OG21 – OIL AND GAS IN THE 21ST CENTURY
NORWAY´S TECHNOLOGY STRATEGY FOR THE 21ST CENTURY
STRATEGY DOCUMENT

OG21 WAS ESTABLISHED BY THE MINISTRY OF PETROLEUM AND ENERGY (MPE) IN 2001.

THE BOARD OF OG21 IS RESPONSIBLE FOR DEVELOPING A *NATIONAL TECHNOLOGY STRATEGY* FOR THE NORWEGIAN PETROLEUM INDUSTRY, AND ALSO TO SERVE AS AN ADVISOR TO THE AUTHORITIES AND THE INDUSTRY AT LARGE.

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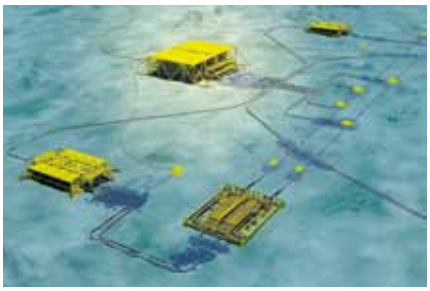
EXECUTIVE SUMMARY AND CONCLUSIONS



OG21 was established by the Ministry of Petroleum and Energy (MPE) in 2001.

The Board of OG21 is responsible for developing a *National Technology Strategy* for the Norwegian petroleum industry, and also to serving as an advisor to the authorities and industry at large.

The previous OG21 strategy is perceived to have successfully aligned the various stakeholders towards a common direction and ambition regarding technology challenges as well as technological opportunities. The strategy has also resulted in coordinated national efforts in research, development, demonstration and commercialization.

A revision of the OG21 strategy has, however, been necessary for the following reasons:

- The focus on climate change from the authorities, industry and society at large has intensified the drive to find, develop and produce oil and gas resources in a cleaner and more energy-efficient manner.

- The mature part of the Norwegian Continental Shelf (NCS) requires acceleration of efforts to find, develop and produce oil and gas resources to sustain societal value creation.

- The situation on the NCS in 2010 has radically changed compared to 2000. Historically, larger developments have carried significant technology development and deployment responsibilities. The current portfolio of smaller discoveries and developments is unable to provide capital for technology advancements, which must be supported by other means.

- Both the Norwegian Sea and the Barents Sea now appear more than before, to be areas with significant potential, although with increasing upside and uncertainty in the northern areas.

In the short term perspective it is important to convert existing resources into reserves[1] and in the long term perspective finding new resources is essential.

1] Resources are technically recoverable volumes, reserves are the economically recoverable part of petroleum in a field or a discovery.

THE OG21 STRATEGY SHOULD GUIDE THE GOVERNMENTAL FUNDING AND BE USED AS INPUT TO TECHNOLOGY STRATEGIES IN THE OIL & GAS INDUSTRY

The key strategic **goals** are:

- *Value creation through production and reserve replacement:* Reserve growth of 5 bn boe before 2015.

- *Energy efficient and cleaner production:* Maintain the Norwegian position as the oil and gas province with the highest energy efficiency, the lowest level of emissions to air, and lowest harmful discharges to sea per produced unit.

- *Value creation through increased export of technology:* Continue the current growth path with annual oil and gas technology sales of NOK 120 bn by 2012.

- *Value creation through employment and competence development:* Sustain and further develop Norway's position as a leading and competitive oil and gas technology cluster.

The key **means** for implementation of the 2010 OG21 strategy are:

- To arrange forums and meeting places to create awareness and common understanding of the challenges and opportunities.

- To establish and develop Technology Target Areas (TTA) work groups engaging a broad set of experts, within:

1] Energy efficient and environmentally sustainable technologies;
2] Exploration and increased recovery;
3] Cost-efficient drilling and intervention;
4] Future technologies for production, processing and transportation.

- OG21 strategy is a framework and source of input for:
  - Government funding related to Research and Development (R&D)
  - Specific governmental funded R&D programmes like PETROMAKS and DEMO2000
  - Companies, higher education institutions and research bodies targeting the oil and gas industry
  - Companies, higher education institutions and research bodies targeting renewable energies, Carbon Capture and Storage (CCS) and potential spin-offs to other industries where oil and gas industry competence and resources can be applied.

In order to implement the strategy, OG21 recommends that Government funding of at least NOK 600-800 mn/year is allocated to oil and gas R&D. In addition, clear signals must be sent to companies that Norway is an attractive place to carry out R&D. This calls for incentives that allow equipment suppliers and contractor companies to undertake research, development, prototyping and deployment tests of new technologies at an attractive risk level.

The Government's petroleum R&D funding should be stable over time and give priority to:

- Energy efficient technologies to further reduce emissions to air and discharges to sea

- Solutions and services for increased oil recovery to maximize recovery rates from mature assets within the lifespan of the existing infrastructure

- Drilling technologies to reduce cost and environmental impact

- Stimulate advanced subsea systems to maximize value creation in Norwegian offshore assets

- Developing long-distance subsea multiphase transportation technologies to meet challenges in remote areas and enable the utilization of existing processing facilities

- Developing incentives for piloting new technologies to reduce uncertainty for small and medium-sized companies

- Higher education to secure high levels of oil and gas competence in Norway

The OG21 strategy is designed to guide the governmental funding and be used as input to technology strategies in the oil and gas industry.

