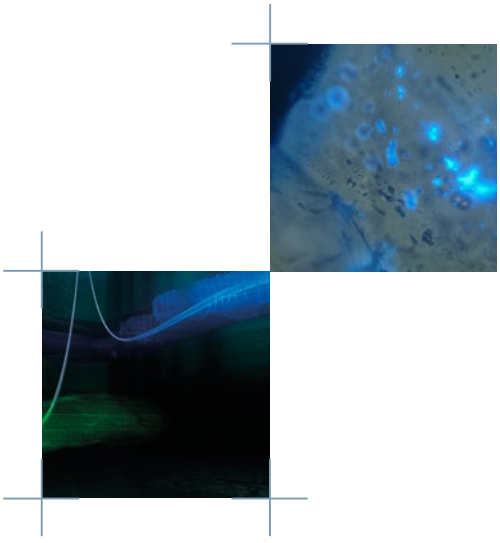
The Research Council of Norway

Raising energy efficiency and reducing greenhouse gas emissions

An analysis of publicly funded petroleum research – 2nd Revision

Programmes
PETROMAKS 2 / DEMO 2000



About the programmes
PETROMAKS 2/DEMO 2000

Large-scale Programme for Petroleum Research (PETROMAKS 2)

The PETROMAKS 2 programme is part of the Research Council of Norway's Large-scale Programme initiative. The programme has an overall responsibility for promoting research to ensure optimal management of Norwegian petroleum resources and promote future-oriented industrial development of the petroleum sector. The programme's overall activities encompass strategic basic research, knowledge- and competence-building, applied research and technology development.

The research questions being addressed require a high degree of multidisciplinary research and interdisciplinary integration involving academia, the petroleum-related service and supply industry, and petroleum companies.

The programme will advance the objectives set out in the petroleum industry's strategy Oil & Gas in the 21st Century (OG21) for research and technology development, as well as promote research to achieve priority targets for health, safety and the work environment.

www.forskningsradet.no/petromaks2

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

The DEMO 2000 programme is a technology programme at the Research Council of Norway. The programme provides funding for piloting/demonstration of new technology that will contribute to reduced costs, enhanced efficiency and improved performance in offshore activities on the Norwegian continental shelf.

Funding under the programme is intended to enhance the industry's own efforts to develop new technology and to support projects of high relevance and significant socio-economic benefit.

www.forskningsradet.no/demo2000

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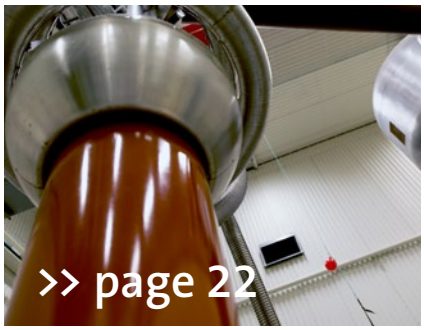
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Researchers at SINTEF are working on solutions for connecting high-voltage subsea power cables.

Photo: Shutterstock

Preface

Petroleum activities on the Norwegian continental shelf play a key role in Norway's economy in terms of state revenues, industrial activity, jobs and technology development – and will continue to do so for decades to come. Thus, it is crucial to obtain research-based knowledge about the impact of these petroleum activities, now and in the future, and to explore the many possibilities for minimising their environmental footprint. The petroleum sector is one of the largest emitters of greenhouse gases from Norwegian territory, and petroleum-related activities on the Norwegian continental shelf account for 26 per cent of Norway's total greenhouse gas emissions. Companies working in the offshore sector must help to achieve the Government's target to reduce overall greenhouse gas emissions by at least 40 per cent by the year 2030. Developing more energy-efficient technologies and production methods for the petroleum sector is essential for achieving the objectives set out in the white paper on Norway's new emissions commitment for 2030 – a joint solution with the EU (Meld. St. 13 (2014–2015)).

The world is in need of energy, but there are tremendous challenges related to reducing global emissions of greenhouse gases. Norway has an overall responsibility to carry out research that promotes the best possible management of Norwegian petroleum resources within an environmentally sustainable framework. As a result of the Agreement on Climate Policy achieved in the Storting, raising energy efficiency and reducing harmful emissions and discharges has become a criterion when selecting new research projects for the petroleum industry for public funding.

The analysis on which this brochure is based shows that since 2004 the Research Council's PETROMAKS/PETROMAKS 2 and DEMO 2000 programmes have allocated funding to more than 150 projects that are relevant to the climate challenges and that are carried out by the research community and private industry. When these projects have concluded, they will have received a total of over NOK one billion in public funding, and will have triggered an additional NOK 1.9 billion in private research financing. There is no doubt that many of the measures recommended by these projects will have positive impacts on the environment if they are implemented. Many of these research findings can contribute to making processes more energy-efficient or to directly reducing greenhouse gas emissions. The brochure presents a selection of these projects. At the end of this brochure is a complete list of PETROMAKS/PETROMAKS 2 and DEMO2000 projects that have confirmed in the analysis survey that they contribute to raising energy efficiency. A similar analysis was conducted in 2012.

Our goal is to promote Norway in the role as the oil and gas province with the highest energy efficiency, lowest level of emissions to air, and lowest levels of hazardous emissions to sea per produced unit. The implementation of research and technology development that benefit both the petroleum sector and the environment is crucial in order to reach this goal. The analysis also confirms that petroleum-related research is indeed very important for more energy-efficient and environment-friendly petroleum recovery. In the years ahead, the PETROMAKS 2 and DEMO 2000 programmes will continue to prioritise the development of technology and knowledge that can reduce the petroleum industry's environmental footprint, and will work to ensure that this information reaches decision-makers in the industry.

I hope you will find this brochure informative.

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

Raising energy efficiency and reducing greenhouse gas emissions

The white paper on a new commitment target on emissions (Meld. St. 13 (2014-2015)) states that in the course of 2015 Norway will submit a commitment to the UN conditionally committing Norway to reduce greenhouse gas emissions by at least 40 per cent by 2030, compared to the levels in 1990. The white paper on Norwegian climate policy (Meld. St. 21) presented in April 2012 states that Norway should have one of the world's most ambitious climate policies, and that this means implementing new and more efficient technology.

The petroleum industry will play a key role in realising the Government's objective to reduce total emissions in Norway. An increasing amount of energy will be required to recover oil and gas deposits as more and more fields on the Norwegian continental shelf mature. The white paper points out that petroleum research can help to reduce greenhouse gas emissions through more energy-efficient development of and operation on 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 solutions.

Electrifying the Norwegian continental shelf

Oil and gas installations on the Norwegian continental shelf emit roughly 14 million tonnes of CO_2 equivalents annually, which amounts to about one-fourth of Norway's total CO_2 emissions. According to Facts 2014 - The Norwegian Petroleum Sector (Norwegian Petroleum Directorate), some 80 per cent of these emissions stem from on-platform electricity production using gas turbines for offshore operations. One potential measure for reducing CO_2 emissions from Norwegian petroleum activities is to power the offshore installations with electricity from the mainland. However, such a solution will only yield significant environmental benefits if this mainland electricity is produced using clean sources of energy. Existing subsea transmission cables are either high-voltage alternating current (HVAC) power supply cables to offshore installations, or high-voltage direct current (HVDC) power cables between Norway and the Continent. Viewed overall, this will require reliable power supply and transmission from mainland power generation, transmitted via components such as cables, transformers and converters to electrical process equipment such as pumps and compressors. In the future, offshore installations may also be partially powered directly by electricity from offshore wind farms, but this is an intermittent power source dependent on weather conditions and must therefore be considered supplemental, at least to start with.

Examples of relevant thematic areas/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

Lowering energy use for produced water handling 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 it is transported for refining. 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. The technology that is used for inducing water droplets to join together into larger droplets is called coalescence. The technology yields other benefits as well: there is less need for chemicals to break down the oil/water emulsions and the technology reduces the need to heat the oil/water mixture, which in turn raises the energy efficiency of the process. Performing parts of the oil/water separation process on the seabed helps to make oil production more energy-efficient. Reinjecting the water back into the oil well makes room in the pipeline up to the platform, so less energy is spent on pumping water hundreds of metres up

Photo: SINTEF Energy Research

Doctoral fellow He Zhao studying droplet-film interactions relevant to flow phenomena observed in e.g. LNG heat exchangers.

to the platform for separation and then down again.

Decreasing the time needed for energy-intensive processes

An indirect way to cut 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. Reducing completion time for energy-intensive processes may be achieved by shortening the time spent performing a drilling operation, drilling without a rig or drilling by using a unit mounted on the seabed, for instance.

Reducing flaring

Flaring is the practice of burning off excess flammable gas and oil from petroleum recovery. In 2012 flaring accounted for 9.6 per cent of the total CO_2 emissions from Norway's offshore petroleum industry (Facts 2014 - The Norwegian Petroleum Sector). This is both a waste of resources and a significant environmental problem as flaring leads to heavy CO_2 emissions. Flaring should thus be kept to a minimum. The practice does, however, provide a safe way to vent gas and fluid when a malfunction occurs in the processing equipment, so a small pilot flame will burn from the flare stack on 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 environment-friendly measures for saving energy and cutting emissions.

Photo: FMC Technologies

Projects that create new possibilities

In 2012 the Research Council's Department for Petroleum Research carried out a survey study on petroleum research projects. The purpose was to identify projects that have potential to improve energy efficiency and/or reduce emissions to air should the new technology and research findings be implemented. This survey study is now updated with new projects.

The analysis is based on close dialogue with the project managers of more than 190 projects funded under the Research Council`s programmes PETROMAKS/ PETROMAKS 2 and DEMO 2000. In 2012, managers of a selection of projects awarded funding under the programmes were asked to classify their respective projects potential to raise energy efficiency and/or reduce greenhouse gas emissions compared to currently available technology. Only a selection of the projects in the programmes' portfolios were surveyed, which means that the numerical basis does not include all projects that have received funding under the programmes. The new study, however, analyses all the projects under the PETROMAKS 2 and DEMO 2000 programmes that started up in 2012–2014 and that address the priority thematic areas in the strategy "Oil and Gas in the 21st Century" (OG21).

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 and new methods.

For the new survey, managers of the 115 projects with start-up in the period 2012–2014 were contacted and 90 per cent of these responded. Based on this feedback, 61 per cent of 104 new projects are of relevance in terms of either raising energy efficiency and/or reducing emissions to air. The findings show that across a variety of project types and scientific disciplines, 43 per cent of the projects have the potential for energy efficiency, while 45 per cent have the potential to reduce emissions to air. This suggests that new technology in general contributes to both raising energy efficiency and lowering greenhouse gas emissions. In addition, 46 per cent of the project managers responded that their projects also have potential for other environmental benefits such as lower discharges to sea and less use of chemicals. When comparing these figures with the 2012 study, it may appear that the proportion of projects with the potential for raising energy efficiency and cutting emissions has decreased. This is not the case, however, since the new analysis encompasses all new projects under the programmes, while the previous analysis focused on finding projects with this potential.

