

Work Programme for the PETROMAKS programme (2010–2013)

Large-scale Programme
Optimal Management of norwegian petroleum resources – PETROMAKS



Large-scale Programmes

The RCN initiative
to meet national
research priorities

About the Programme

Optimal Management of norwegian petroleum resources – PETROMAKS

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

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

Contents

1. Summary	3
2. Background	4
2.1 Strategic perspectives	4
2.2 Scientific perspectives	5
3. Objectives of the programme	5
4. Priority research tasks	5
4.1. Thematic priority areas	5
4.2. Strategic priorities	6
5. International cooperation	7
6. Communication and dissemination activities	7
7. Budget	7
8. Coordination with other related instruments at the Research Council	8
9. Organisation	8
10. Attachments to the work programme	9
Environmental technology for the future (TTA 1)	10
Exploration and reservoir characterisation (TTA 2)	10
Enhanced recovery (TTA 3)	11
Cost-effective drilling and intervention (TTA 4)	11
Integrated operations and real-time reservoir management (TTA 5)	12
Subsea processing and transportation (TTA 6)	12
Deepwater, subsea and Arctic production technology (TTA 7)	13
Gas technology (TTA 8)	13
Health, safety and the work environment	14

1. Summary

This work programme establishes the formal framework and focus of the PETROMAKS programme and provides guidelines for R&D players seeking funding under the programme.

Calls for proposals for funding for R&D projects will be based on the content of this work programme (including the attachments describing the thematic priority areas of the programme), together with the national budget, the appurtenant allocation letters from the Ministry of Petroleum and Energy and the Ministry of Labour and the annual analysis of the programme's project portfolio.

Primary objective:

The PETROMAKS programme will promote knowledge creation and industrial development to enhance value creation for society by ensuring the optimal management of petroleum resources within an environmentally sustainable framework.

The programme will provide support for both basic research and applied research to generate new expertise and innovations that may lead to:

- > More discoveries of oil and gas
- > Enhanced recovery from existing fields
- > More environmentally sound and cost-effective drilling and well technology
- > More efficient long-distance transport of well streams
- > Cost-effective and energy-efficient solutions for the Norwegian continental shelf
- > Enhanced petroleum-related industrial development in Norway and abroad
- > Improved solutions in the area of health, safety and the work environment
- > Reduced emissions to the air and sea

As one of seven Large-scale Programmes at the Research Council of Norway, the PETROMAKS programme is designed to realise objectives set out in the Government white paper on research, *Climate for Research*, and the strategy of the Research Council, *In the Vanguard of Research*. A major part of petroleum-related research activities at the Research Council are consolidated under the PETROMAKS programme, which encompasses long-term basic research, competence-building, applied research and technology development. The programme will be a key instrument for implementation of the national technology strategy for the petroleum industry – the OG₂₁ strategy (Oil & Gas in the 21st Century) (www.og21.no).

The PETROMAKS programme is targeted toward Norwegian companies and research and educational institutions that can advance the development of the petroleum industry. Collaboration between various industry players is vital in both a national and an international context. In terms of international research cooperation, the programme places special focus on collaboration with North America and Russia. The programme will primarily promote industrial development by encouraging the establishment of research-based start-up companies.

The PETROMAKS programme was launched in 2004 and will run for a 10-year period. During the first five years, activities under the programme were mainly focused on exploration and reservoir characterisation as well as challenges relating to enhancing recovery from fields in production. In response to the broad-based political agreement on climate policy achieved in the Storting in 2008 and measures to solve global challenges proposed in the white paper *Climate for Research*, the PETROMAKS programme will place greater focus on research projects aimed at raising energy efficiency and reducing emissions, especially to the air but also to the sea. This is in keeping with changes in strategic and thematic focus in the revised OG₂₁ strategy, as well as with Research Council initiatives addressing global climate and energy challenges.

2. Background

2.1 Strategic perspectives

A critical success factor in the metamorphosis of Norwegian petroleum activities into a globally renowned industry has been the willingness of the Government and the industry players to invest in research and technology development from the very start, when the first oil was discovered on the Norwegian continental shelf. The production forecasts of the Norwegian Petroleum Directorate indicate that even after 40 years of operations, the potential for petroleum recovery on the Norwegian continental shelf will be very great for many years to come. It will, however, become increasingly difficult to realise this potential, and continued investment in research and development in the sector is crucial.

In 2004 much of the publicly-funded petroleum research at the Research Council was consolidated under the PETROMAKS programme, one of seven programmes under the Large-scale Programme initiative. The PETROMAKS programme works to achieve objectives set out in the Government white paper on research, *Climate for Research*, and the strategy of the Research Council, *In the Vanguard of Research*, addressing social challenges relating to development of the industry in the context of global climate and energy concerns. The programme attaches importance to achieving cooperation across company and institutional boundaries as well as promoting international participation in research projects, viewing this as a means of further developing the structure of the Norwegian research system. The programme's priority areas for research and innovation are based on the national technology strategy for the petroleum industry – the OG₂₁ strategy – ensuring that research findings will be relevant and applicable to the industry. Furthermore, the concentrated focus on incorporating an education component into research projects funded under the programme will directly benefit both the industry itself and society as a whole.