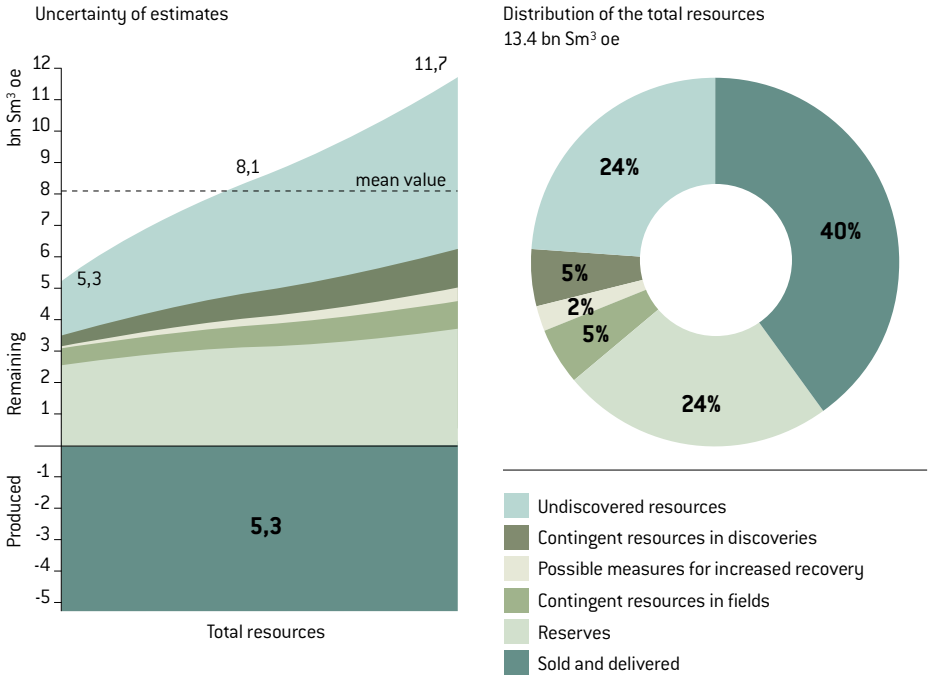
1. INTRODUCTION

During the last 40 years, the Norwegian petroleum industry has created value from the Norwegian Continental Shelf (NCS) totalling more than NOK 7000 bn measured in 2009 monetary value (ref. Facts 2009 by MPE). By the end of 2008, the NCS had produced 32 bn boe (5.3 bn Sm^3 oe) so far and proven but not yet produced are 31 bn boe (5.3 bn S m^3 oe). So far only 1/3 of expected Norwegian resources have been produced (Fig. 1.1). The basis for this enormous value creation has been a long series of world class technological breakthroughs. The petroleum industry is Norway's leading industry and the largest contributor to the economy with 1/3 of government income, 1/2 of all exports and 1/4 of GDP. The remaining potential resources, especially on gas, indicate that the industry still has a growth potential and a long-term future on the NCS.

The global demand for oil and gas is expected to grow throughout the 21st century. The outlook for 2030 shows that the energy mix will remain almost unchanged. Oil and gas will continue to be an important contributor to the world's energy supply for many years (Fig. 1.2 IEA, Key Energy Statistics 2009). The supply of renewable energy is likely to be insufficient to cover existing and new demand in the next few decades. This is also supported by the 450 ppm scenario[2] from IEA. Activities on R&D must therefore continue, to manage the balance between the need for more energy and the environmental focus.

On the NCS, the "easily" recoverable resources have been produced. The remaining resources are more challenging

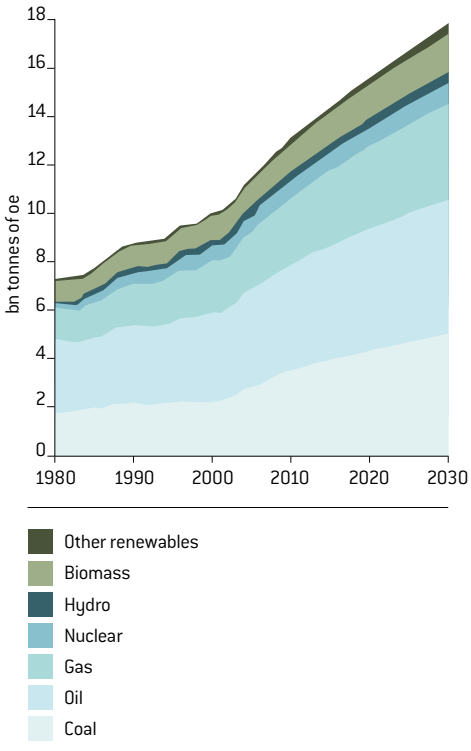
FIG. 1.1 NORWEGIAN RESERVES/RESOURCE SITUATION



Low estimate (P90) to the left and high estimate (P10) to the right

Source: NPD

FIG. 1.2 FUTURE GLOBAL ENERGY MIX



Source: IEA WEO Reference Scenario

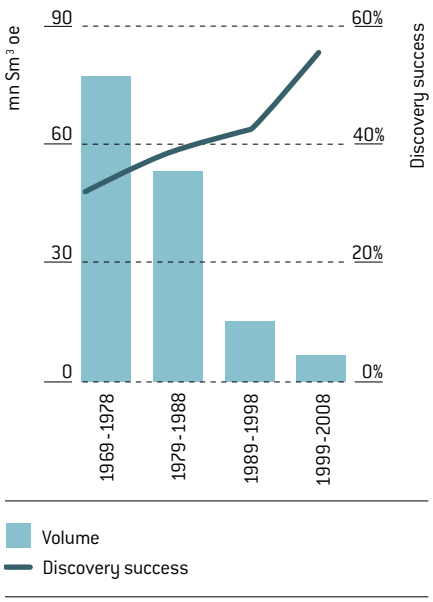
2] The 450ppm scenario anticipates a long-term concentration of greenhouse gases in the atmosphere to 450 parts per million of CO_2-equivalent.

THE PETROLEUM INDUSTRY IS NORWAY'S LEADING INDUSTRY AND THE LARGEST CONTRIBUTOR TO THE ECONOMY. REMAINING POTENTIAL RESOURCES, ESPECIALLY ON GAS, INDICATE THAT THE INDUSTRY STILL HAVE A GROWTH POTENTIAL ON THE NCS

and require further technology development. In addition, discoveries are smaller (Fig. 1.3). The activity moves into new areas with new challenges i.e. deeper water, arctic conditions and developments that are closer to the coast and much further away from infrastructure. These challenges require further emphasis on R&D. This OG21 Strategy addresses these evolving challenges in the petroleum industry. Focus is on the strategic technology themes for adding reserves and maximizing production, achieving cleaner and more energy efficient production and maximizing value creation through exporting technology.