The new study also shows a positive trend towards renewable energy. Ten per cent of the respondents stated that their projects are relevant in the context of renewable energy as well. This indicates that much of the research carried out under the petroleum-related programmes has high transfer value to other important thematic areas involving future energy security, such as offshore wind and geothermal energy.

The projects' own classification of potential for environmental benefits	Quantity	Per cent
Energy efficiency	117	61
Lower emissions to air	109	57
Electrification	19	10
Other (discharges to sea/renewable energy)	83	43
Total projects relevant to energy efficiency and/or lower emissions to air	152	

The data used in the analysis is based on feedback from the project managers themselves and excludes projects for which no one responded.

The 2012 and 2015 studies find that over 150 relevant projects under the petroleum-related research programmes, PETROMAKS/PETROMAKS 2 and DEMO 2000, have potential for energy efficiency and/or reducing greenhouse gas emissions. Note that since many of the 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 graph below provides an overview of public funding and associated supplementary financing allocated in 2004–2014 to projects that can contribute to environmental benefits. The programmes have allocated NOK 1.18 billion for projects relevant to energy efficiency and/or reducing emissions to air from the petroleum sector. These allocations have in turn triggered an additional NOK 1.91 billion in cash financing and in-kind from the project owners and their partners, bringing the total budget used for research of pertinence under the Agreement on Climate Policy to over NOK 3 billion. Most of the projects fall under the technology areas subsea processing and transport (50 per cent) and cost-effective drilling and intervention (25 per cent).

At the end of this brochure is a list of the projects that can contribute to raising energy efficiency and/or cutting greenhouse gas emissions.

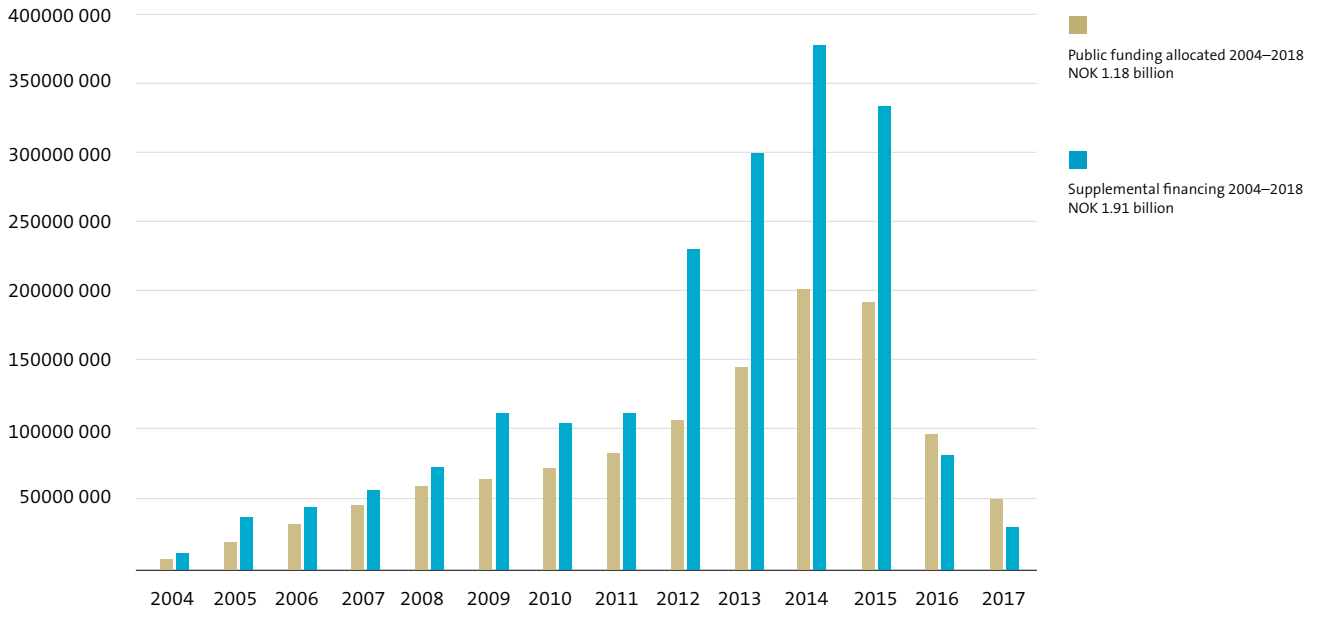
Research on environment-friendly utilisation of petroleum resources

Many of the projects in the petroleum portfolio aim to develop technologies for raising the energy efficiency of oil and gas production on the Norwegian continental shelf. Implementing new, environment-friendly technology will boost the efficiency of power production and reduce energy consumption, thereby cutting CO_2 emissions.

More energy-efficient power production is one of the environment-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. Implementing a bottoming-cycle steam turbine on one gas turbine of each platform on the Norwegian continental shelf would cut CO_2 emissions equivalent to the emissions of 1.1 million motor vehicles at 2013 levels. Several projects with funding from the Research Council have studied how to utilise waste heat from gas turbines to generate electricity. One such project also examined possible ways to develop control systems for the network of gas turbines and how to optimise energy flow on platforms. The project found that implementing these measures could reduce the platforms' energy consumption and CO_2 emissions by 15–20 per cent.

Data from 2012 indicate that 79.4 per cent of CO_2 emissions from offshore petroleum activities come from the gas turbines used for generating electricity (Facts 2014 - The Norwegian Petroleum Sector). Measures to raise energy efficiency or reduce the need for energy would thus have a major positive impact on emissions to air. One project seeks to develop fuel cells to replace gas-fired power plants on petroleum platforms. Fuel cells operate with far greater energy efficiency than current gas turbines.

Public funding and supplemental financing allocated to petroleum research with potential for raising energy efficiency and/or reducing greenhouse gas emissions



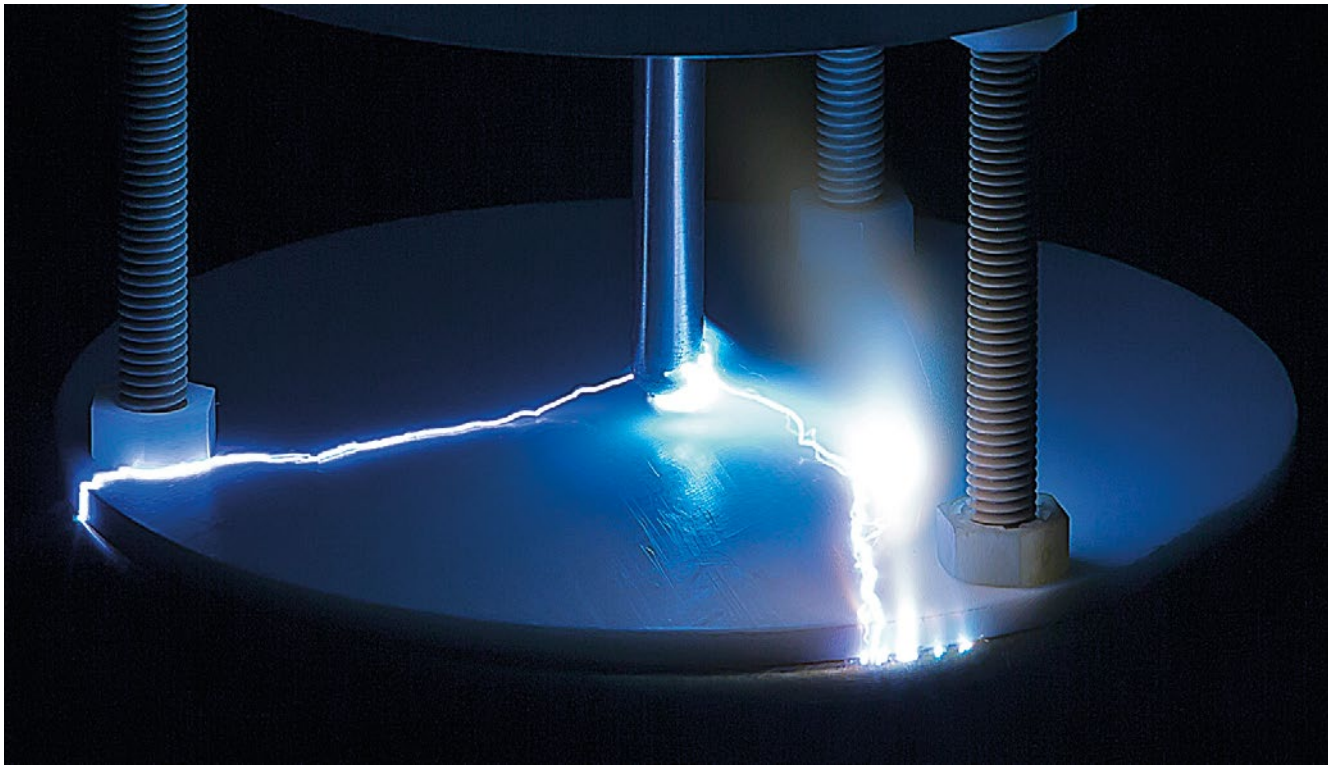


Photo: SINTEF/Geir Mogen

The technology may be an important step towards realising subsea factories, which further reduce the need for power compared to current processing solutions.

Another important research area in the portfolio is treatment of produced water and subsea separation. Two examples from the portfolio show that:

>> A new osmotic valve called the Osmotic Membrane Pressure Actuator (OMPA) is designed to seal off side tracks (horizontal sections of an oil and gas-producing well) when those sections begin to produce large volumes of water. This allows the well to continue producing its oil and gas rather than being shut down due to excessive water production. It is estimated that this valve technology will make it possible to produce up to 30 per cent more oil and gas resources from these wells and reduce the volume of produced water needing to be treated – resulting in a more energy-efficient recovery operation with higher production AND less produced water.

>> Produced water treatment using membrane filtration is very energy-intensive due to the high differential pressure needed (typically 40–70 bars) to "filter" the water. A new technology called Subsea Intake and Treatment (SWIT) will make it possible to produce very sterile water without residual chemicals over a long time period, so that the membrane facility can be moved to the seabed. Carrying out this process on the seabed supplies all or parts of the pressure for free (depending on the depth), which reduces the use of energy by 25-50 per cent.

Major potential to benefit the environment
Among the projects carried out by research groups, it has been those in the area of subsea processing, electrification and optimisation of the drilling process that to the greatest extent have led to the development of technology that can raise energy efficiency and reduce greenhouse gas emissions to air. Although the main objective of these projects has been technology development for other specific issues such as separation technology, multiphase transport, enhanced understanding of the drilling processes and increased oil production, they have made important contributions to developing technology with great potential for environmental benefits. The projects address a wide array of topics and promote advances in many areas.

Greatest potential for environmental benefits in drilling and well technology
Research carried out by the petroleum industry itself indicates that advances in drilling and well technology have the greatest potential to yield benefits for the environment. Energy efficiency in itself is not the main objective of these projects, but is often triggered when developing innovations primarily designed for completely different purposes. The analysis goes on to show that although the contributions of each individual project may be modest, they can have great potential for significant changes in the petroleum industry when put together with other innovations.

The potential for energy efficiency and reduced greenhouse gas emissions can be realised primarily by implementing technology in a number of technology areas such as robotisation, automation and faster drilling. Input from the project managers indicates that the sector has come a long way in developing new and improved methods to drill farther and more efficiently than with the use of conventional methods.