The PETROMAKS programme addresses a number of challenges relating to the sector's desire to extend the time horizon of the industry and attain increasingly cleaner, more cost-effective production:

- > Annual oil production is declining and new finds no longer make up for the drop in production volume.
- > High and rising cost levels present an increasing challenge.
- > Development of new knowledge and technology is time-critical to extending the lifetime of mature fields.
- > Growth in resources through enhanced recovery from fields in production, natural gas findings and marginal oil findings will require ongoing development of new and improved technology that increases productivity and forms the basis for cost-effective solutions.
- > Exploration for new fields requires new knowledge and must be implemented more efficiently.
- > New exploration areas far from existing infrastructure pose challenges in terms of construction and transport solutions.
- > Petroleum-related activities in the Arctic and in areas adjacent to the coastline represent a particular challenge with regard to emissions to the sea.

- > Greenhouse gas emissions from oil and gas production make up a substantial portion of Norway's overall emissions and pose a key challenge to the industry.

The public sector has special responsibility for boosting the pace of innovation in the business sector and supporting competence-building in the form of education, recruitment and basic research. The PETROMAKS programme therefore encompasses strategic basic research, competence-building, applied research and innovation activities. The programme spans a broad thematic area and supports a wide range of projects, giving it significant value-added and weight.

At the Research Council, petroleum-related research and innovation activities are also conducted under the Centres of Excellence (SFF) and Centres for Research-based Innovation (SFI) schemes as well as under strategic institute and university programmes (SIP/SUP). The DEMO2000 programme provides funding for demonstration and pilot-testing of fully developed technology, while a number of scientific and technology-oriented thematic programmes share an interface with the PETROMAKS programme: the RENERGI programme (new and renewable energy), the CLIMIT programme (CO₂ capture, transport and storage), the HAVKYST programme (effects of emissions to the sea), the MAROFF programme (maritime and offshore operations) and the NANOMAT programme (nanotechnology and new materials). Within the social sciences, the PETROMAKS programme is responsible for conducting research on health, safety and the work environment (HSE) in the petroleum sector and shares an interface with the SYKEFRAVÆR programme (sickness absence and exclusion from working life). The remainder of social science research on petroleum activities is carried out under the PETROSAM programme.¹

As an integral component of the Research Council's Focus on the Arctic and Northern Areas initiative, the PETROMAKS programme will encourage the submission of project proposals of direct or indirect significance to development in the Arctic. This includes research projects addressing planning, development, installation and operation of fields under extreme climatic conditions, as well as specific environmental and geoscientific challenges of relevance to the Arctic.

When relevant, these activities must also be viewed in the context of international research activities, especially in North America and Russia.

The programme is targeted toward Norwegian companies, independent research institutes, universities and university colleges that can advance the development of the petroleum industry.

It is essential that the Ministry of Petroleum and Energy and the Ministry of Labour are supplied with up-to-date knowledge to provide a basis for political decision-making. These ministries are therefore part of the programme's target group as well. Recent signs that the authorities expect petroleum research to take adequate account of climate challenges as well as increase focus on the external environment in general indicate that the target group should be extended to include the Ministry of the Environment.

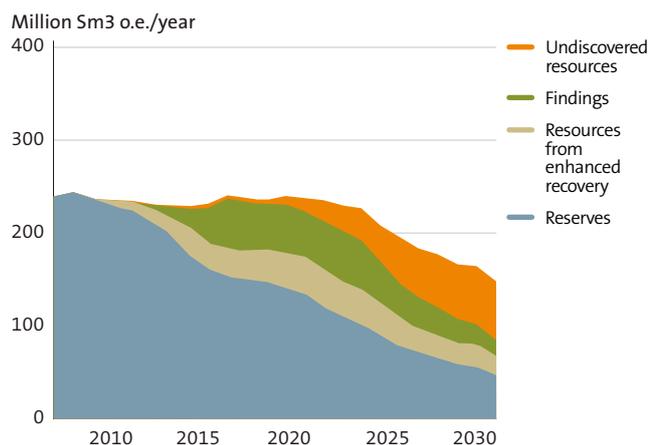
¹) At the request of the Ministry of Petroleum and Energy.

2.2 Scientific perspectives

Norway is a major producer of oil and gas, and the petroleum sector generates 34 per cent of the Government's revenues and 26 per cent of the country's GDP (2008 figures). The sector will continue to make a significant contribution to value creation and welfare in Norway for years to come. The motivation of the Government to invest in petroleum research is therefore very clear.

The challenges relating to the status of and knowledge needed by the sector have their origin in the desire to maintain a high level of production well into the future (see Figure 2.1), while at the same time achieving cleaner production with reduced emissions of greenhouse gases to the air and damaging emissions to the sea. With regard to the challenges relating to production levels and environmental issues, finding solutions will require research-based knowledge and technological development in a wide array of natural science disciplines and technology areas.

Figure 2.1 Production forecasts



(Source: Norwegian Petroleum Directorate)

Figure 2.1 presents the Norwegian Petroleum Directorate's forecasts for petroleum production for the next 20 years. These indicate that the industry has a long time horizon, but that production will become increasingly difficult and knowledge-intensive. In order to meet production forecasts it is essential that the industry acquires and applies new knowledge and research-based technology in all areas, from exploration to enhanced recovery and production through to environmental protection. Development of new technology will be time-critical for continued operations and recovery at many major fields.