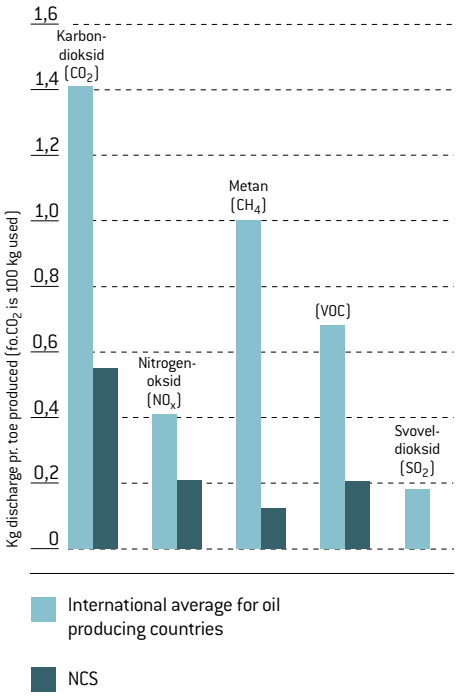
The Norwegian petroleum sector has adopted a policy with strong social responsibility and has developed the field of Health, Safety and Environment (HSE) to high industrial standards. Still there are HSE challenges in the petroleum sector, especially in relation to environmental challenges in sensitive areas. Fig. 1.4 shows emissions to the air from the petroleum industry in Norway compared to the international average.

FIG. 1.3 DEVELOPMENT OF DISCOVERIES AND RATE OF SUCCESS ON THE NCS



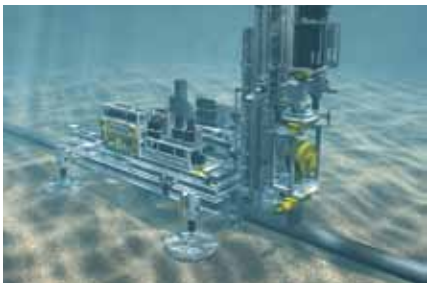
Source: NPD

FIG. 1.4 SHOWS EMISSION PR. UNIT TO AIR FROM THE PETROLEUM INDUSTRY



Source: OGP and OLF

2. THE ROLE OF TECHNOLOGY ON THE NORWEGIAN CONTINENTAL SHELF



Technology has been critical for the development of Norway as a leading petroleum-producing nation. The Government recognized this by placing considerable emphasis on motivating and supporting R&D. The result has been the creation of the world's cleanest petroleum industry and significant value creation. Most of the "easy oil" has been found; hence technology will be essential in the future. The market alone will not secure the technologies that are required to sustain production and discover new resources on the NCS. To maintain Norway's position as a technology leader, Government funding will stimulate the availability of needed technologies. OG21 is an enabler for continued technology success and for realization of the value of Norwegian oil and gas resources.

THE IMPACT OF NORWEGIAN PETROLEUM TECHNOLOGY SO FAR

The willingness to invest in R&D has been a key success factor for the development of the Norwegian petroleum industry since the very beginning (Box 2.1). NCS operators have pioneered innovative technology such as horizontal drilling, time lapse seismic surveying (4D) and subsea technology. The development of horizontal drilling and multilateral wells on Troll, and the subsea developments with multiphase transport directly to shore on Snøhvit and Ormen Lange are examples of Norwegian technological excellence. On Troll, new technology enabled the development of the oil rim, which released reserves worth more than NOK 500 bn that would otherwise have been left in the ground (Fig. 2.1). Global companies have used the NCS as a testing ground for new technology which can also be applied elsewhere. Therefore exports of advanced technology solutions have prospered.

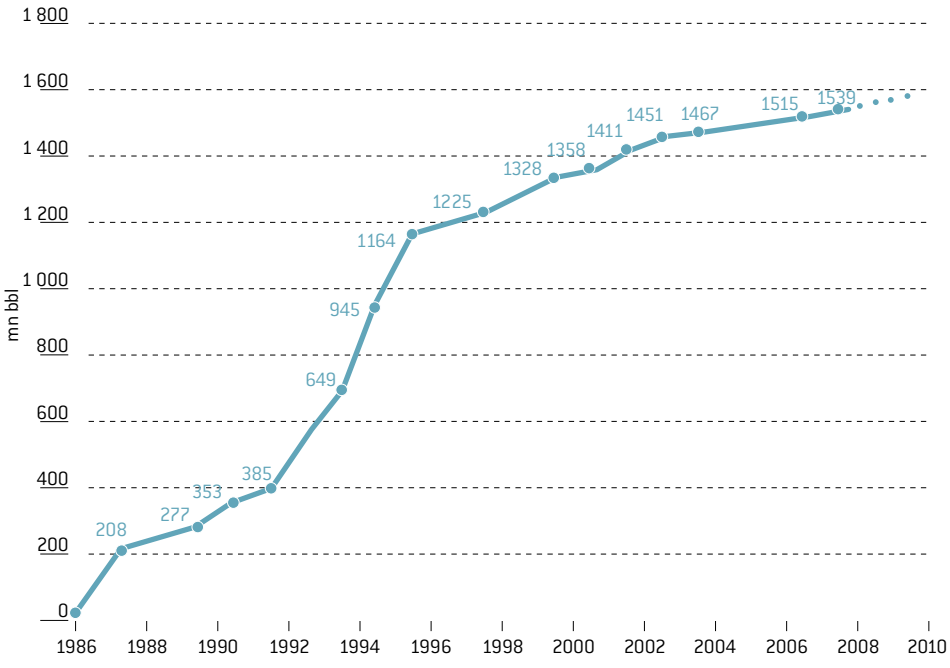
Norwegian petroleum technology has also had a positive effect on the environment. As an example restrictions and new technologies, have reduced CO_2 emissions by 40 mn tonnes since 1994 (Konkraft Report No.5). The enabling technologies for lower emissions have since been implemented in many locations around the world.

THE FUTURE

Technology will continue to be a critical enabler for the Norwegian petroleum industry. The Norwegian Petroleum Directorate (NPD) estimates that there is between 33 and 75 bn boe remaining on the NCS and therefore there is a considerable potential for further value creation (Fig. 1.1). Realizing this potential depends on continued willingness to invest in R&D.

The overall rewards of R&D by far outweigh the initial investment and effort required, and the benefits spread far beyond the initial application.