Solutions that make it possible to drill longer and deeper wells also open up new possibilities for drilling into deeper, hotter layers of the Earth's crust than has ever been feasible. It turns out that drilling technology developed in one of the projects can also be used when extracting geothermal energy as a primary energy source to replace fossil fuels. Developing this technology further will make it possible to drill ultra-deep wells in the Earth's crust and utilise geothermal energy, as well as generate electricity and chemical energy carriers. This illustrates how technology developed for one purpose can often spark innovations with completely different applications.

Another aspect of several projects is methods for recovering more oil from productive fields without requiring higher use of energy. Research shows that improved methods for decision support and production optimisation, by exploiting bottlenecks in the production system better than is currently done today, could increase production on a field in operation by 1-3 per cent.

>> Research indicates that using water-based rather than oil-based fluids during drilling operations reduces local emissions and results in higher energy efficiency for the drilling process and treatment of drill cuttings. In addition it will improve the working environment for operations personnel and reduces the risk of oil discharges to sea.

>> Project results show that improved control of the drilling process, such as optimising cuttings transport and reducing the need for multiple hole cleaning procedures in the well, has great potential to save both energy and operations time. Better hole cleaning also allows for longer range and thus fewer wells than with the use of current technology. Improved process control will also result in fewer undesired events, such as well packing, which in turn will lower the risk of losing control of the operation. This also reduces the risk of discharges to sea.

>> A new technology called EC Drill will make it possible to drill an oil/gas well up to 20 per cent faster and with higher energy efficiency than by using currently available technology. Figures will vary from well to well, but use of the EC Drill technology will save roughly 12 days on a typical well on the Norwegian continental shelf. A drilling rig will normally emit some 50 tonnes of CO_2 daily, so the technology could mean saving the environment roughly 600 tonnes of CO_2 per drilled well.

>> The company E Plug has developed a new method for setting and releasing barrier plugs during well operations. The method allows a plug to be set and released in one operation, saving as much as 42 per cent in operations time compared to time used with conventional methods. The plug is called TorcPlug and incorporates several functions to minimise the risk of getting stuck during a well operation. Utilising this technology will have an indirect impact on discharges to sea, since it reduces the operational hours of a drilling rig or intervention vessel during well operations.

>> A newly developed Down-Hole Mapping tool should be able to significantly replace offshore production tests after opening a well. Currently, production tests with today's technology will typically take two to four weeks. The new method will normally be able to conduct the same tests in only one to two operation days.

>> Utilising Subsea Storage Units (SSUs) to store oil on the seabed rather than on a floating storage vessel will reduce the need for manpower and sharply cut emissions of volatile organic compounds (VOC). Replacing a storage vessel of roughly 100 000 m^3 capacity with an SSU will save up to 16 m^3 of diesel per day. This amounts to energy savings of 160 MWh per day and emission cuts of roughly 42 tonnes of CO_2 and one tonne of NOx per day. Moreover, storage placed on the seabed is less exposed to weather and wind, which lowers the risk of collisions and thus reduces the risk of oil spills.

Photo: Colourbox

Photo: EMCS

Better imaging method for more reliable oil exploration

The Norwegian service provider Electromagnetic Geoservices ASA (EMGS ASA) is developing a new imaging method (inversion) for Controlled-Source Electro Magnetic (CSEM) data. EMGS ASA anticipates that this new method will provide petroleum companies with better information from electromagnetic data. This will in turn make it easier for oil companies to use this data in their decision-making processes, both in connection with exploration for oil and gas, and for appraisal and development of fields where oil or gas has already been discovered.

Photo: EMGS

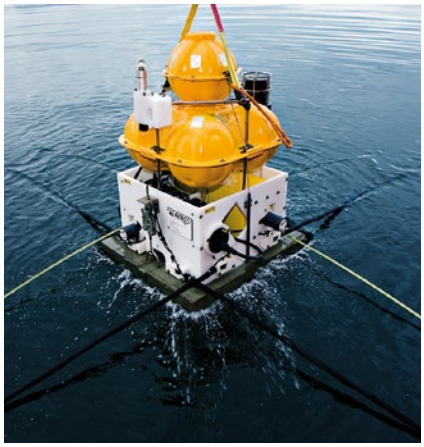


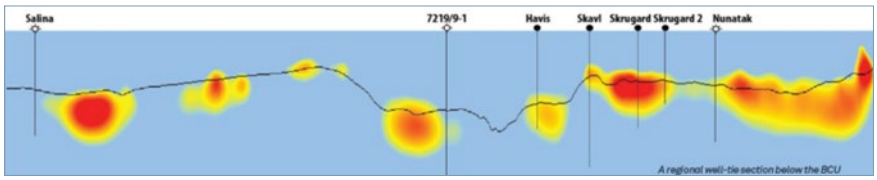
Photo: EMGS

Photo: EMGS

▶ One of the challenges petroleum companies face when using electromagnetic data is that the calculation methods used to convert the collected data into 3D resistivity volumes carry a relatively high degree of uncertainty. This uncertainty is particularly high when there is limited geological information available. Generating reliable imaging results using today's technology requires a great deal of expertise and experience. Although the new calculation method being developed under this project is more mathematically complex, it should yield more reliable results.

Studies have been carried out showing that proper use of CSEM data in connection with exploratory drilling can substantially reduce the number of dry wells drilled*. The correct application of 3D CSEM technology can indirectly help to reduce emissions to air and lower the risk of discharges to sea by improving the accuracy of drilling activities and reducing the frequency of unnecessary drilling.

www.emgs.com



Integrated interpretations of 3D electromagnetic and seismic data have shown a close correlation with the results from recently drilled wells in the Barents Sea. Seismic: TGS.

*Fanavoll, Gabrielsen and Ellingsrud, Interpretation, 2014

Hammer drilling for cost-efficient well interventions and drilling in hard formations

The DEMO 2000 project of the company Resonator AS seeks to demonstrate a new electric concept for removal of hard mineral deposits in production wells in the North Sea. This is accomplished with the help of percussion drilling, which removes deposits in less time than the e-line drilling technology currently in use.

The project is also studying whether electricity-based concepts can be used in other types of well interventions. The first project phase will serve as a springboard for the development of an energy-efficient electric, down-hole hammer-drilling system.

Percussion drilling is proven to be more effective on hard-rock formations than conventional rotary drilling. By using an electric, down-hole drilling system, it is possible to steer and monitor the drilling activity more quickly and more efficiently. It will also be possible to adapt the drilling parameters to different formations and, in this way, optimise drilling speed. There is still much to learn about what happens in the interaction between the formation and the hammer's drill bit, and between the hammer and the drill bit while in operation. This is particularly the case when drilling at depths of 600 metres and below. The mining industry has rarely had the need to drill such deep holes, and the oil and gas industry is still facing challenges relating to drill speed in hard formations.

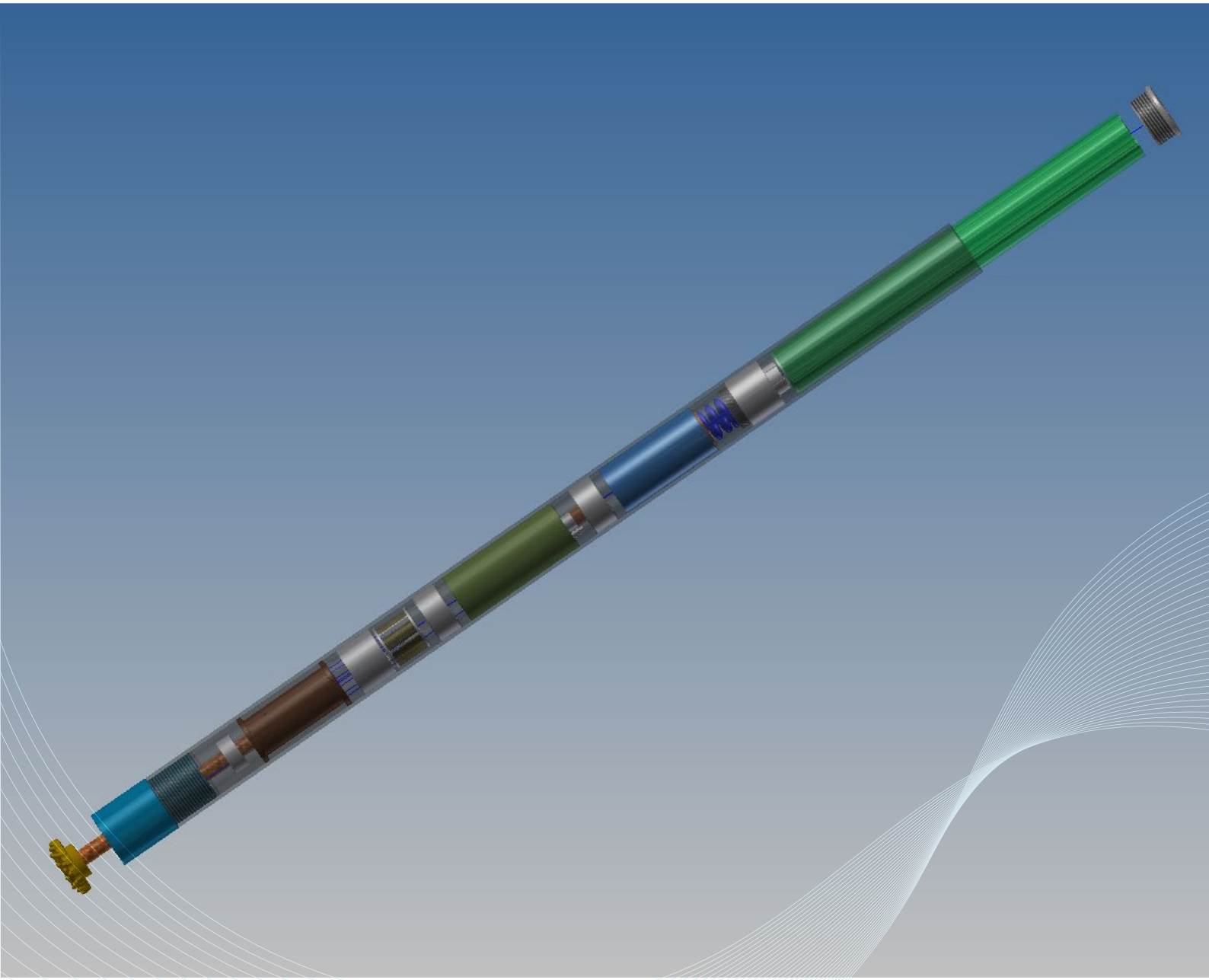
So far, the company has identified a further need for research and development to reduce costs tied to well interventions and drilling in hard formations. This new, energy-efficient concept will employ innovative procedures, automation, adaptive control and safety measures that will help to reduce the operational costs considerably.

Resonator AS is developing a number of concepts for enhanced oil recovery and cost reduction in hard-rock drilling. One of the key components behind these concepts is the Resonator, which is based on patented technology.