With its widespread use of technology, the petroleum industry can also serve as a driving force for the development of other technology-based industries. For example, the industry is the largest user of information and communication technology (ICT) in Norway, which has given a boost to national ICT research. Within the field of new and renewable energy, the petroleum industry's research on and expertise in materials, anchoring and maritime operations will be vital for research on offshore wind power, wave power and electrification of offshore installations. Likewise, the industry's expertise in geology and reservoir behaviour will be essential to research on storage of greenhouse gases.

3. Objectives of the programme

a. Primary objective

The PETROMAKS programme will promote knowledge creation and industrial development to enhance value creation for society by ensuring the optimal management of petroleum resources within an environmentally sustainable framework.

b. Secondary objectives

The programme will support both basic research and applied research to generate new expertise and innovations that may lead to:

- > More discoveries of oil and gas
- > Enhanced recovery from existing fields
- > More environmentally sound and cost-effective drilling and well technology
- > More efficient long-distance transport of well streams
- > Cost-effective and energy-efficient solutions for the Norwegian continental shelf
- > Enhanced petroleum-related industrial development in Norway and abroad
- > Improved solutions in the area of health, safety and the work environment
- > Reduced emissions to the air and sea

4. Priority research tasks

4.1. Thematic priority areas

The PETROMAKS programme will work to aid in the realisation of the national technology strategy devised by the strategic body for the petroleum industry – OG₂₁ (Oil & Gas in the 21st Century) – to the greatest possible extent. Together with industry initiatives, the programme will be a key instrument for implementation of the strategy. The programme's thematic priority areas therefore correspond closely to the strategy's Technology Target Areas (TTA).

The thematic priority areas of the PETROMAKS programme are:

1. Environmental technology for the future
2. Exploration and reservoir characterisation
3. Enhanced recovery
4. Cost-effective drilling and intervention
5. Integrated operations and real-time reservoir management
6. Subsea processing and transport
7. Deepwater, subsea and Arctic production technology
8. Gas technology
9. Health, safety and the work environment

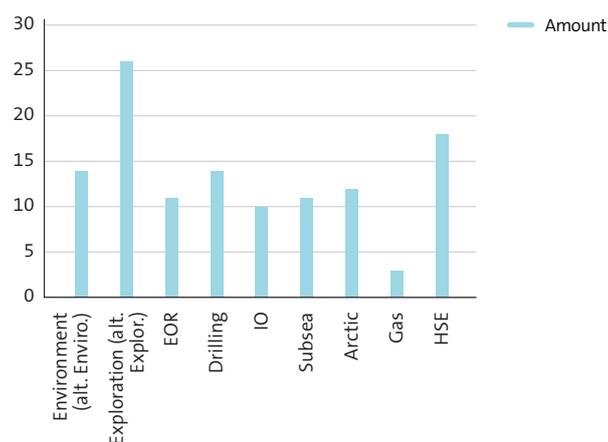
Thematic priority areas 1-8 are based on the thematic challenges and priorities from the OG₂₁ strategy that lie within the scope of the PETROMAKS programme. Thematic priority area 9 is based on the PETROMAKS programme's own strategy for HSE research, for which the programme receives funding from the Ministry of Labour. The thematic priority areas are described in greater detail in the attachments to this work programme.

Although the programme seeks to cover all the thematic priority areas over time, the makeup of its project portfolio may vary

from year to year depending on the directions provided by the allocating authorities via the national budget and appurtenant allocation letters, the strategy and guiding principles set out by the Research Council, the strategic decisions taken by the programme board and the number of grant applications received in response to the individual calls for proposals.

During the first five years of the PETROMAKS programme, activities were mainly focused on the thematic priority areas addressing exploration for resources, realisation of reserves and improvement of recovery rates. In response to the direction signalled in the broad-based political agreement on climate policy achieved in the Storting in 2008 and the allocation letter from the Ministry of Petroleum and Energy, more of the funding under the programme will now be targeted toward new research projects dealing with energy efficiency and cleaner production. At the same time the focus on enhancing recovery in a broad perspective will be maintained. This is in close keeping with the objectives of the white paper on research, *Climate for Research*.

The figure below illustrates the distribution of funding among the various thematic priority areas during the 2004-2008 period.



4.2. Strategic priorities

The largest overall challenge facing the petroleum industry is the steady decline in oil production on the Norwegian continental shelf. The main issues to contend with thus revolve around increasing the recovery rate in existing fields and developing and implementing new technologies that make marginal fields profitable. Development of cost-effective technology within all the thematic priority areas of the programme is time-critical.

Emissions to air have been a topic of growing concern in recent years and are highly relevant to the petroleum industry. In 2007 emissions from the petroleum sector made up 31 per cent of Norway's total CO₂ emissions², with offshore power generation as the largest source of emissions. The PETROMAKS programme will encourage research-based solutions and technology development that will result in more energy-efficient processes with lower emissions of CO₂ and Nox. Technology development to reduce emissions to the air is a task that extends across all the thematic priority areas.