FIG. 2.1 TROLL OIL RESERVE DEVELOPMENT



Source: Statoil

THE WILLINGNESS TO INVEST IN R&D HAS BEEN A KEY SUCCESS FACTOR FOR THE DEVELOPMENT OF THE NORWEGIAN PETROLEUM INDUSTRY SINCE THE VERY BEGINNING

BOX 2.1: EXAMPLES OF VALUE CREATION BY NEW TECHNOLOGIES

Value creation on the NCS has been dependent on developing, qualifying and applying new technology. The NCS has a reputation for being one of the most innovative petroleum regions in the world:

- Crossing the Norwegian Trench in 1985 to allow gas exports to Emden from Statfjord and also bringing gas to the Norwegian continent allowing value creation in Norway (Kårstø)

- Troll started production in 1996 from the largest structure that has been moved on earth, the 472 m high Troll A concrete platform. Troll developed horizontal precision drilling to produce the 11-13 m thin oil layer underneath the gas, giving an additional NOK 500 bn of value.

- Ekofisk, Statfjord, Oseberg and Gullfaks have produced 10.3 bn boe oil by the end of 2008, due to world class IOR with extensive infill drilling, water and gas injection, time lapse seismic (4D) and reservoir characterization.

- Sleipner started the first offshore Carbon Capture and Storage (CCS) in 1998 and deposited 1 million tonnes CO_2 per year to reduce the CO_2 content from 9% to 2.5% sales specification.

- Development of analytical tools for multiphase flow has made it possible to have long reach subsea wells and subsea to beach solutions.

- Subsea separation pilot at Troll, and later subsea platform (subsea separation, boosting and water injection) at Tordis.

- Ormen Lange started production in 2007 and had to overcome the extreme challenges of steep subsea slopes through the Storegga submarine landslide trench down to 800–1100 m water depth and has the world's longest subsea gas trunk line 1,200 km from Aukra to Easington, UK.

- Norway has the lowest emission to air per produced unit in the world.

The NCS resources could not be developed without a long series of world class technological breakthroughs.

3. CHALLENGES FOR THE NORWEGIAN PETROLEUM CLUSTER

Large areas of the NCS can be considered to be mature in that remaining developments are mostly satellites to and redevelopment of producing fields. The brown field phase introduces new challenges if production is to be sustained. Fig. 3.1 indicates that there is a potential to further reduce the minimum threshold size to make more Norwegian discoveries profitable.

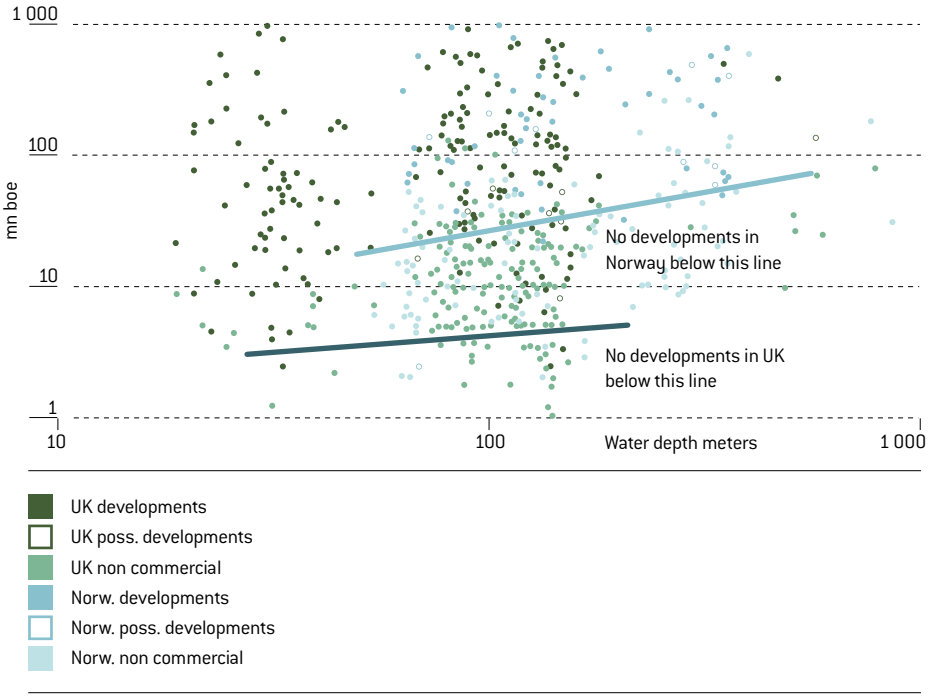
3.1 PRODUCTION AND RESERVE REPLACEMENT

There are substantial resources remaining in the NCS (Fig. 3.2). The large potential comes from increasing the recovery rate from existing fields and from the undiscovered resources. Focus on cost effective technological development and putting new technology to use are vital topics in how this potential can be realized. This requires substantial effort. In addition large areas are still not available for exploitation. The North Sea, Norwegian Sea and Barents Sea all have similar expected resource base with increasing upside potential and uncertainty in the northern areas.

In certain sectors of the NCS the remaining volumes will require more effort in order to be found, developed and produced. The following challenges have been identified:

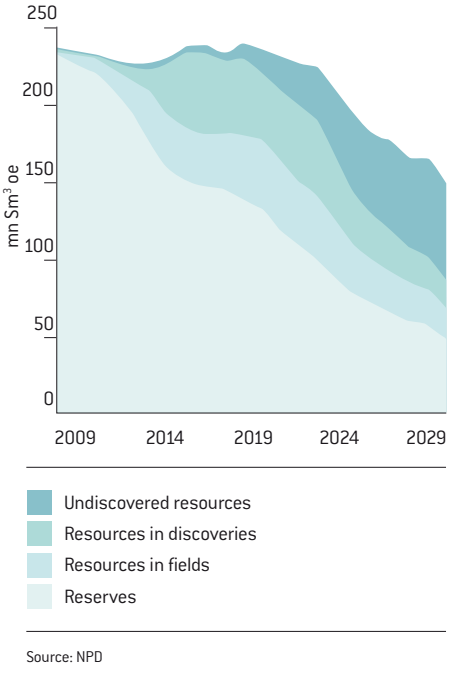
- There are several unexplored areas with potential for new large discoveries, also in areas that are not yet opened like the Barents Sea. It requires more knowledge and technological development to find and make these accessible.
- Technologies that make small discoveries economically viable are a key factor. Several of these minor discoveries depend on an ageing infrastructure approaching decommissioning. This gives a narrow window of opportunity.
- There are more challenging reservoirs (tighter, faulted, multiple zone reservoirs, high temperature and pressure, high CO_2 content etc.) remaining – most of the "easy barrels" have been produced. New technologies to tackle these challenges are needed.
- Smaller discoveries depend on cost effective solutions, which can be achieved through focus on standardization and by clustering of several developments to ensure sustainable volumes. Optimal

FIG 3.1 DISTRIBUTION OF MARGINAL FIELDS AND THE DIFFERENT ECONOMIC THRESHOLDS BETWEEN NORWAY AND THE UK



Source: WoodMackenzie data

FIG. 3.2 REMAINING POTENTIAL NCS INCLUDING UNDISCOVERED RESOURCES



Source: NPD

technology for use across many opportunities must be found.