Photo: Resonator

www.resonator.no
Invention / hard rock deep drilling with a Resonator

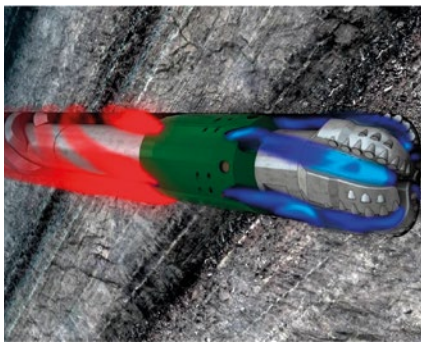
Illustration: Resonator



Better field recovery? Drill like a dentist

Tomax AS is seeking to improve oil recovery in existing fields by drilling from existing infrastructure into reserves sheltered in unstable and pressure-depleted layers, often far from the platform.

Photo: Foton4 Film AS



For more documentation, please contact us by email at: tomax-norway@tomax.no

▶ Researchers at Tomax AS working on the Afterburner project have developed an ejector pump which is simply placed behind the drill bit and is driven by the drilling fluids circulated through the system. The unit ensures gentle cleaning of the drill bit using underpressure in much the same way a dentist does, which keeps the disturbance of any unstable rock to a minimum. At the same time, the pulling force generated makes it possible to drill beyond the conventional limitations of gravity.

The Afterburner unit comprises five ejector pumps with its suction side or inlet oriented down towards the drill bit. The ejector pumps resemble the water-jet motors used on boats that navigate into unclean waters. The pumps are driven by the powerful flow of fluid circulated down the drill string to keep the hole clean of drill cuttings. The pumps create a low-pressure region locally between the bottom of the borehole and the suction valves, keeping the bottom clean without the need of powerful jet nozzles regularly used. In field trials, the pressure against the bottom of the borehole has been reduced by 34 bars. When the same pressure reduction is needed for stability reasons in conventional systems, it usually requires expensive changes in the drilling rig and equipment to be safe. In addition, erosion forces against the borehole walls have been reduced by 94 per cent. This means that this technology can enable the operator to drill through both unconsolidated and highly unstable layers, which are almost like packed soil.

At the same time, the underpressure gives the bit a push or tractive force of between three and five metric tonnes. This force works like a tow line attached to the very end of the drill string, ensuring that there is almost no limit to how far it can reach.

The Afterburner unit is placed just behind the drill bit. At the outlet, the flow regime returns to its normal form and serves to carry the drill cuttings to the surface. The underpressure created at the bottom is less than the backpressure exerted from the drilling fluid and cuttings lifted towards the surface. In this way, the pressure balance against the borehole, and thus the barrier situation in the well, remains unchanged.

Full-scale testing of the patented solution has shown that the technology can yield 80 per cent lower emissions during the operational phase by eliminating free-standing well templates on the seabed in relation to today's technology. According to estimates, the technology will be able to safely extend wells from existing platforms to reach stranded resources at 30 per cent of the cost compared to drilling and tie-in of a separate, subsea well for the same purpose.

Photo: Foton4 Film AS

The Afterburner project has devised a solution that keeps the drill bit clean without the use of spray nozzles during drilling operations so that it is possible to drill into the formation (unstable rock) with a greater safety margin. A stable tractive force extends the range of the wells, allowing better utilisation of existing infrastructure.


RX


Photo: WiSub

Innovative connectors provide simpler and more intelligent links on the seabed

The subsea connectors from WiSub will contribute to electrification of subsea installations and allows for easier and more intelligent data and power connections in subsea networks. Pins in traditional connectors are failure points; removing pins from connectors addresses reliability issues directly. Pinless subsea connectors will also support the operation of the new, fully electric subsea systems that can replace more traditional hydraulic systems.

▶ The WiSub connector removes the mechanical complexity from existing underwater connection systems and eliminates pins and moving parts by using microwave electronics and inductive power transfer. This simplifies and optimises subsea operations and the risk of oil leaks that are associated with the use of oil-filled wet-mate connectors is eliminated.

Carrying out operations for linking connectors on the seabed more simply and rapidly reduces the vessel time and thus the amount of fuel needed for the operation. The WiSub connection systems make it possible to use residential seabed-based AUV (autonomous underwater vehicles) and ROV's (remotely operated vehicles) instead of launching and recovering these during ship-based operations. These new connection systems enable docking of AUV systems subsea, which was previously not possible when using conventional subsea connection systems. The connection interface is also used in environmental monitoring technologies such as leak-detection systems. The technology is also suitable for renewable wind and wave energy deployments offshore. The WiSub connector has a faster and more robust connection to subsea facilities and offshore installations, and thus optimises the interface for numerous types of service operations.

Using AUVs to carry out IMR operations (inspection, maintenance and repair) in a field instead of ROVs with their support vessels can cut fuel consumption by up to 80-90 per cent. This is because placing an AUV on location only needs to be done once and the subsea interface makes it possible to re-task and recharge the batteries underwater. Surface vessels are not necessary except during launch and recovery.

www.wisub.com

Enhanced oil recovery by reducing mechanical degradation of polymers

Advances in petroleum recovery are driven by the desire to better utilise precious natural resources. Increasing the oil recovery rate on the Norwegian shelf by just one per cent (above today's 45–50 per cent) would yield nearly NOK 300 billion in extra revenues for Norway.

Photo: Dalen Industridesign AS

▶ Injecting water containing polymers or gel has become a common method to enhance oil recovery. Polymers consist of thin strands which over time intertwine and make the water solution more viscous. One challenge associated with using polymers is that they are prone to mechanical degradation, making them less viscous as they pass through processing equipment on the way down to the oil reservoir.

The Norwegian entrepreneurial business Typhonix is developing technology to minimise this mechanical degradation of polymers and the goal is to increase oil recovery beyond the reach of current technology. Additional benefits are higher energy efficiency and lower emissions to air. Typhonix' technology aims to improve current polymer injection processes in order to enhance oil recovery while decreasing the use of polymers.

The project's primary objective is to minimise mechanical degradation and the subsequent loss of viscosity by up to 50 per cent compared to the current state of the art. With today's technologies, 50 per cent of the polymer solution typically degrades after injection into the reservoir. Cutting this degradation by 50 per cent means that 25 per cent less polymers could be injected to achieve the same oil recovery effect.

Polymer flooding is a process of injecting polymer solution through an injection well and down into the reservoir over an extended time. The injected polymer solution will have a higher viscosity than the oil, making it easier to push the oil out of the reservoir. Current injection equipment subjects the polymer solution to high shear stress and irreversible mechanical degradation during pressure reduction, leading to loss of viscosity. This results in an inefficient flooding operation that forces less oil out of rock pores in the reservoir. The use of low-shear equipment will reduce the pressure loss, either over a longer distance (by coil or spiral) or in a larger volume (cyclonically).

The industry has been compensating for the degradation problem with higher polymer concentrations to maintain solution viscosity and by injecting larger volumes of polymer solution. This increases both the use of polymers and CO_2 emissions to air since these practices require more energy in the form of mixing, transporting and injecting the extra polymer solution. Typhonix is developing new, low-shear processing equipment to minimise degradation and thus avoid the need to raise the polymer concentration and increase injection rates. The new equipment will help to reduce energy consumption involved in the transport, mixing and injection of polymer solutions – which will cut the petroleum companies' costs and CO_2 emissions.

www.typhonix.com

Photo: Dalen Industridesign AS

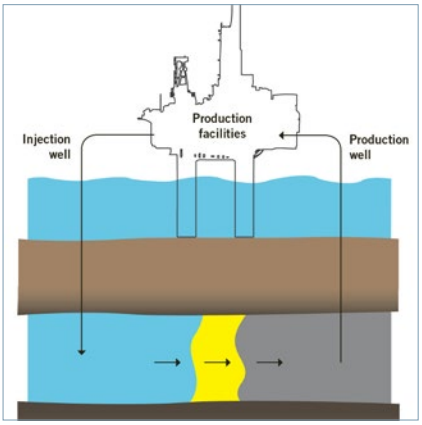


Figure 1:
Illustration of a typical polymer flood operation.

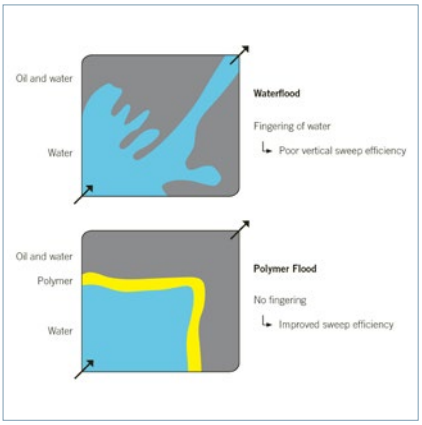


Figure 2:
Illustration of the efficiency difference between water flooding and polymer flooding.

Connecting high-voltage power cables on the seabed

A number of offshore installations may be electrified using electricity from the mainland as a measure to reduce CO_2 emissions from Norwegian petroleum activity.

▶ Long distances and the transmission of increased electrical power require new and improved technology. This applies particularly to high-voltage subsea power cables used to supply energy to motors, pumps, compressors for underwater processing, as well as pipe-warming equipment and separators. The subsea connectors are the most critical component for the cable systems. In principle, these are advanced cable terminations that are connected underwater and insulate the electrical conductors from seawater under high pressure after connection. To avoid using inefficient gas turbines offshore while still supplying the need for more power, the transmission capacity must be increased. New technology for high-voltage subsea connectors is needed, and researchers at SINTEF are working to develop new connectors to meet this need.

Why are subsea high-voltage connectors in demand? It is possible to increase the efficiency of power transmission by increasing the current, but this often results in impractical dimensions, heavy weight and significant power loss. A better alternative is to increase the transmission system voltage. The main challenge is to maintain a high dielectric strength of the interfaces after connection. How will these perform under high hydrostatic pressure, which can lead to moisture penetrating along material interfaces over time? How should they be designed? These are some of the questions the project seeks to answer.

Seen in a broad perspective, this is a question of reliable power supply and transmission – from land-based power generation through components such as cables, transformers and converters to motorised processing equipment such as pumps and compressors located on the seabed. Present-day subsea connectors for voltages up to 24 kV are very important components in this context.

Electrification of the Norwegian continental shelf could one day substantially cut local emissions from platforms and floating production units - particularly from inefficient gas turbines. This adds up to roughly 10.5 million tonnes of CO_2 equivalents as of today. Over a period of 20–30 years, phasing out fields with topside installations and developing new fields with subsea installations can cut greenhouse gas emissions by half.

In terms of raising energy efficiency and safeguarding the environment, R&D on subsea oil and gas production will result in equipment being placed on the seabed and powered from clean on-shore energy sources.

www.sintef.no

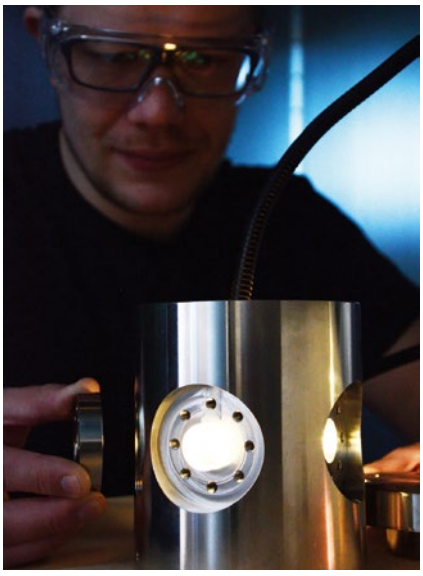


Photo: SINTEF/Sverre Hvidsten

Pressure tank with see-through glass to study surface phenomenon under the combined action of high hydrostatic pressure and voltage.