2) Source: "Facts 2008 – The Norwegian Petroleum Sector", Norwegian Petroleum Directorate.

The Norwegian continental shelf is considered to be one of the least polluted oil production areas in the world, and substantial progress has been made in reducing emissions of pollutants to the sea in the past 20 years. Meeting the target of zero-emissions³ on the shelf will entail stringent requirements for environment-friendly solutions for application in both exploration and production. New knowledge and technology is needed in many areas, particularly with regard to the Arctic where a more rigorous regulatory regime is in place.

Under the PETROMAKS programme research activities will be focused on finding ways of managing acute emissions under extreme climatic conditions and/or in areas adjacent to the coastline. It is particularly essential to develop technology and knowledge that make it possible to conduct safe, secure operations in the Arctic.

Increasingly complex operations involve a high risk potential. A great deal of knowledge is still needed in order to generate an adequate fact base from which to set requirements for and take decisions regarding health, safety and the work environment (HSE). There is much to be gained from incorporating HSE-related issues into all the thematic priority areas of the programme.

The petroleum industry will have a substantial need for new recruits in the years to come. To this end, the PETROMAKS programme will provide support for long-term competence-building and education of research fellows and strive to maintain a solid portfolio of basic research projects.

The programme will primarily promote industrial development by encouraging the establishment of research-based start-up companies through the allocation of funding to related research projects.

The involvement of both trade and industry and academia helps to ensure that research projects retain their industrial relevance. The programme will strive to achieve a satisfactory distribution of projects between the business sector and the higher education sector as well as a balance between contributions from the private and public sectors within the project portfolio as a whole.

Individual calls for proposals issued by the programme will provide guidelines and requirements for grant proposals. The calls will be based on the work programme including the attachments describing the thematic priority areas as well as on portfolio analyses and the national budget and appurtenant allocation letters from the ministries. Research priorities within each thematic area will be determined on the basis of identified technology gaps and will incorporate both the needs relating to education and expertise and the potential for new business opportunities, in Norway and abroad.

To achieve its objectives, the PETROMAKS programme will employ a wide array of project types, support schemes and strategic measures used by the Research Council. In addition to grants based on the standard types of research projects, the programme board may design targeted strategic measures and launch special initiatives when it deems such as necessary. Projects organised around partnerships, for example between smaller companies, knowledge communities and large companies, will be encouraged.

3) Report No. 26 (2006-2007) to the Storting.

5. International cooperation

Participation in international cooperation within the framework of the programme is aimed at achieving two main objectives:

- > Strengthening Norwegian research groups through collaboration on projects with leading international players.
- > Promoting the interests of Norwegian research groups in the international petroleum research arena.

International cooperation must be structured to safeguard Norwegian interests and value creation. Collaboration with leading international research groups will enable Norwegian researchers to acquire the knowledge needed to enhance Norwegian competitiveness and will foster the internationalisation of Norwegian technology.

Stakeholders on the Norwegian continental shelf are technology leaders in many areas and their experience in itself may hold significant international market potential. In cases where collaboration between Norwegian companies/R&D groups and international companies/R&D groups is required to realise this potential, the PETROMAKS programme may contribute to covering Norway's share of the funding.

The white paper on research, *Climate for Research*, sets out guiding principles for international cooperation, as do the allocation letters from the ministries. International cooperation under the PETROMAKS programme is primarily targeted toward North America and Russia.

In a national context, it will be fruitful to use the programme's instruments systematically in certain thematic areas to develop world-class research groups – both to enhance the level of expertise in industry-oriented and applied R&D, and to improve quality in strategic research. Formal international cooperation on projects requires that participating players set aside a defined amount of resources, personnel and funds for the individual project.

6. Communication and dissemination activities

Targeted communication and dissemination activities

Communication and dissemination of research findings will be an ongoing activity under the programme. In addition to the traditional concerns relating to communication that all research programmes face; the PETROMAKS programme must cope with special challenges relating to the structure of the petroleum industry and the focus on the industry in the public debate.

The systematic, targeted and professional use of communication measures is thus a vital tool in the effort to achieve programme objectives. The programme's communication goals are:

- > To create a larger applicant pool.
- > To provide an arena for the various players through dissemination of information.
- > To disseminate research findings and communicate the relevance and benefit of the research being conducted.

- > To promote development of a fact base.
- > To lay the foundation for petroleum research after 2013.

Communication activities under the PETROMAKS programme will be directed toward achieving the following:

- > Drawing greater attention to what the programme does by documenting synergies, initiatives and findings that promote value creation.
- > Cultivating contact with the authorities and promoting greater awareness that as an oil and gas nation Norway must allocate more public funding to petroleum research to enhance value creation for society.
- > Encouraging petroleum companies and other segments of trade and industry to become more involved in petroleum research.
- > Creating common meeting places for the industry.
- > Communicating the importance of petroleum research to the public at large.

Communication and dissemination tools

To highlight its efforts and achieve its objectives, the programme will, among other things:

- > publish information on the programme webpages;
- > issue monthly newsletters/fact sheets with project findings;
- > organise and participate in national and international seminars.

The communication strategy for the programme is revised on a regular basis to address new needs and opportunities and ensure its relevance relative to the Research Council's overall strategic communication activities and procedures.