- Due to smaller field developments it is harder to obtain pilot testing of new technologies and implementation of improved oil recovery (IOR) technologies within a single licence.

The industry's willingness to develop and deploy new technologies to meet these challenges will be essential for realizing this potential both in the mature and frontier areas. Several challenges with potential to lead to technological solutions have been highlighted, however, there is an important timing dimension associated with these challenges.

3.2 ENERGY EFFICIENT AND CLEANER PRODUCTION

It is now more important than ever for Norway to focus on cleaner and more energy efficient production. The petroleum industry is responsible for more than a quarter of the national CO_2 emissions. There is decreasing tolerance for greenhouse gas emissions and discharges to sea. Further reduction will require more engagement and will be more challenging. Two factors have been instrumental:

- a comprehensive and strict regulatory framework and policy instruments

- innovation and deployment of new technologies

The petroleum industry in Norway as well as globally has to look to new areas for exploration to replace reserves and production. As petroleum exploration and production move into frontier areas, it becomes vital to ensure that there is minimum impact on the environment, and that the petroleum industry can coexist with other industries (e.g. fisheries). This requires continued efforts to make improvements that provide safeguards against emissions to air and discharges to water. The main challenges to the petroleum cluster are:

- Focus on energy efficiency has great potential and will contribute to a further reduction of the environmental footprint.

- Further reductions of emissions to air (CO_2, NOx, SOx).

- The industry must assess and calculate the risks of unforeseen incidents and then establish technical and operational solutions to reduce these. The ability to have continued safe operations will be a prerequisite for opening frontier areas.

- There is a need to introduce new environmentally friendly chemicals for both enhanced oil recovery (EOR) and oil spill technology.

3.3 EXPORT OF TECHNOLOGY

New technologies that create value on the NCS often have export potential. It is therefore important to focus on win win opportunities for both increased production / reserve replacement on the NCS and maximizing value creation through export.

The participation of the larger international oil companies in R&D activities in Norway has been important. This has contributed both to the funding of R&D and enhanced the global marketing opportunities for Norwegian suppliers. Future government funding and the tax regime should support the continued attractiveness of Norway as an oil and gas R&D nation. There is a need for a fiscal instrument that covers the risks the supplier companies have when prototyping and executing deployment tests of new technology. Likewise, operators need to be bolder with respect to piloting and putting new technology into use.
It is not only large contractors that operate internationally today. Small and medium size companies are also active in niches. The global players can provide the international network that small companies need in return for new ideas and technology.

3.4 EMPLOYMENT AND COMPETENCE DEVELOPMENT

The increasing complexity to discover and produce hydrocarbons requires more "knowledge" per produced unit. The need for highly educated personnel will therefore continue to increase. It is of vital importance to maintain the high level of competence in the universities and research institutes. In order to recruit young talent to the industry, it is paramount that there is a positive perception of the long-term outlook of the industry. Oil and gas is not in the sunset phase but has a 100 year perspective. Maintaining leading edge capabilities and workforce, requires continuous challenging projects also on the NCS. Active international collaboration between Norwegian and international universities to exchange ideas, create new solutions, etc., must be stimulated.

4. OG21 TARGETS

4.1 VALUE CREATION THROUGH PRODUCTION AND RESERVE REPLACEMENT

To be able to keep Norwegian production at today's level, new reserves must be discovered and developed. OG21's target is to realize NPD's goal for reserve growth: 800 mn Sm^3 oil (5 bn boe) before 2015 (Fig. 4.1). Approximately 75% of this has to come from fields in production (Fig. 3.2). The results so far are that the reserve replacement is behind the planned schedule for reserve growth. The target for reserve growth is still valid.

Fig. 4.1 shows that the replacement rate is falling behind plan and indicates that efforts must be intensified to reach the goal.

4.2 ENERGY EFFICIENCY AND CLEANER PRODUCTION

In a global context, the NCS is the leader in clean and energy efficient production (Fig. 1.4 and 4.2). The goal is to maintain this global position as the oil and gas province with the highest energy efficiency, the lowest level of emissions to air, and lowest harmful discharge to sea per produced unit.

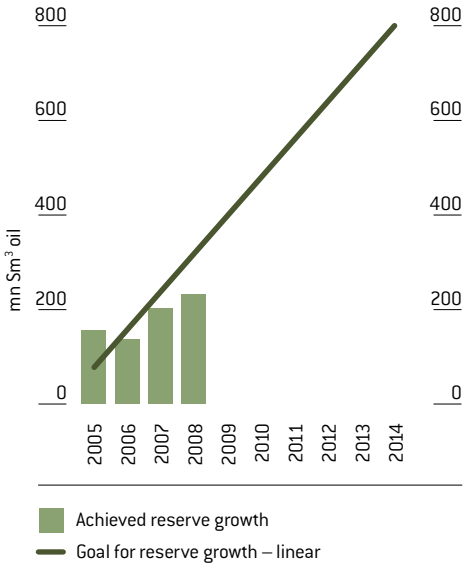
4.3 VALUE CREATION THROUGH EXPORT OF TECHNOLOGY

Growth in oil and gas technology sales from companies in Norway to international markets has been a success and has increased from NOK 15 bn/year in 1995 to NOK 95 bn/year in 2007 (Fig. 4.3). This has developed into an important export element and will secure employment and income even with declining production on the NCS. OG21's target is to realize the goal of NOK 120 bn/year by 2012 set by Intsok. Even if the level was reached in 2008, it is regarded as an ambitious goal since 2008 was an extraordinary year.