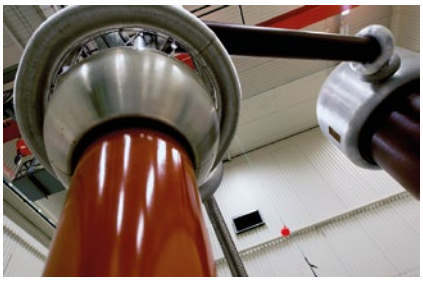
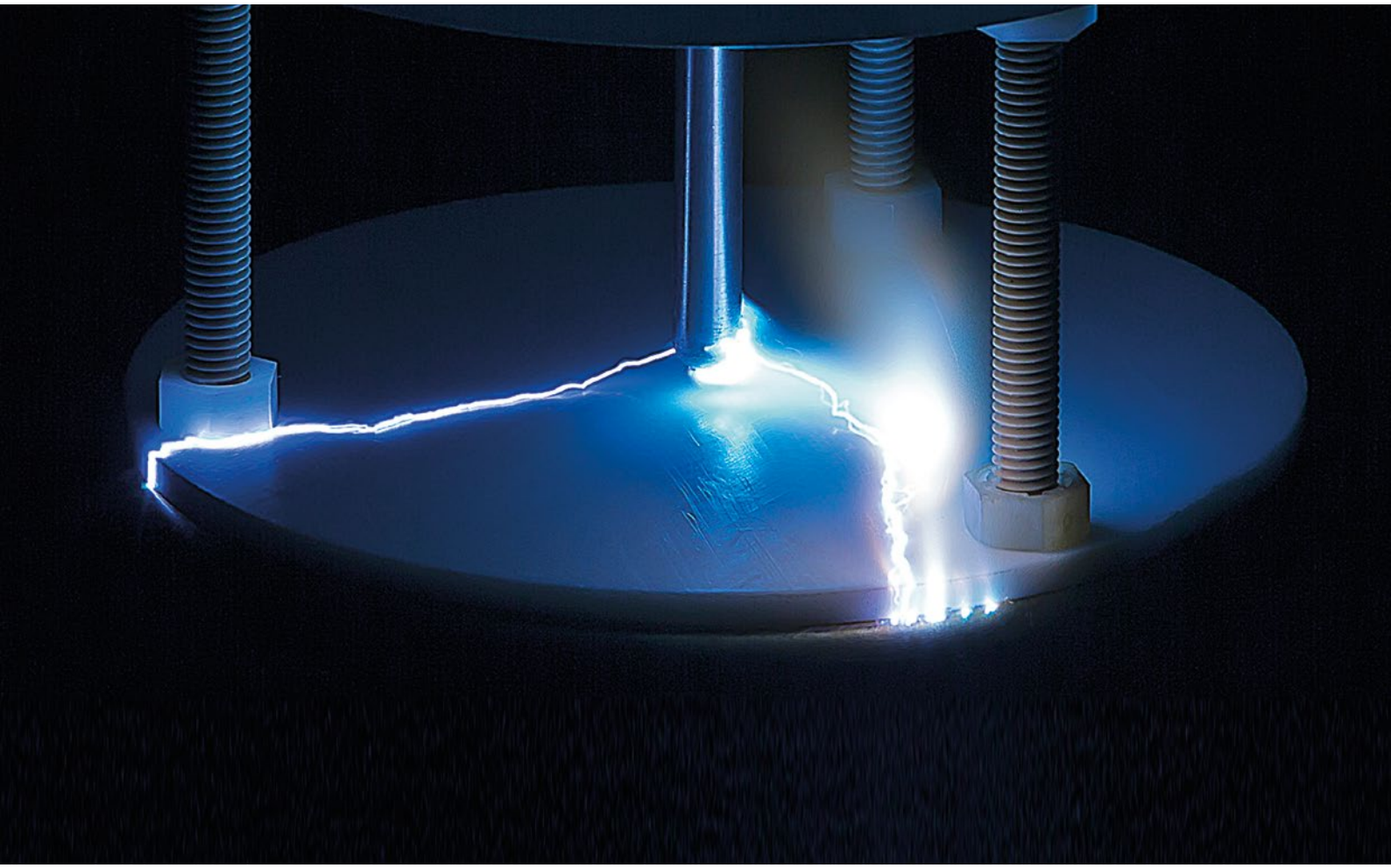


Photo: SINTEF/Torgrim Melhuus

Close-up from the high-voltage laboratory – a high-voltage transformer and a voltage divider.

Photo: SINTEF/Torgrim Melhuus



Electric arc along an insulated surface.

Compact offshore steam cycles – waste heat recovered

To reduce global warming, Norway – like the EU – has set a goal to decrease its CO_2 emissions by 40 per cent by 2030.

▶ Raising energy efficiency is one of the most cost-effective measures for cutting CO_2 emissions and promoting climate change mitigation. The implementation of high-efficiency equipment often pays for itself within 2-6 years through the operating costs saved from consuming less energy. The COMPACTS project is paving the way for more efficient energy consumption on the Norwegian continental shelf – an industry sector which accounts for 29 per cent of Norway's total greenhouse gas emissions.

Eight out of ten kilos of the CO_2 emitted from offshore platforms comes from the gas turbines that generate electricity for the platforms. The escaping turbine exhaust, however, contains a great deal of usable heat. By attaching a steam bottoming cycle that utilises this waste heat to create a combined-cycle power system, electricity is produced twice from the same gas combustion process. This supplies the platform with the power it needs using far less gas than it consumes today, cutting platform CO_2 emissions by 22-30 per cent.

Steam cycles for this purpose already exist, but they are too large and heavy to use on many of the platforms. The COMPACTS project is addressing this need for lighter, more compact units.

The project is looking to apply the same approach as the automotive industry, which once manufactured heavy steel vehicles with large engines, but has now converted to lighter-weight aluminium and plastics, with higher-efficiency engines. The result is fuel savings that have greatly decreased the automobile industry's carbon footprint. The COMPACTS project seeks to contribute to the same kind of development on petroleum platforms.

The COMPACTS project has two objectives. The first is to reduce the weight of the steam turbine and its associated equipment by up to 50 per cent. Specifically, this will be done in two ways: by lowering the weight of the heat exchangers that recover the exhaust heat, and by replacing the steel materials used in the framework for offshore installations with aluminium and titanium.

The second objective of the project is to improve the reliability of the combined system to a level consistent with the standards of offshore technology. The same principle of combined cycle has long been the standard for land-based power plants. If the COMPACTS project achieves its objectives, combined-cycle power plants for offshore power production will become the rule instead of the exception.

The COMPACTS project is a collaboration between SINTEF (the project owner), the Norwegian University of Science and Technology (NTNU) and several large petroleum companies and vendors in the oil and gas industry.

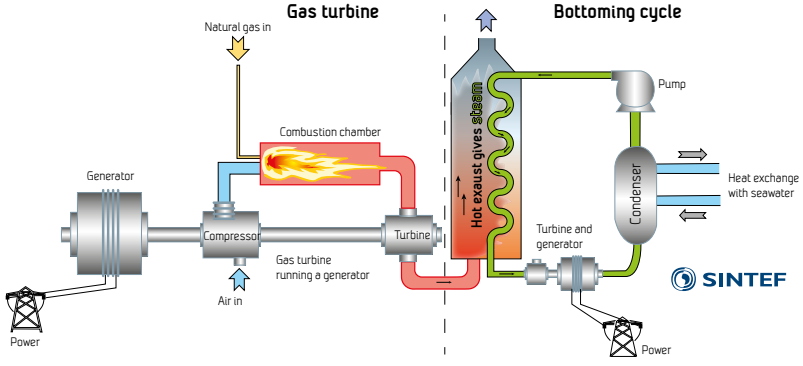


Photo: Harald Pettersen Statoil

Oseberg Plattformen,Statoil.

The knowledge-building project EFFORT

The EFFORT project – predecessor of the knowledge-building project (KPN) COMPACTS – explored the potential for installing steam bottoming cycles and associated equipment to supplement the gas turbines on three platforms.

In two of the three cases, it was possible to install a bottoming-cycle turbine. One of these platforms was a semi-submersible on the Norwegian shelf. It was calculated that a bottoming-cycle turbine would cut CO_2 emissions by 22 per cent (60 000 tonnes annually). If the gas turbine had operated at higher load, the reductions would amount to 25 per cent.

Lower CO_2 emissions cut annual operating costs by USD 17 million (savings on gas consumption and carbon tax).

The weight of the fully installed steam bottoming cycle and its boiler was 700 tonnes. Integration into the existing power system was not possible due to weight restrictions, but it could have been built into the original design.

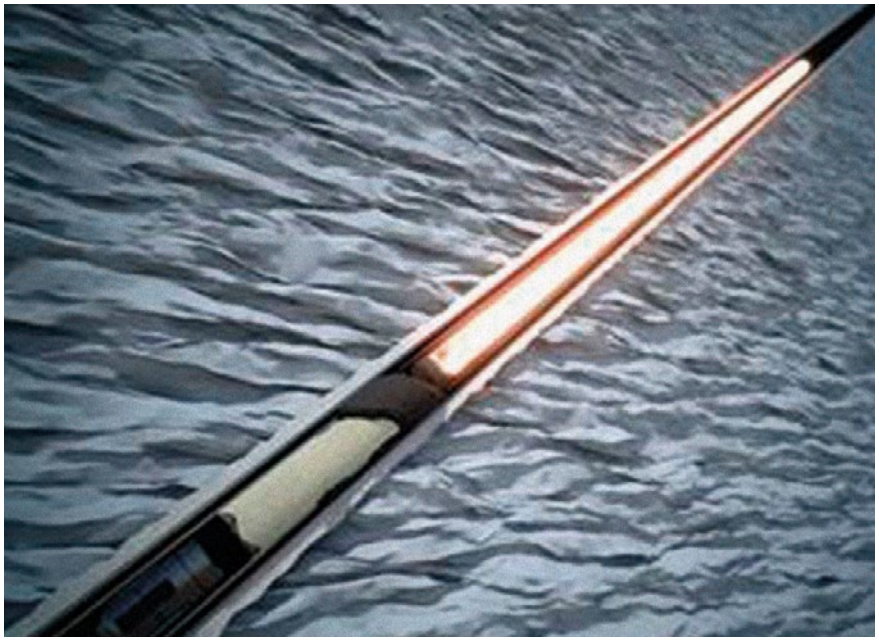
A case study of an FPSO vessel in Brazil also calculated a potential for cutting CO_2 emissions by 22 per cent by installing a steam bottoming cycle and associated equipment.

www.sintef.no

New concept for plugging wells

When oil and gas wells on the Norwegian shelf reach the end of their lifetimes, they must undergo plugging and abandonment, or P&A, as defined in the requirements set out in NORSOK D-010 standard. According to the Norwegian Oil and Gas Association, this job will cost NOK 876 billion if performed using the currently available solutions.