The programme itself will have primary responsibility for communication activities, and will draw upon resources within the Division for Strategic Priorities in particular and the Research Council in general.

7. Budget

The PETROMAKS programme was launched in 2004 and will run for a 10-year period. In 2010 overall funding for petroleum research at the Research Council totalled approximately NOK 400 million. The PETROMAKS programme has a budget of NOK 232 million for 2010, of which NOK 19 million are earmarked allocations from the Ministry of Labour for research on HSE in petroleum-related activities. The programme received a budget increase from 2009 to 2010 and will continue its efforts to secure further growth in allocations from the funding ministries.

Zero-growth budget

Income	2010	2011	2012	2013	Total
Transferred to first year	0				0
Ministry of Petroleum and Energy	161 250	161 250	161 250	161 250	645 000
Ministry of Labour	18 800	18 800			37 600
Fund for Research and Innovation	51 000	51 000	51 000	51 000	204 000
The BILAT programme	800				800
Total	231 850	231 050	212 250	212 250	887 400

With a zero growth budget, the programme plans to issue four to five calls for proposals starting in spring 2010. These calls will in part be open to all the programme's thematic areas and in part target specific topics such as energy efficiency and HSE.

During the last phase of the programme, any directions and budgetary guidelines for allocations will need to be realised within the amount of unused budget funding available. Efforts will also be made within the framework of the programme to ensure that decisions regarding future funding for the field are taken within a broad-based scientific context. The PETROMAKS programme will cooperate with the OG₂₁ strategic body in various budget processes to promote focus on R&D topics that are time-critical for the petroleum industry and areas in which Norwegian players have long-term ambitions.

8. Coordination with other related instruments at the Research Council

The PETROMAKS programme shares an interface with several related programmes at the Research Council, including the DEMO2000, MAROFF⁴, RENERGI⁵, HAVKYST⁶, PETROSAM⁷, SYKEFRAVÆR⁸, CLIMIT⁹ and NANOMAT¹⁰ programmes.

www.forskningsradet.no/demo2000
www.forskningsradet.no/maroff
www.forskningsradet.no/renergi
www.forskningsradet.no/havkyst
www.forskningsradet.no/petrosam
www.forskningsradet.no/sykefravaer
www.forskningsradet.no/climit
www.forskningsradet.no/nanomat

- 4) The MAROFF programme – Innovation Programme for Maritime Activities and Offshore Operations
- 5) The RENERGI programme – Clean Energy for the Future
- 6) The HAVKYST programme – The Oceans and Coastal Areas Programme
- 7) The PETROSAM programme – Social Science Petroleum Research
- 8) The SYKEFRAVÆR programme – Programme on Sickness Absence Research and Exclusion from Working Life
- 9) The CLIMIT programme – Programme on Power Generation with Carbon Capture and Storage
- 10) The NANOMAT programme – Large-scale Programme on Nanotechnology and New Materials

9. Organisation

The programme board of the PETROMAKS programme is appointed by and reports to the Research Board of the Division of Strategic Priorities. The programme board will strive to achieve programme objectives by implementing the instruments available to the programme, in accordance with the intentions and objectives of the overall strategy for the Research Council, guidelines from the Executive Board of the Research Council and the Research Board of the Division of Strategic Priorities, the work programme and the OG₂₁ strategy. It is especially important to assess and adjust the programme objectives and the prioritisation of research tasks according to the financial framework conditions in the event of unforeseen changes in the national budget and the ministerial allocation letters. The programme board's activities shall at all times be in compliance with the overall principles and guidelines for the establishment, operation and conclusion of research programmes as set out by the Research Council. The programme board acts on behalf of the Research Council and reports to the Research Board via the Executive Director.

The programme administration of the PETROMAKS programme is responsible for carrying out the day-to-day tasks of the programme and consists of a programme coordinator assisted by personnel with scientific and administrative expertise. The programme administration carries out the administrative functions of the programme and the programme board and facilitates the implementation of the programme board's decisions. The programme coordinator reports to the programme board and shall take a proactive role in ensuring that the programme is carried out in accordance with the approved work programme.

The PETROMAKS programme is a key instrument for the implementation of the national OG₂₁ technology strategy. The programme administration will therefore cultivate cooperation with the OG₂₁ secretariat, board and groups under the various Technology Target Areas (TTA). A representative for the Research Council will have a seat on the OG₂₁ board.

Processing of grant applications

Grant proposals for Researcher Projects and Knowledge-building Projects with User Involvement will primarily be assessed by international referees. When feasible, the referees will convene together for consensus discussions. The consensus process will provide the formal basis for application assessment.

User-driven Innovation Projects will be assessed by national referee panels convened for discussion. The programme administration will incorporate the referee assessments into its recommendation to the programme board. Applicants who wish have their applications for innovation projects treated confidentially must explicitly request this. In such cases applicants will have the opportunity to comment on the proposed referees.

Environmental technology for the future (TTA 1)

Vision:

To establish the petroleum industry on the Norwegian continental shelf as a leader in environmentally sound solutions, as well as health and safety, and to develop the world's foremost knowledge and technology cluster for environmental technologies that support sustainable exploration, development and production.