4.4 VALUE CREATION THROUGH EMPLOYMENT AND COMPETENCE DEVELOPMENT

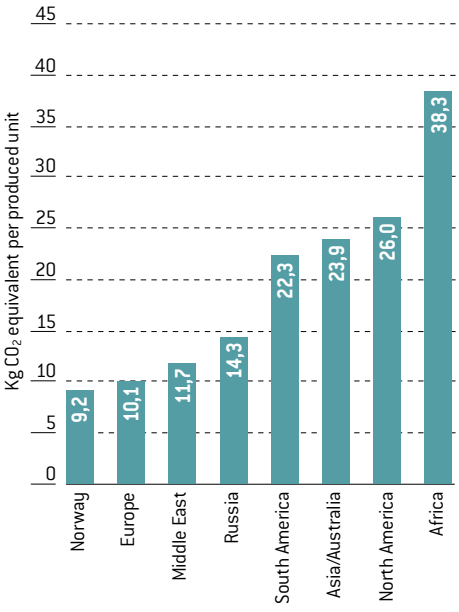
The oil and gas sector is the largest industry in Norway employing 250,000 people directly and indirectly. It is necessary to have a significant and stable home market, and maintain and further

FIG. 4.1 FUTURE EXPECTED PRODUCTION LEVEL AND GOAL FOR RESERVE GROWTH ON THE NCS



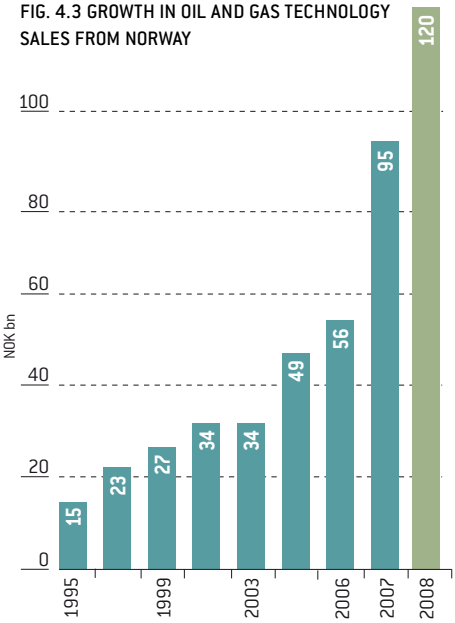
Source: NPD

FIG. 4.2 CO_2 EMISSION PER PRODUCED UNIT, NORWAY VS. OTHER PETROLEUM PROVINCES



Source: OGP and OLF

FIG. 4.3 GROWTH IN OIL AND GAS TECHNOLOGY SALES FROM NORWAY



Source: Intsok/Menon
Source: Intsok/Econ Pöyry

THE GOAL IS TO MAINTAIN THE POSITION AS THE OIL AND GAS PROVINCE WITH THE HIGHEST ENERGY EFFICIENCY, THE LOWEST LEVEL OF EMISSIONS TO AIR, AND LOWEST DISCHARGE TO SEA PER PRODUCED UNIT.

develop the technology and competence of the Norwegian oil and gas cluster, i.e. oil companies, suppliers, research institutes and higher educational institutions. OG21's goal is that the Norwegian Cluster develops and delivers competitive and high tech solutions also in the future. This is the foundation for further developing the successful Norwegian oil and gas technology cluster.

The Norwegian oil and gas cluster's technological competence and the revenue generated from the oil and gas production will be critical for the development, deployment and operation of marine renewable energies like wavepower and wind power and may also have application to other renewable energy technologies.

5. STRATEGIC RECOMMENDATIONS

In order to meet the targets outlined in the previous section, the OG21's strategy is that the research and technology developments should focus on:

- Adding reserves and maximizing production
- Cleaner and more energy efficient production

Successful cooperation between all parties in the Norwegian petroleum cluster (sometimes referred to as the "Norwegian Model") has so far been a success and has been the foundation for the results from the NCS. To continue this and even improve it will be a success factor in the future.

Expert groups called Technology Target Areas (TTA) will further define the technological needs and priorities outlined in section 5.1–5.4. These TTA groups consist of specialists covering the specific technical area. They are led by oil companies' representatives (Lead Parties), to ensure industry engagement and maintain a user-driven focus on technological development. The new TTA structure is further outlined in section 6.1.

5.1 VALUE CREATION THROUGH PRODUCTION AND RESERVE REPLACEMENT

There are four areas of prioritized technology activities in both new and existing fields, which will increase production:

1] Exploration and increased recovery
   a] Play analysis for new exploration models (geology)
   b] Geophysical imaging and interpretation (subsalt, sub-basalt, deep and complex reservoirs, fluid identification)
   c] EOR methods including low energy methods
   d] Reservoir characterization
2] Cost-effective drilling and intervention
   a] Low cost drilling and increased drilling efficiency
   b] Light (rigless) well intervention
   c] Technology for production from discoveries with low permeability and hydrostatic pressure.
   d] Low cost drainage points, including advanced well construction.

3] Subsea production, processing and transportation
   a] Low pressure production: subsea boosting, compression, separation, subsea produced water reinjection, and downhole artificial lift
   b] Long-distance multiphase transport

THE OBJECTIVE IS TO REDUCE THE ENVIRONMENTAL FOOTPRINT OF EXISTING FIELDS AND TO MINIMIZE FOOTPRINT FOR NEW EXPLORATION AND DEVELOPMENT ON THE NCS.

4] Enabling commercial development of marginal resources, through cost-effective development solutions on the NCS
- a] Develop modular technology solutions and standardized interfaces between tools, equipment and software across the industry
- b] Products and sub assemblies optimized for easy installation
- c] Re-use of products and solutions
- d] Standardization in administration, e.g. formats for prequalification and tenders, consistent use of standards and specifications

5.2 ENERGY EFFICIENT AND CLEANER PRODUCTION

The objective is to reduce the environmental footprint of existing fields and minimize the footprint for new exploration and development on the NCS. These goals are particularly relevant for environmentally sensitive areas, as well as areas where the petroleum industry coexists with other industries.

There are three areas of prioritized technology activities, which will reduce the environmental footprint.