Photo: Klipp og Lim



▶ The state, meaning Norwegian taxpayers, will be covering 78 per cent of this amount. Studies have discovered leakage from abandoned wells that were plugged using current P&A methods. Thus a massive P&A job lies ahead in the coming years, and Interwell Technology AS is addressing the need for viable solutions. If the project is successful it will contribute to a sufficiently permanent seal that can prevent major discharges from man-made wells in the future, and at the same time save the industry and the Norwegian state considerable expense.

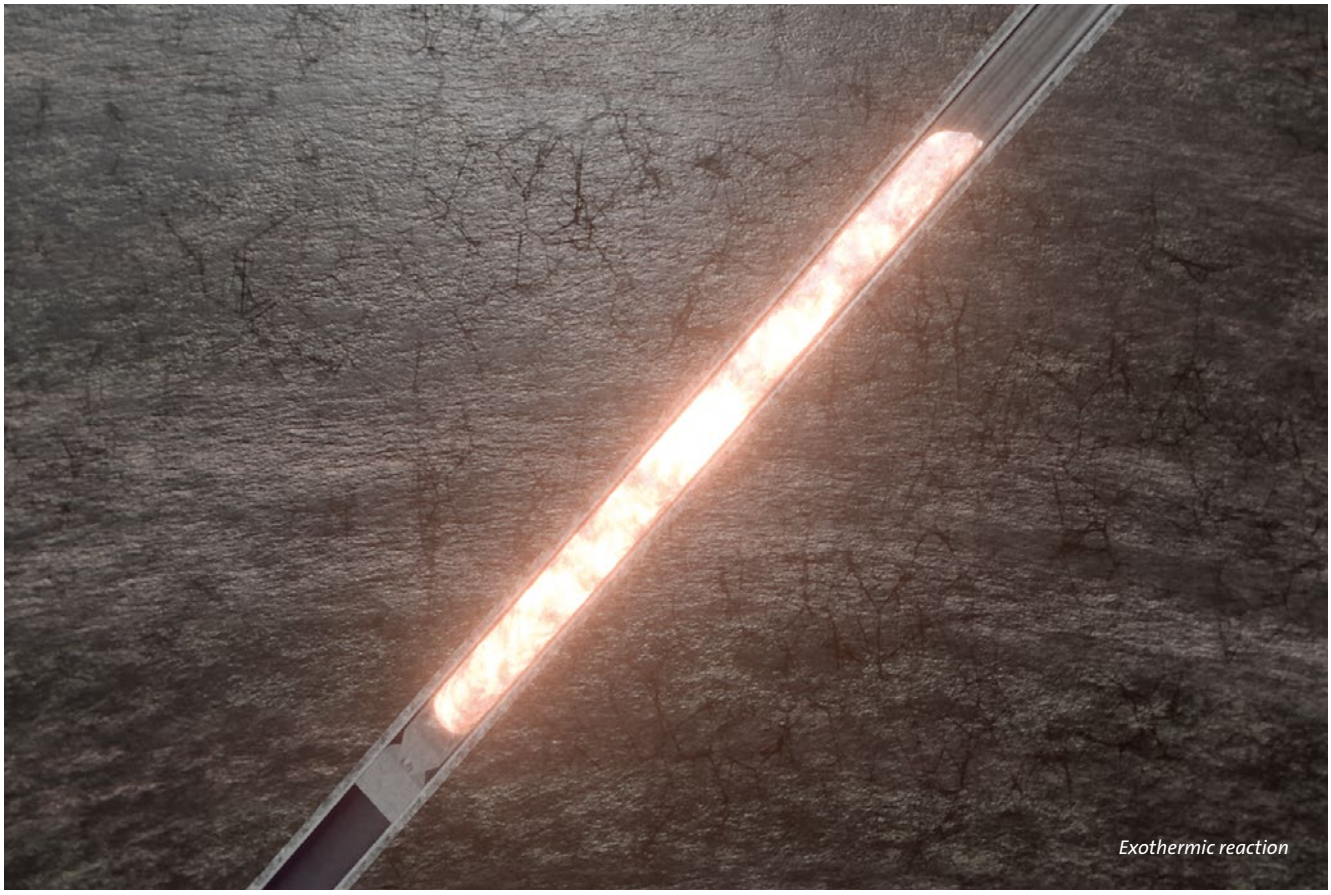
According to the Petroleum Safety Authority Norway (PSA), roughly 4 600 Norwegian wells will be permanently shut down in the years to come. Without proper sealing these wells could pose a potential risk of discharging major oil and gas emissions to sea or air. In 2011 the PSA conducted a study that revealed leakage from 74 of 193 (38 per cent) temporarily abandoned wells on the Norwegian shelf. The study concluded that the mechanical sealing solutions used to plug these wells were not viable long-term solutions.

The petroleum industry is facing a huge challenge in meeting these requirements, and no satisfactory solution currently exists. The concept patented by Interwell Technology will make it possible to plug wells without the use of a conventional drilling rig, and it will also eliminate the need to pull or mechanically remove the well elements. Adding energy to a metal powder composition starts an exothermic reaction which releases heat that is used to melt the well elements. Once the reaction is complete, the melted mass will harden and create a barrier (seal) towards the formation (cap rock).

The objective of the project is to develop a concept for permanent abandonment of wells that satisfies the NORSOK D-010 standard. In order to meet the requirements, a deep barrier plug must be set in the cap rock as close as possible to the reservoir. The seal must cover the entire cross-section including all the annuli (the spaces between any piping, tubing or casing that protect the well from the surrounding bedrock). There are also requirements for the mechanical properties deemed essential for forming a permanent seal, such as impermeability, everlasting integrity, non-shrinkage and ductility.

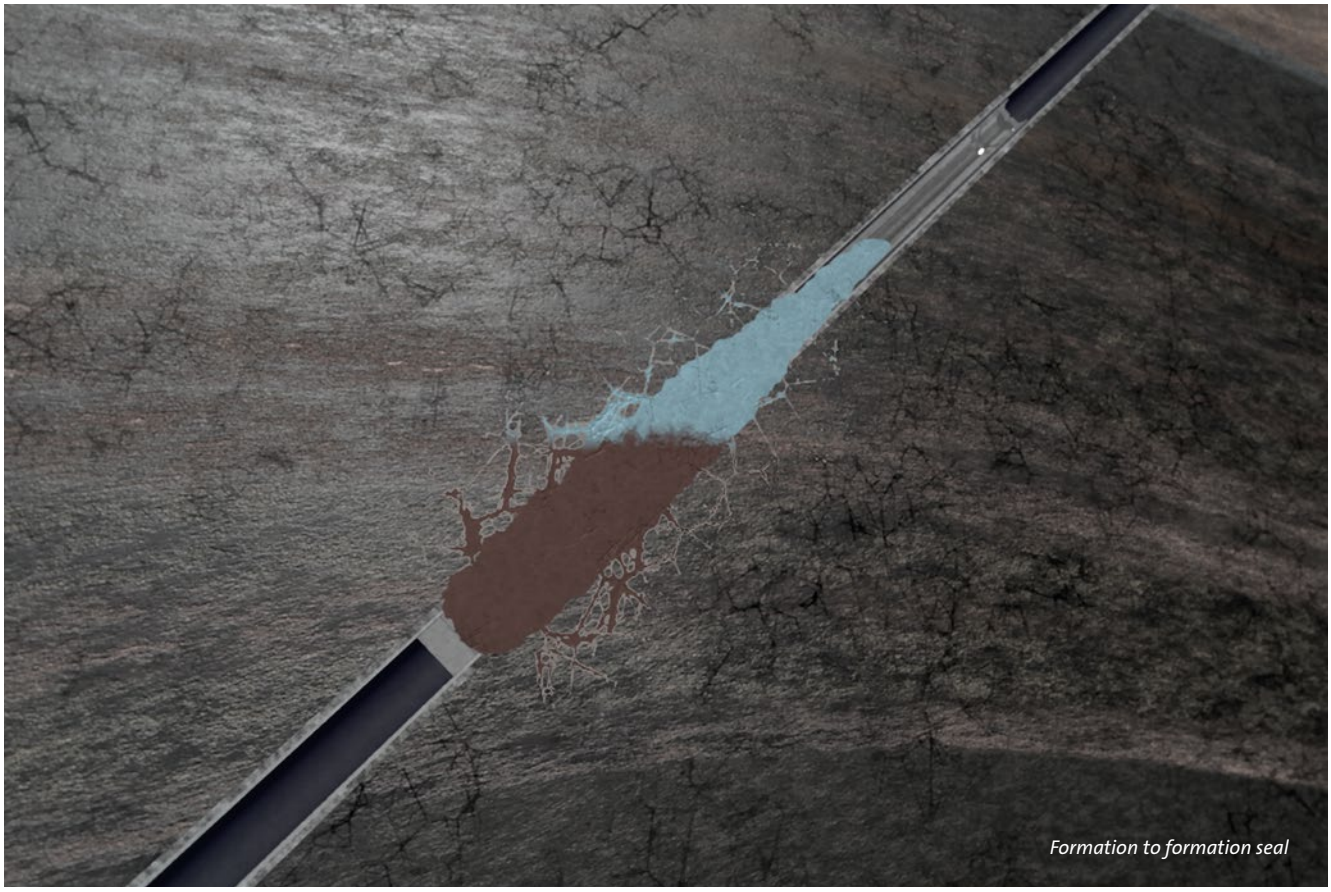
The project's new concept will significantly cut petroleum companies' P&A operational costs compared to the costs using current technology. There is also great potential for raising energy efficiency through reduced operational time, since no mechanical removal or pulling casing is necessary. Another environmental benefit will be to ensure proper reservoir integrity and thus prevent discharge of hydrocarbons and other hazardous substances.

www.interwell.com



Exothermic reaction

Photo: Klipp og Lim



Formation to formation seal

Photo: Klipp og Lim

Simple system for automatic detection and reduction of produced water

For each barrel of oil that is recovered, an average of 2.5 barrels of water is produced. Environmentally sound treatment of all this produced water involves high costs and entails high energy consumption.

Photo: Resman AS

The picture shows a sample of A porous polymer matrix that allows oil to pass through.

▶ The company RESMAN AS is developing a system called RES ● GUARD that will detect and reduce water production without using energy, intervention or cables. The system is integrated in the production tubing of new oil wells. The RES ● GUARD system employs an autonomous reacting polymer that reduces water breakthrough, and a polymer that allows only oil to permeate. The polymers release tracer substances that detect the zones with water breakthrough or where oil is flowing in. RES ● GUARD will introduce minimal risk and can be removed as needed.

How much energy is saved by using RES ● GUARD will depend on the composition of the well. Water cuts in productive wells can range from 0 to 99 per cent, and water production can occur at various times in the course of a well's lifetime. The largest benefit involves the increased utilisation of platform capacity to produce oil. The next-largest benefit of the system is the decreased need for constructing and operating facilities to separate and process large volumes of produced water on the platform. Lower water cuts can also extend the lifetime and utilisation of both reservoirs and platforms. Depending on the energy source, less greenhouse gas will be emitted to air as well. Reduced volume of produced water also makes for more effective treatment processes, which results in less discharge to sea.