Future challenges:

Challenges range from conducting activities in mature areas such as the North Sea to development and operations in new environments such as the Barents Sea and the Arctic. Activities in the Arctic will entail operations under conditions of darkness, cold and ice, and with long distances to shore. In addition, there is a greater awareness of climate issues, and more efficient production with lower greenhouse-gas emissions will be called for. Meeting these challenges will involve:

- > being proactive in relation to new national and international legislation
- > employing responsible methods of exploration and production, in terms of both safety and environmental protection.

Priority areas for research and innovation under the PETROMAKS programme encompass:

- > Reduction of daily operational emissions to the air and sea, including technologies that enable operations with lower CO₂ emissions. (For information on CO₂ for enhanced recovery and CO₂ related to natural gas, please refer to TTA 3 and TTA 8, respectively.)
- > Further improvement of the management of produced water.
- > Enhanced knowledge about risk and risk management, particularly with regard to activities in new areas.
- > Development of leakage detection systems.
- > Development of new technologies for managing acute emissions to the sea.
- > Development of new methodologies and knowledge for minimising the overall environmental impact on air and sea during exploration, recovery and production.

For a more in-depth description, please refer to the OG₂₁ strategy revised in May 2008. Research on technology for CO₂ management of onshore power production lies within the scope of the CLIMIT programme. Research to generate knowledge about the impact and effects of oil contamination on plant and animal life lies within the scope of the PROOFNY sub-programme under the HAVKYST programme.

Exploration and reservoir characterisation (TTA 2)

Vision:

To increase production on the Norwegian continental shelf by employing new methods and technology that will lead to more discoveries and better understanding of reservoirs.

Future challenges:

- > A higher frequency of reserve discoveries is needed in order to replace the volumes produced on the Norwegian continental shelf. In recent years there have been far fewer discoveries than the volumes produced.
- > Optimised production and understanding of reservoirs are essential to achieving higher recovery rates from existing fields.

Priority areas for research and innovation under the PETROMAKS programme encompass:

- > Regional geology and basin analysis on the Norwegian continental shelf with particular focus on areas with little exploratory activity. Studies that address topics such as thermal history, regional stratigraphy and basin formation.
- > Geophysical methods that yield better data collection and visualisation, as well as new methods such as 4C seismics and EM technology.
- > Reservoir simulations and modelling, e.g. reservoir models that are better integrated with seismics, and new methods that enhance understanding of heterogeneities and complex reservoirs.
- > Reservoir geology, including 1) rock physics and geomechanics, and 2) high-resolution reservoir characterisation.

Other areas, such as future exploration technology and unconventional resources on the Norwegian continental shelf. Exploration technology of the future may include biotechnology for new exploration methods and unconventional resources. Mapping of gas hydrates on the Norwegian continental shelf is also important.

The first four points are a paraphrasing of the thematic priority areas under TTA 2 based on a rational division of projects allocated funding under the PETROMAKS programme. Please refer to the OG₂₁ strategy for information on thematic priority areas such as sub-basalt challenges, larger-scale integrated projects in seismics, rock physics, sequence stratigraphy and reservoir characterisation, as well as technologies for areas with extreme weather conditions or very deep waters.

Environmental relevance:

There are few environmentally relevant topics under TTA 2 other than seismics associated with exploration activities.

Enhanced recovery (TTA 3)

Vision:

To enhance recovery of oil from fields on the Norwegian continental shelf and achieve the target of recovering five billion extra oil barrel equivalents from existing fields on the Norwegian continental shelf by 2015.

Future challenges:

- > Existing methods of enhancing recovery must be improved through research and development.
- > New methods that integrate existing methods of enhancing recovery must be devised.

Priority areas for research and innovation under the PETROMAKS programme encompass:

- > Water-based EOR methods such as:
 - Low-saline water injection
 - Polymer-water injection
 - Surfactant-water injection
- > Injection of CO₂ for enhanced recovery.

Environmental relevance:

TTA 3 involves a number of environmental challenges. The environmental impact of chemical substances employed to enhance recovery from the fields must be minimised to the greatest extent possible. In addition, the use of produced water in enhancing recovery must be improved, while at the same time avoiding emissions of produced water to the sea. There is great potential in utilising CO₂ to enhance recovery as it may be sequestered in the reservoir, which would enable the petroleum companies and the Norwegian Government to improve their CO₂ balance sheet.

Cost-effective drilling and intervention (TTA 4)

Vision:

To develop innovative, cost-effective, environmentally-sound drilling and well intervention technology that will establish Norway as the world's leading supplier.

Future challenges:

The primary challenge is reserves replacement of the volumes being produced. In recent years the increase in new reserves has been slower than anticipated. Drilling rig availability has been a limiting factor for exploration, as have skyrocketing related costs. The development of cost-effective drilling technology is therefore essential. Furthermore, the petroleum industry is moving into areas with more extreme weather conditions, which will require the development of new technology to make the drilling process more environmentally sound and better prepared for unforeseen incidents. Obtaining qualified personnel and educating and training new technologists are currently major challenges within this field. Initiatives to enhance drilling and intervention-related expertise and competence are of vital importance in this context.