1] Reduce emissions of CO_2 (in cooperation with Energi21)
- a] Development and qualification of well technology, pipelines and injection strategies for safe transportation and storage of CO_2
- b] Development of cost-effective ways of increasing the share of renewable energy supply and infrastructure to existing and future petroleum developments

2] Energy efficient production
- a] Improve and optimize energy use (hardware, software and processes), in particular for offshore power generation
- b] Reduce energy consumption in gas transportation and processing.
- c] Subsea or downhole processing

3] Reducing the environmental risk from operational and accidental discharges to sea
- a] Rapid detection systems and oil spill response for coastal areas
- b] New drilling technologies that increase the available time-window for exploration drilling in sensitive areas.
- c] New technology to avoid or reduce the discharge of produced water. Develop greener alternative products to replace existing hazardous chemicals (e.g. hydraulic fluids, process chemicals, all-electric subsea systems)
- d] Development of a holistic eco-system approach towards environmental risk assessment and monitoring
- e] Develop better risk assessment approaches that address the complex interfaces between people, technology and organizations involved in avoiding accidental discharge

5.3 VALUE CREATION THROUGH EXPORT OF TECHNOLOGY

Increasing challenges for international exploration and production create new and growing opportunities for the export of technology from Norway. This will have a positive impact on skills, competence and the level of employment in Norway. International experience and success in broader technology markets will contribute to drive down the unit costs and enable lower cost for redeployment on the NCS.

OG21 will promote strong focus on technologies with significant export potential as well as high potential for increased production or replacement of reserves or cleaner and more energy efficient production on the NCS.

5.4 VALUE CREATION THROUGH EMPLOYMENT AND COMPETENCE DEVELOPMENT

OG21 will contribute to the understanding of the contribution from the petroleum industry to economic development with challenging jobs to be filled in a 100 year perspective.

After 40 years of growth the petroleum cluster in Norway now has an aging work force. It will need to train and develop highly skilled and well educated engineers and natural scientists. There is and will be a large need for more staff particularly at MSc and PhD levels for many years to come. There is a concern that too few students in secondary school study mathematics and physics. It is also a concern that the number of Norwegian applicants to PhD studies is at an extremely low level.

Competence is developed through challenges and high activity both in R&D and field development. It is therefore important that recruitment to R&D and the level of R&D are strengthened. A high level of activity on the NCS will contribute to develop the industry.

6. IMPLEMENTING THE STRATEGY

The purpose of the OG21 strategy is to align the various stakeholders to a common direction and understanding regarding technological challenges as well as technological opportunities. This will ensure a coordinated national effort in research, development, demonstration and commercialization.

6.1 THE ROLE OF OG21

OG21 acts as a catalyst for change and cooperation between key stakeholders (see Appendix 1 – the OG21 mandate as formulated in Norwegian by MPE). OG21 consist of a board established by the MPE and a secretariat reporting to the board. OG21 monitors and highlights new industry trends and swiftly brings them to the attention of its participants. OG21 influences the allocation of resources by advising the MPE who in turn use the Research Council of Norway's petroleum-related R&D programmes to implement the technology strategy. This model secures a link between basic and applied research, via pilot demonstration and qualification to commercialized products.

OG21 stimulates technological collaboration across the whole petroleum industry. The Technology Target Area groups (TTA) remain a key in the implementation of the OG21 strategy. Their work enables efficient and focused technology- and knowledge development. Based upon this strategy, OG21 has revised the TTA structure, reduced the number of groups and focused on the following four themes:

1] Energy efficient and environmentally sustainable technologies
2] Exploration and increased recovery
3] Cost-effective drilling and intervention
4] Future technologies for production, processing and transportation

The establishment of a holistic strategy for Carbon Capture and Storage is to be done in cooperation with Energy21.

Implementing the OG21 strategy will depend on cooperation with relevant organizations such as OLF, Federation of Norwegian Industries, Intsok, the Research Council of Norway and Innovation Norway. The main instrument to present the strategy to the different parties will be the OG21 Forum. The OG21 Forum brings together operators, researchers and the authorities to meet and discuss technological challenges. OG21 is also arranging seminars for discussion of the strategy and how to close identified gaps. OG21 is also playing an active role in promoting awareness of the types of education needed in the industry.

The Technology Target Area teams will detail the OG21 strategy into sub-strategies that give clear prioritizing of technology needs. Each Technology Target Areas addresses the whole value chain, from education to R&D, incl. piloting. TTA members are from universities, research institutes, supply industry, oil companies and, where appropriate, the authorities.

Each TTA will use the strategy themes and the priorities that OG21 has developed, to identify gaps that need to be closed. Their expertise will be used to define sub-strategies within the overall focus areas. Special emphasis will be placed on cooperation between the TTAs to develop integrated solutions. This will require enhanced inter-disciplinary communication. The TTA groups will arrange workshops/seminars where the strategy is presented to the whole petroleum cluster.

6.2 THE ROLE OF THE GOVERNMENT

Public funding should primarily focus on education, basic science, long-term technology development and the stimulation of technology pilots. Short-term challenges will to a larger extent be the responsibility of the industry. The funding should focus on the fundamental research element of the value chain and provide risk reductions for important technologies that otherwise might not be developed and matured.

Governmental engagement is important to stimulate research and develop high levels of competence is executed in Norway. Without incentives the industry may go abroad with their research activities. Increasing international competition makes it necessary for the Government to show a long-term commitment and through that, provide support to the supplier industry based in Norway.

6.3 THE ROLE OF THE RESEARCH COUNCIL OF NORWAY (RCN)

The Research Council of Norway serves as a national strategic body for research, as a research funding agency and a bridge between Norwegian and international research. The RCN is responsible for research of national importance such as the oil and gas sector. The financial instruments of the RCN are the main sources for Governmental R&D funding to this sector and cover basic and applied science as well as innovation and demonstration projects. The large-scale strategic programme PETROMAKS, the demonstration programme DEMO2000 and several Centres of Excellence and Centres of Innovation are set up to address the challenges and potentials within the Norwegian oil and gas sector. The profile of the strategic research funded by the RCN mirrors the priorities of the OG21 strategy and ensures a coordinated effort between universities, the research institutes and the industry. In addition, the RCN's funding of long-term basic science, infrastructure for science and PhD and post.doc positions are key building blocks with significant impact for developing petroleum-related products, processes and services. R&D within fields like materials- and nanotechnology, maritime technology, mathematics, geophysics, geology and chemical technology are examples of this.