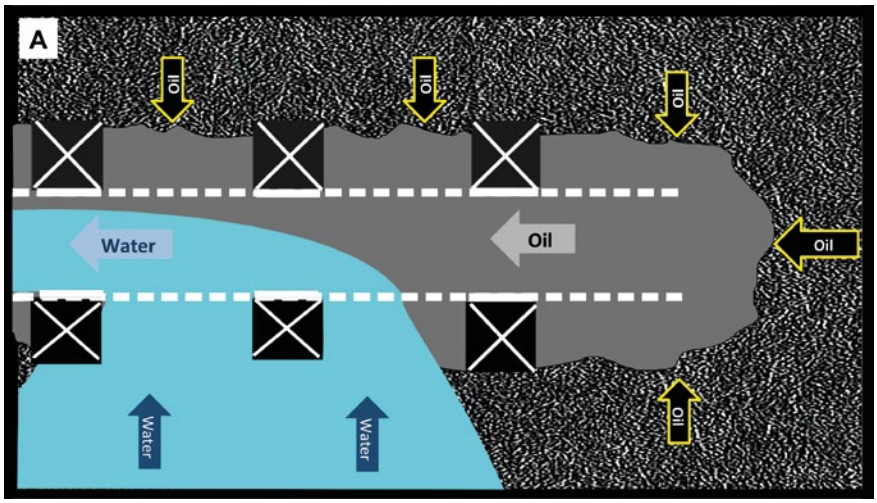
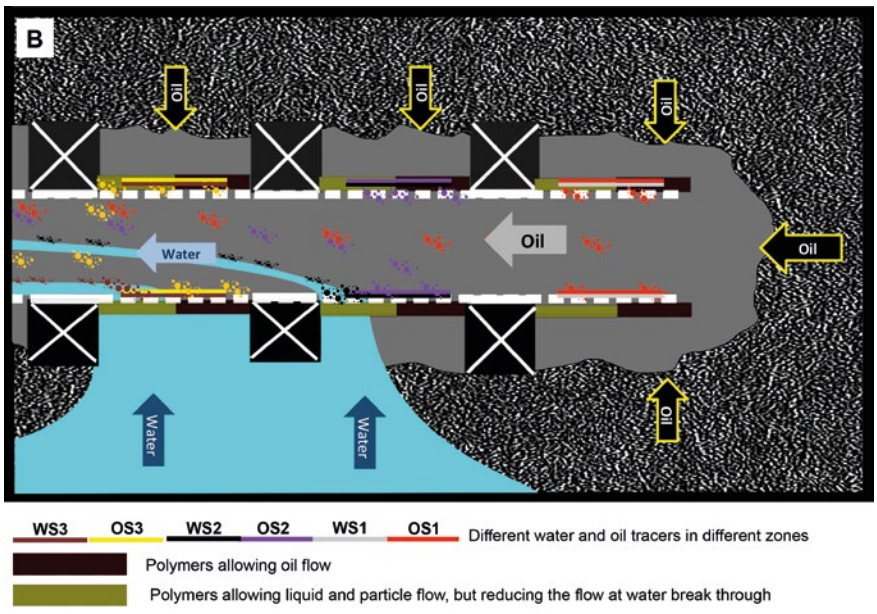


Illustration (A) shows an oil well without RES•GUARD, with 80 per cent water cut, while Illustration (B) shows the same well using RES•GUARD, where water cut is reduced to 20 per cent.



The figure (B) demonstrates the two types of polymers integrated beside one another and their release of different tracers: WS1–3 are tracers released into water in zones 1–3. OS1–3 are tracers released into oil in zones 1–3.

Projects included in the analysis
PETROMAKS / PETROMAKS 2

Key

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

PETROMAKS / PETROMAKS 2 projects on raising energy efficiency / lower emissions to air

Project	Project owner	Project title				
235440	ECOTONE AS	New technology and methods for mapping and monitoring of seabed habitats	✓	✓		
235366	C6 TECHNOLOGIES AS	Advanced Composite Well Intervention Rod for Extended Operating Environments	✓		✓	
235317	SOLUTION SEEKER AS	Decision support for production optimization	✓	✓		
235254	VISURAY AS	3D Cement Evaluation in new and old wells using novel X-ray tomography		✓		
235245	BADGER EXPLORER ASA	Research and Development of Downhole High Power (Ultra) Sonic Technologies and Applications	✓	✓		✓
235238	RESMAN AS	A unit for automatic detection and reduction of produced water	✓	✓		✓
235233	INTERWELL TECHNOLOGY AS	New concept for plugging wells	✓	✓		✓
234162	STIFTELSEN TEL-TEK	Improving Efficiency of Offshore Drill-cuttings Handling Process	✓			✓
234161	SINTEF PETROLEUM AS	Hole Cleaning Performance of Oil and Water based Drilling Fluids in Circular and Non-Circular Boreholes.	✓	✓		✓
234131	INTERNATIONAL RESEARCH INSTITUTE OF STAVANGER AS	Three-Phase Capillary Pressure, Hysteresis and Trapping in Mixed-Wet Rock	✓	✓		✓
234130	NTNU FAKULTET FOR INGENIØR-VITENSKAP OG TEKNIKK	Hydrogen-induced degradation of offshore steels in ageing infrastructure - models for prevention and prediction (HIPP)		✓		✓
234122	INSTITUTT FOR ENERGITEKNIKK	Condition monitoring tool for separators based on combined use of tracer technology and multiphase flow modeling	✓			✓
234115	STIFTELSEN SINTEF	Thermo Responsive Elastomer Composites for cold climate application		✓		✓
234112	NTNU FAKULTET FOR NATURVITENSKAP OG TEKNOLOGI	Improved Mechanisms of Asphaltene Deposition, Precipitation and Fouling.	✓			✓
234111	UNI RESEARCH AS	VOM2MPS: from virtual outcrop models to multipoint statistics training images for improved reservoir modelling	✓	✓		✓
234110	STIFTELSEN SINTEF	Knowledge basis for repair contingency of pipelines		✓		✓
234108	NTNU FAKULTET FOR INGENIØR-VITENSKAP OG TEKNIKK	Next Generation Subsea Inspection, Maintenance and Repair		✓		✓
234074	SINTEF PETROLEUM AS	Shale rock physics: Improved seismic monitoring for increased recovery	✓	✓		✓
233947	SINTEF ENERGI AS	Compact Offshore Steam Bottoming Cycles	✓	✓		
228599	NORGES TEKNISK-NATURVITEN-SKAPELIGE UNIVERSITET NTNU	Nano-enabled Sustainable Cement Sheath Behind Casings		✓		✓

Project	Project owner	Project title				
228513	STIFTELSEN SINTEF	Fundamental studies of materials behaviour for future cold climate applications	✓	✓		✓
228400	NORGES TEKNISK-NATURVITEN-SKAPELIGE UNIVERSITET NTNU	Geophysical methods for subsurface imaging and monitoring		✓		
228391	INTERNATIONAL RESEARCH INSTITUTE OF STAVANGER AS	Advanced Wellbore Transport Modelling	✓	✓		✓
228357	UNIVERSITETET I BERGEN	Modelling and inversion of seismic waveform and electromagnetic data using integral equation methods		✓		✓
228344	SINTEF ENERGI AS	High Voltage Subsea Connections	✓	✓	✓	✓
228222	INSTITUTT FOR ENERGITEKNIKK	Increased Knowledge of Localized Internal Corrosion in Pipelines		✓		✓
228105	NORGES GEOLOGISKE UNDERSØKELSE	NEONOR2 Neotectonics in Nordland - Implications for petroleum exploration		✓		
226160	HAUGALAND KUNNSKAPSPARK AS	Improved safety and efficiency in O&G operations by developing superhydrophobic nanotechnology for passive anti-icing protection.	✓			✓
226009	HAMMERTECH AS	AquaWell Permanent Downhole Water Fraction and Salinity Measurement	✓			✓
225965	BERGEN TECHNOLOGY CENTER AS	Ultrasonic spatial imaging and flow measurement through casing for assessment of cement condition and well integrity		✓		✓
225958	TYPHONIX AS	Enhanced oil recovery by reduced mechanical degradation of polymers	✓	✓		
225926	WISUB AS	MicroWave communication for high performance wet-mate subsea connectors		✓	✓	✓
225922	IMPACT TECHNOLOGY SYSTEMS AS	"Enhanced oil recovery by pressure stimulation employment - Method proposed by Impact Technology Systems AS"	✓	✓		
224878	UNIVERSITETET I BERGEN	Reservoir Scale Simulation of Hydrate Dynamics		✓		
217234	NORTEK AS	Real-time subsea wireless sensor network for monitoring ice drift in the northern areas	✓			
217233	PRO ANALYSIS AS	Robust anti-fouling and cleaning technology for optical windows enabling maintenance-free subsea operation of optical instrumentation	✓			✓
217223	ELECTROMAGNETIC GEOSERVICES ASA	Next generation CSEM inversion and modelling		✓		✓
217211	STATOIL PETROLEUM AS	Development of an Osmotic Membrane Pressure Actuator for Enhanced Oil & Gas Recovery	✓			✓
215665	SINTEF IKT AVD OSLO	Flow diagnostics on stratigraphic and unstructured grids	✓			
215584	SINTEF Energi AS	Pressure Tolerant Power Electronics for Subsea Oil and Gas Exploitation	✓		✓	✓
215577	INTERNATIONAL RESEARCH INSTITUTE OF STAVANGER AS	Reservoir data assimilation for realistic geology	✓	✓		✓
215563	Institutt for kjemisk prosessteknologi	A Combined Surface-Colloid Chemical and Rock-Fluid Interaction Approach towards more Efficient Enhanced Oil Recovery Strategies	✓			
210432	NTNU	Intelligent Drilling–Automated Underbalanced Drilling Operations	✓			
208677	Typhonix AS	Low shear centrifugal pump for produced water applications	✓	✓		✓
208526	Iris-Software AS	Energy Efficiency of Field Development: IOR, System Analysis and Risk Evaluation	✓			

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Key: Energy efficiency | Lower emissions to air | Electrification | Other