Priority areas for research and innovation under the PETROMAKS programme encompass:

- > Technology to reduce the risk of unforeseen incidents during drilling and intervention.
- > Cost-effective methods of drilling and intervention.
- > Technology for deepwater drilling, including HPHT wells.
- > Technology for long-reach wells.
- > Smart wells and technology for achieving high-production wells.
- > Innovative drilling processes for challenging waters, including Arctic waters.
- > Enhanced drilling and intervention-related expertise.

Environmental relevance:

The risk of acute emissions to the sea during the drilling process is one of the most critical environmental challenges facing the industry. It is crucial that new technology developed to raise efficiency and lower costs also contributes to improving safety. This applies particularly to new technology developed for use in operations in the Arctic.

Integrated operations and real-time reservoir management (TTA 5)

Vision:

To establish the petroleum industry on the Norwegian continental shelf as a global leader in integrated operations (IO) and real-time reservoir management (RTRM) and to enhance recovery, reduce costs, improve health, safety and the work environment (HSE), and generate export opportunities for Norwegian players.

Future challenges:

Introducing integrated operations and real-time reservoir management will be the preferred method of conducting exploration and operation, not only in future field developments but also in existing fields. An analysis of the present situation reveals some major gaps that must be filled in order to fully exploit the potential of these technologies. These gaps are related to well drilling and completion, production optimisation and reservoir management, operations and maintenance, and HSE, and they must be filled by developing new solutions involving hardware, software, communications and work processes.

- > Advanced, standardised real-time data processing must be developed.
- > Remotely operated technology must be introduced.
- > Sensor technology and wireless signal transmission must be improved.
- > Simulation tools and virtual techniques must be enhanced.
- > New, effective work processes and safety systems for IO must be developed.

Priority areas for research and innovation under the PETROMAKS programme encompass:

- > Software development for data handling, with an emphasis on integrated data systems.
- > Sensor development and new communications solutions.
- > Cross-disciplinary use of visualisation, simulation and model development, particularly in the areas of drilling and reservoir management.
- > MTO perspective, change management and virtual team development.
- > Consequences of IO for HSE, including IT security and vulnerability.
- > Education, training, and recruitment in general, with an emphasis on new data systems and new types of interaction.

Environmental relevance:

Integrated operations involve a number of technology areas related to the environment, the most important of which are environmental and processes monitoring, real-time data analysis, modelling and real-time risk management in order to prevent emissions and major accidents.

Subsea processing and transportation (TTA 6)

Vision:

To establish the leading international knowledge and technology cluster in subsea processing and transport in Norway.

Future challenges:

The primary challenges on the Norwegian continental shelf and internationally will involve:

- > increased proportions of water, sand and gas production from mature fields
- > small discoveries, both remote and within tie-in distance from existing infrastructure
- > handling complex fluids that are difficult to transport
- > establishing deepwater developments, possibly far from existing infrastructure
- > dealing with cold environments

Subsea processing and transport are two key enabling technologies in the development of resources in the Arctic. The OG₂₁ strategy recommends that the Government give priority to funding research in the thematic priority areas listed below. For a more in-depth description, please refer to the OG₂₁ strategy revised in May 2008.

Priority areas for research and innovation under the PETROMAKS programme encompass:

- > Fundamental knowledge about multiphase pipeline flow and flow assurance with a focus on complex fluids, including heavy and highly viscous oils.
- > Fundamental understanding of and models for oil/gas/water separation, including fluid characterisation and fluid mechanics.
- > Subsea electrical power supply.
- > Compact separation equipment for deepwater use.
- > Fundamental understanding of multiphase thermodynamics and flow aspects related to equipment.
- > Subsea compression technology with high capacity and energy efficiency.
- > Monitoring and control systems for subsea processing.
- > Reliable equipment with high capacity for downhole separation systems.
- > Development of subsea compressors for injection of gas.
- > Fundamental knowledge about mechanical design of subsea multiphase pumps and compressors.

Several of these thematic areas partially overlap with thematic areas under TTA 7.

Environmental relevance:

Offshore field development completely or partially based on subsea processing and transport technologies will leave a softer environmental footprint than the use of conventional solutions by virtue of lower energy requirements and reduced emissions to the air and sea. In addition, power supply, control and monitoring will be from land or other infrastructure, reducing the need for offshore manpower.

Deepwater, subsea and Arctic production technology (TTA 7)

Vision:

To enhance Norway's position as a leader in technology for offshore solutions for deep waters, subsea and Arctic waters.

Future challenges:

This technology area encompasses a variety of challenges and is addressed by several programmes at the Research Council. The thematic priority areas defined under the PETROMAKS programme have been limited to offshore field development and subsea and Arctic operations.

Activities in Arctic areas place stringent requirements on engineering solutions. The costs of offshore Arctic operations are considerably higher than those of corresponding operations in more southerly areas, so the challenge will be to develop technology that reduces the cost multiplier for Arctic operations and offshore developments, while safeguarding the environment.

Subsea fields are being developed in deeper waters and more demanding areas, and the challenge will be to create subsea systems that enable cost-effective field development and operation. Particular focus will be placed on reducing the costs of subsea wells; this is addressed under TTA 4, while subsea processing is addressed under TTA 6.

