owner | Project title | | | | |
|---|---|---|---|---|---|---|
| 136622 | Framo Engineering A/S | Subsea Wet Gas Compressor | | | | |
| 136959 | Kværner Oilfield Products AS | Kværner Subsea Processing System, Multiphase pumping | | | | |
| 139636 | Framo Engineering A/S | Offshore Cryogenic Loading – Full scale Test. | | | | |
| 139739 | Petrotech AS | SILD-A New concept for Well Testing and Reservoir Fluid Sampling | | | | |
| 149637 | Petrotech AS | Big Sild – A new concept for Well Testing and Reservoir Fluid Sampling | | | | |
| 149651 | Framo Engineering A/S | Testing Wet Gas Compressor – Subsea Wet Gas Compressor | | | | |
| 158025 | SINTEF Materials and Chemistry | ResMan Downhole Water Monitoring System – Field Verification | | | | |

Photo: Colourbox

| | | | | | | |
|---|---|---|---|---|---|---|
| 163803 | Petrotech AS | SILD Phase 2 – A new concept for Environmental Friendly Well Testing and Reservoir Fluid Sampling | | ☁ | | |
| 163827 | Framo Engineering A/S | Pilot installation of the Wet Gas Compressor WGC2000 on a live gas field in the North Sea | | ☁ | | |
| 188948 | Rolls-Royce Marine AS | Heavy Duty Fibre Rope Deployment System JIP, Phase 1 – Rope testing programme | ▮ | ☁ | | |
| 188970 | FMC Kongsberg Subsea | Next Generation Deepwater Subsea Gas-liquid Separation System | ▮ | ☁ | | |
| 188979 | Seabox AS | Seabed Water Injection and Treatment – Pilot Plant | ▮ | | | |
| 188981 | eDrilling Systems AS | eDrilling Qualification and Demonstration | ▮ | ☁ | | ✓ |
| 188982 | RESMAN AS | Environmentally friendly chemical tracers for production monitoring in sensitive Arctic areas | ▮ | ☁ | | ✓ |
| 188983 | Deep Sea Anchors AS | Installation of Two Permanent Deep Penetrating Anchors at the Gjøa Field in the North Sea | | ☁ | | ✓ |
| 188989 | Typhonix AS | Pilot Installation and Testing of Typhoon Valve | ▮ | | | ✓ |
| 188991 | Seabed Rig AS | Prototype test of submerged fully automated drilling rig | ▮ | ☁ | 💡 | |
| 189003 | Aker Subsea AS | High Pressure Deep Water (HPDW) LiquidBooster Pump | ▮ | ☁ | | |
| 206972 | Marine Ecosystem Technologies AS | Active Acoustic leak detection of oil and gas from sub sea installation | | | | ✓ |
| 206991 | Computas AS | CODIO Pilot | ▮ | | | ✓ |
| 207013 | Nemo Engineering AS | Subsea Cooler Qualification | | | | ✓ |
| 207203 | Drilltronics Rig Systems AS | Drilltronics system onshore demonstrations | | | | ✓ |
| 207247 | Reelwell AS | Reelwell – Extended Reach Drilling beyond 20 km | ▮ | ☁ | | ✓ |
| 207278 | Seabed Rig AS | Qualification of autonomous, robotic drill floor for subsequent implementation on offshore platform, phase 3 | ▮ | ☁ | 💡 | |
| 207280 | OCTIO Geophysical AS | OCTIO GEOPHYSICAL DEMO2000 – A solution for advance warning of leakage to surface from waste injection wells | | ☁ | | ✓ |
| 215548 | Reelwell AS | Reelwell Drilling Method – Applications for Subsea Wells | ▮ | ☁ | | ✓ |
| 215551 | Badger Explorer ASA | Badger Explorer Seismic Field Demonstrator | ▮ | ☁ | | ✓ |
| 215597 | Force Technology Norway AS | SmartPipe Pilot Project | | | | ✓ |
| 215605 | Seabox AS | Subsea Membrane Testing | ▮ | | | |
| 215631 | West Drilling Products AS | Build Pilot of CMR Rig at Ullrigg Test Centre | ▮ | ☁ | 💡 | ✓ |
| 215664 | FMC Kongsberg Subsea | The Development and Qualification of a Compact Subsea Oil/Water Separation System | ▮ | ☁ | | |
| **Responses** | **31** | **Category subtotals** | **19** | **22** | **3** | **15** |

This publication may be ordered at:
www.forskningsradet.no/publikasjoner

**The Research Council of Norway**
Stensberggata 26
P.O. Box 2700 St. Hanshaugen
NO-0131 Oslo

Telephone: +47 22 03 70 00
Telefax: +47 22 03 70 01
post@forskningsradet.no
www.forskningsradet.no/english

June 2012
ISBN 978-82-12-03116-6 (printed version)
ISBN 978-82-12-03117-3 (pdf)

Translated by Darren McKellep,
Glenn Wells and Victoria Coleman
Number of copies: 500
Printed by: 07 Gruppen AS
Design: Agendum AS
Cover photos: Colourbox, SINTEF Energy Research, Badger Explorer ASA