Project	Project owner	Project title				
207661	IRIS	Water weakening of chalk at realistic reservoir conditions	✓			✓
207538	NTNU	Increased energy savings in water/oil separation through advanced fundamental emulsion paradigms	✓	✓		
207537	IFE	Improved Glycol Loop Operation	✓	✓		✓
206989	SINTEF Materialer og kjemi	High Pressure Gas Liquid Separation – II	✓	✓		
206976	SINTEF Energi AS	Fundamental understanding of electrocoalescence in heavy crude oils	✓	✓		✓
203404	Teknova AS	Optimization of electrical energy production in offshore installations	✓	✓	✓	
203310	SINTEF Energi AS	Energy efficiency in offshore oil and gas production	✓	✓		
203284	Iris-Software AS	Automated drilling fluid processing	✓			✓
200714	Wireless Instrumentation Systems AS	Wireless communication and power generation for Downhole Wireless Retrofit Instrumentation	✓	✓		
200665	Hole in One Producer AS	Hole in One Producer Prototype	✓	✓		
200624	IFE	Shut-in and Restart of Waxy Crude Pipelines: Software Module Development	✓			
200600	IRIS	Optimizing Water Chemistry for Enhanced Oil Recovery	✓			✓
200593	SINTEF Petroleumsforskning AS	Non-circular wellbores – a new dimension in well construction	✓	✓		
200553	Schlumberger Norge AS	Environmental technology for the future – Automated EPCON CFU system	✓			
200548	Smartmotor AS	Innovative efficient and survivable electric drive systems for subsea and downhole applications	✓		✓	✓
200500	Badger Explorer ASA	Drilling in a Closed Cavity near Pore Pressure	✓	✓		✓
200492	ResMan AS	Design concept for environmentally friendly tracers and matrix systems for permanent monitoring of well influx	✓	✓		✓
200455	SINTEF Materialer og kjemi	Acid Gas Removal with no damaging Effect on the Environment in offshore applications	✓	✓		
193134	NTNU	Improved imaging, mapping and monitoring of hydrocarbon reservoirs		✓		
193108	SINTEF IKT	High Temperature Power Electronic Packaging	✓			
193062	SINTEF Energi AS	Enabling low-emission LNG systems – Fundamentals for multilevel modeling	✓	✓		
192974	Typhonix AS	Development of a subsea Typhoon Valve	✓			✓
192967	SINTEF Materialer og kjemi	Deep water repair welding and hot tapping	✓	✓		✓
192950	eDrilling Systems AS	Complex Operations Control	✓	✓		
188981	eDrilling Systems AS	eDrilling Qualification and Demonstration	✓	✓		
187391	IRIS	Water Weakening of Chalk - Physical and Chemical Processes	✓			✓
187389	SINTEF Materialer og kjemi	Arctic Materials - Materials technology for safe and cost-effective exploration and operation under arctic conditions	✓	✓		✓
187320	Seabed Rig AS	Development of Seabed Drilling Rig, Co-operation with Universities	✓	✓	✓	

Project	Project owner	Project title				
180038	SINTEF Materialer og kjemi	SMOOTHPIPE: Applied Surface Technology for Multiphase Pipelines				
179790	Seabed Rig AS	Development of Seabed Drilling Rig, Phase 1				
176611	SICOM AS	SmartPipe - Self diagnostic pipelines and risers for future integrated process management				
176137	IFE	Liquefaction of Unprocessed Well-Stream				
176134	SINTEF Energi AS	Electrical Insulation Materials and Insulation Systems for Subsea High Voltage Power Equipment				
176025	SINTEF Energi AS	Feasible power electronics for demanding subsea applications				
176024	SINTEF Energi AS	Electric power systems for subsea processing and transportation of oil and gas				
176018	IRIS	E-centre laboratories for automated drilling processes				
175997	Typhonix AS	Development and testing of a new low shear valve concept				
175968	Universitetet i Bergen	CO_2 Injection For Stimulated Production Of Natural Gas				
175918	SINTEF Materialer og Kjemi	Reducing the Environmental Impact of Acid Gas Cleaning Technology				
174036	Eureka Pumps AS	Underwater ElectroMagnetic Sensorsystem				
169477	NTNU - Institutt for kjemisk prosessteknologi	High Pressure Gas Liquid Separation				
169466	SINTEF Energi AS	Electrocoalescence - Criteria for an efficient process in real crude oil systems				
169439	Axon Norway AS	Drilling optimization in Real Time				
169429	Institutt for energiteknikk	Optimisation of Glycol Loop Design and Operation				
169381	Seabed Rig AS	Feasibility Study regarding a Subsea Drilling Module				
169293	Seabox AS	SWIT - Subsea water injection and treatment				
168284	Remora AS	Model Test - HiLoad LNG Regas Terminal				
168274	Statoil	Compressed Energy Technology				
168159	SINTEF Petroleumsforskning	Prediction of deposition and transport of sand in sand-liquid flows (STRONG)				
163253	Badger Explorer ASA	Badger Explorer Prototype				
156662	Statoil ASA - Trondheim	Compact LNG Heat Exchangers				
146710	SINTEF Energi AS	Dropletdroplet interaction and coalescence in electric fields and turbulent flow experiments and modelling				
143992	Norges teknisk-naturvitenskapelige universitet - NTNU	High Pressure Gas SEparation (HiPGaS)				
Total number	**99**	**Numbers**	**80**	**69**	**13**	**56**

Projects included in the analysis
DEMO 2000

Key

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

DEMO 2000 projects on raising energy efficiency / lower emissions to air

Project	Project owner	Project title				
239129	ELECTROMAGNETIC GEOSERVICES ASA	Next Generation CSEM Equipment Field Test. A demonstration / pilot project of the next generation CSEM technology prototype.		☁		✓
239118	OIL TOOLS OF NORWAY AS	Downhole Umbilical Release Assembly Pilotering Prosjekt i DEMO2000	▮▮▮	☁		
239096	DEEPOCEAN AS	Demonstration of intelligent inspection ROV		☁		✓
239084	SEABOX AS	Technology for removal of Sulphate and Salts from seawater at the seabed. SWIT sul/sal	▮▮▮			
239044	TYPHONIX AS	Qualification and Demonstration of a Subsea Typhoon Valve.	▮▮▮			✓
235322	FISHBONES AS	Dreamliner pilot well qualification for Smørbukk Sør application	▮▮▮	☁		✓
235300	PETROTECH AS	New technology in downhole mapping will provide enhanced recovery solutions, huge cost reductions and reduced environmental impact	▮▮▮	☁		✓
235244	E PLUG AS	Prototype construction, FAT and qualification of 5 ½" mechanical well plug with appurtenant electric manipulation tool for multiple settings	▮▮▮			✓
226170	ENHANCED DRILLING AS	RID – Riser Isloation Device	▮▮▮	☁		
226054	COMPUTAS AS	Enterprise IO Collaboration		☁		
226039	WEST DRILLING PRODUCTS AS	Build Pilot of CMR Automated Drill Floor(ADF)	▮▮▮	☁	💡	✓
225952	REELWELL AS	ERD Beyond 20 km – Phase 2 – Demo phase	▮▮▮	☁		✓
225913	TOMAX AS	The Afterburner development project	▮▮▮	☁		✓
225875	FISHBONES AS	Fishbones Consolidated Chalk Project including pilot well installation	▮▮▮	☁		✓
225828	PARTNER PLAST AS	Full scale verification of float steering and positioning system for seismic gun arrays	▮▮▮	☁		
225816	KONGSBERG OIL & GAS TECHNOLOGIES AS	The Qualification and Demonstration of the Subsea Storage Unit (SSU) Technology.	▮▮▮	☁		✓
220938	ENHANCED DRILLING AS	System qualification and pilot testing of ORS' Low Riser Return System	▮▮▮	☁		
220924	RESONATOR AS	Resonator high frequency electrified hammer for cost efficient well intervention and percussion drilling	▮▮▮	☁	💡	
220923	WEST DRILLING PRODUCTS AS	Build Pilot of Continuous Drilling and Circulation Unit (CDU)	▮▮▮	☁	💡	✓
215664	FMC Kongsberg Subsea	The Development and Qualification of a Compact Subsea Oil/Water Separation System	▮▮▮	☁		
215631	West Drilling Products AS	Build Pilot of CMR Rig at Ullrigg Test Centre	▮▮▮	☁	💡	✓

Project	Project owner	Project title				
215620	PRESENS AS	New generation subsea dp sensor for subsea single and multiphase meters				
215605	Seabox AS	Subsea Membrane Testing				
215597	Force Technology Norway AS	SmartPipe Pilot Project				✓
215565	FRAS TECHNOLOGY AS	Condition monitoring of hydraulic- and subsea machinery				
215551	Badger Explorer ASA	Badger Explorer Seismic Field Demonstrator				✓
215548	ReelWell AS	Reelwell Drilling Method-Applications for Subsea Wells				✓
215538	GASSECURE AS	Pilot testing and technology qualification of system for wireless gas detection				
207280	OCTIO Geophysical AS	OCTIO GEOPHYSICAL DEMO2000 - A solution for advance warning of leakage to surface from waste injection wells				✓
207278	Seabed Rig AS	Qualification of autonomous, robotic drill floor for subsequent implementation on offshore platform, phase 3				
207247	ReelWell AS	Reelwell - Extended Reach Drilling beyond 20 km				✓
207203	Drilltronics Rig Systems AS	Drilltronics system onshore demonstrations				✓
207013	Nemo Engineering AS	Subsea Cooler Qualification				✓
206991	Computas AS	CODIO Pilot				✓
206972	Marine Ecosystem Technologies AS	Active Acoustic leak detection of oil and gas from sub sea installation				✓
189003	Aker Subsea AS	High Pressure Deep Water (HPDW) LiquidBooster Pump				
188991	Seabed Rig AS	Prototype test of submerged fully automated drilling rig				
188989	Typhonix AS	Pilot Installation and Testing of Typhoon Valve				✓
188983	Deep Sea Anchors AS	Installation of Two Permanent Deep Penetrating Anchors at the Gjøa Field in the North Sea				✓
188982	ResMan AS	Environmentally friendly chemical tracers for production monitoring in sensitive Arctic areas				✓
188981	eDrilling Systems AS	eDrilling Qualification and Demonstration				✓
188979	Seabox AS	Seabed Water Injection and Treatment - Pilot Plant				
188970	FMC Kongsberg Subsea	Next Generation Deepwater Subsea Gas-liquid Separation System				
188948	Rolls-Royce Marine AS	Heavy Duty Fibre Rope Deployment System JIP Phase 1 – Rope testing programme"				
163827	Framo Engineering A/S	Pilot installation of the Wet Gas Compressor WGC2000 on a live gas field in the North Sea				
163803	Petrotech AS	SILD Phase 2 – A new concept for Environmental Friendly Well Testing and Reservoir Fluid Sampling				
158025	SINTEF Materialer og kjemi	ResMan Downhole Water Monitoring System – Field Verification				✓
149651	Framo Engineering A/S	Testing Wet Gas Compressor - Subsea Wet Gas Compressor				
149637	Petrotech AS	Big Sild - A new concept for Well Testing and Reservoir Fluid Sampling				

Key: Energy efficiency | Lower emissions to air | Electrification | Other

Project	Project owner	Project title				
139739	Petrotech AS	SILD-A New concept for Well Testing and Reservoir Fluid Sampling		☁		
139636	Framo Engineering A/S	Offshore Cryogenic Loading - Full scale Test.	▮	☁		
136959	Kværner Oilfield Products AS	Kværner Subsea Processing System, Multiphase pumping	▮	☁		
136622	Framo Engineering A/S	Subsea Wet Gas Compressor		☁		
Total number	**53**	**Total**	**37**	**40**	**6**	**27**

Photo: Robotic Drilling Systems AS

Research Council of Norway
Drammensveien 288
Postboks 564, NO-1327 Lysaker

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

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