Priority areas for research and innovation under the PETROMAKS programme encompass:

- > Development of solutions to problems resulting from ice and the icing of installations, vessels and equipment during field development and operation, including:
 - Solutions that involve the use of new and lighter materials.
 - Adaptation of vessels and installations to prevailing weather, wave and ice conditions in areas with seasonal ice. This also includes modelling tools for interactions between ships and installations in Arctic environments.
 - New solutions for intervention in areas with seasonal ice.
- > Development of new systems for subsea installation, inspection and maintenance of equipment and pipelines. This includes wirelessly-controlled autonomous underwater vehicles (AUV).

Environmental relevance:

The development of offshore oil and gas fields in Arctic areas places very high demands on safety and preparedness for spills and accidents. Development solutions that completely or partially include subsea production, electrification, control and monitoring from land or other infrastructure will play a significant role in the future development of fields and in lowering emissions to the air and sea. Such solutions will also reduce the need for offshore manpower.

Gas technology (TTA 8)

Vision:

- > To develop the gas industry into a major industrial sector and enable Norway to become a leading gas technology nation in the 21st century.
- > To establish Norway as a leading international gas technology player that promotes Norwegian operatorships internationally as well as the export of technology, products and services.

Future challenges:

Gas technology encompasses a variety of challenges and is addressed by several programmes at the Research Council. Research within the following thematic areas is of relevance under the PETROMAKS programme:

- > Gas transport and processing (pipeline, LNG, other).
- > CO₂ management (limited to reduction of emissions and CO₂ for storage/EOR/EGR).

Research on conversion of natural gas lies within the scope of the GASSMAKS programme and is not part of the PETROMAKS programme. Research on CO₂ capture from power plants (including storage and transport) lies within the scope of the CLIMIT programme but is also addressed by the PETROMAKS programme in terms of storage/enhanced recovery and transport, and is an area for cooperation between the two programmes.

Priority areas for research and innovation under the PETROMAKS programme encompass:

The thematic priority areas for research and innovation listed below are based on recommendations in the OG₂₁ strategy. For a more in-depth description, please refer to the OG₂₁ strategy revised in May 2008.

- > Optimisation of operations, capacity utilisation, and cost-effective and energy-efficient solutions for processing gas and transporting gas via pipeline.
- > New and improved concepts for non-pipeline transport of gas (LNG, CNG, HLG, NGH and others).
- > LNG technology and expertise for both offshore and onshore facilities.
- > CO₂ transport and injection for storage/enhanced recovery. (For CO₂ for storage and transport, please refer to the CLIMIT programme as well.)
- > CO₂ removal from produced natural gas in order to meet specifications for marketable natural gas.

Environmental relevance:

The production of natural gas in Norway is rising; this increase in production for energy purposes is viewed positively, as natural gas is preferable to other carbon-based raw materials. Meeting CO₂-related challenges will require various approaches, and solutions involving gas injection play a vital role. CO₂ for enhanced recovery will not only soften Norway's environmental footprint, it will boost value creation as well.

Health, safety and the work environment

Vision:

Petroleum activities pose the risk of major accidents, injuries to personnel, work-related illnesses and environmental contamination. The vision is therefore to establish the Norwegian petroleum industry as a world leader in health, safety and the work environment, as well as a pioneer in creating value for society based on the cultivation of quality, knowledge and continual improvement.

Future challenges:

During the 2007-2011 period, the objective of the PETROMAKS programme is to generate new knowledge and promote the development of new solutions related to complex relationships between HSE risk and people, organisations and technology in the petroleum industry. This also includes a focus on increasing our understanding of cultural factors that have an impact on risk trends and risk management in MTO interaction.

One challenge is to generate and enhance knowledge about specific topics such as noise, chemicals, working hours, etc., and within overarching thematic areas such as new operations systems and work procedures, organisational culture and risk management. The strategy for HSE in petroleum research activities is grouped into four main categories: personnel, organisation, technology, and culture.

Cultural factors must be taken into account in technology development, risk and safety philosophy, view on human life, HSE efforts, procedural levels and understanding, acceptance in regard to regulations and supervisory authorities, etc. Cultural research must be further developed from characterisation and quantification to understanding and integration within a system context.

Priority areas for research and innovation under the PETROMAKS programme encompass

- > Chemical health risks.
- > Exclusion (senior policy, loss of licence, age and illness).
- > Risk: understanding, acceptance, management ability and competence; risk management, risk indicators, tools for risk modelling and visualisation.
- > Working hours (shift work, managers' work situation, fatigue management).
- > New operations systems and new work procedures.
- > Organisational changes.
- > Organisational culture.
- > Extended human lifespan.



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

The Research Council of Norway
Stensberggata 26
P.O. Box 2700 St. Hanshaugen
N0-0131 Oslo

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

© The Research Council of Norway
PETROMAKS
www.forskningsradet.no/petromaks

February 2010
ISBN 978-82-12-02762-6 (print)
ISBN 978-82-12-02771-8 (pdf)

Number of copies: 200
Print: Allkopi
Design: Agendum AS
Illustration cover:
Seabed Rig AS, Norlense.
Translation:
Victoria Coleman/Carol B. Eckmann