The RCN-funded activities will follow-up OG21's strategy as follows:

- Provide input to the Government on the profile and structure of R&D to meet the OG21 goals
- Give advice to the Government on funding needs for basic research, applied research, innovation and demonstration activities
- Ensure focus at the universities on recruitment and high quality long-term basic science of relevance to the oil and gas sector
- Ensure focus at the research institutes on applied science and cooperation with the industry.
- Provide support to industry-driven projects
- Facilitate cooperation between Norwegian and international research
- Ensure cooperation and coordination among various stakeholders involved in petroleum R&D.
- Provide statistics and analysis of R&D in the oil and gas sector

6.4 THE ROLE OF THE RESEARCH INSTITUTES AND UNIVERSITIES

Research institutes and universities are an important part of the Norwegian petroleum cluster. The institutes have a special focus on research for the medium and long-term needs of the industry, while the universities have the main responsibility for education and basic research. In order to respond to the OG21 challenges it is important to focus on:

- Education and recruitment of petroleum research scientists
- Build strong national research teams that are internationally competitive
- Build, upgrade and maintain a world class research infrastructure
- Cooperation with industry in competence programmes and applied research as well as testing and piloting

A prerequisite to enable the research institutes and universities to carry out world class research and educate and train petroleum personnel is that the Government provides predictable funding and framework conditions. The Norwegian cooperation model is widely recognized, but we can gain even more through closer cooperation between the institutes and universities. Centres for Research-based Innovation (SFI) and Norwegian Centres of Excellence (SFF) are examples of strong national teams, but further funding is required in order to maintain, strengthen and build up groups that are able to develop new technology in cooperation with oil companies and the supplier industry. Access to world class research infrastructure is important for developments in all the Technology Target Areas, and the cooperative use of large scale infrastructure is important to secure cost efficient and innovative research.

Oil companies and suppliers will only carry out their research and development in Norway as long as they benefit from well equipped and strong research organizations, highly educated personnel and sound governmental research funding. In order to keep world class research institutions, Norway must maintain competitive funding models.

THE INTENTION WITH THE OG21 STRATEGY IS TO ALIGN THE VARIOUS STAKEHOLDERS AROUND A COMMON DIRECTION AND AMBITION REGARDING TECHNOLOGY CHALLENGES AS WELL AS TECHNOLOGY OPPORTUNITIES. THIS WILL ENSURE A COORDINATED NATIONAL EFFORT ON RESEARCH, DEVELOPMENT, DEMONSTRATION AND COMMERCIALISATION.

6.5 THE ROLE OF INDUSTRY

To achieve OG21's strategic goals an active participation from the industry is needed. There are four areas of particular importance:

- Using the OG21 strategy as a reference document for internal company technology strategy
- Willingness to actively contribute in the TTA work
- Willingness to provide pilot opportunities/sites
- Pro-actively seek technology collaboration opportunities between oil companies, suppliers and research institutes/universities

This will ensure that efforts in the oil and gas cluster are concentrated to close the technology gaps identified, and should result in business opportunities both short and long term

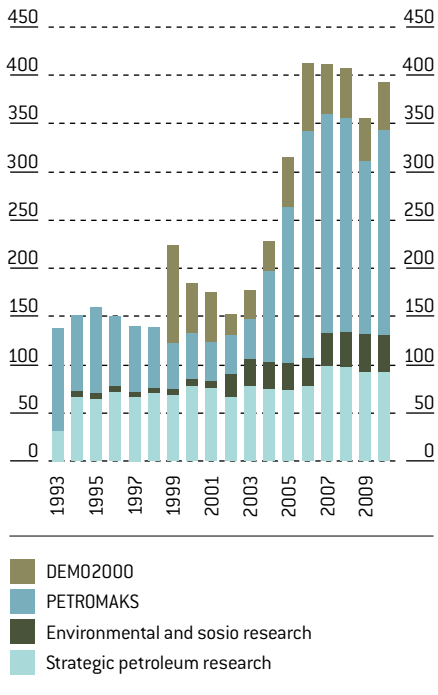
7. FINANCING

7.1 RESEARCH AND DEVELOPMENT

On the NCS, the petroleum industry's ability to meet its challenges and deliver pioneering technology within the new OG21 strategy themes will depend on a predictable, long-term commitment from the whole petroleum cluster. Historically the Norwegian Government's long-standing commitment and emphasis on running R&D activity in Norway has given a corresponding willingness by the Norwegian petroleum industry to invest in and test new technology. Public R&D funding is a precondition to attract international capital and international oil companies to execute R&D in Norway.

Figure 7.1 shows the public funding of petroleum-related R&D since 2000. OG21 has previously recommended an increase to NOK 600 - 800 mn/year. This is approximately NOK 250 mn higher than today's level. Compared to the state revenue of NOK 290 bn (2009 estimate, Ministry of Finance) annually from the oil and gas sector NOK 350 mn/year, represents as little as 0.1 per cent

FIG. 7.1 DEVELOPMENT OF GOVERNMENT FUNDING TO PETROLEUM RESEARCH



Source: RCN

To increase the R&D funding and increase the industrial engagement, OG21 also recommends that the R&D (FoT) percentages/bands as defined in the licence accounting agreement are increased.

In a global context there will be increasing focus on national competence development, and OG21 recommends that public funding of higher education and basic research is increased.

7.2 PILOTING

It is believed that most of the giant fields on the NCS have been developed. Until recently these fields have carried much of the larger successful piloting of new technologies. The current portfolio of many small discoveries requires a new model for technology maturation. Technology development outside large development projects needs to be stimulated using public incentives. Companies will perform technology development where the framework conditions are considered to be the best. Norway has enjoyed internationally competitive incentives and financial tools for demonstration programmes (e.g. DEMO2000) which has attracted competence and private capital to address and solve NCS challenges. This has resulted in new technology which has greatly increased the recovery of hydrocarbons on the NCS, and in addition there has been considerable value creation in Norwegian companies through the export of technology.

Today the frame work conditions are far less attractive. Not only because it is difficult to get financing through projects (small fields), but more due to the fact that public funding is very low. This means that private capital and competence (which is scarce) are prioritized elsewhere, delaying solutions which would benefit increased production on the NCS. This may result in lost reserves due to factors such as aging infrastructure (ref Konkraft report no. 2).

OG21 recommends that governmental funding to demonstrate prototypes and execute pilots is greatly increased to a level of NOK 150–200 mn. It is vital that this increased effort does not make a negative impact on the governmental funding of research.

An alternative proposal is capital funding support systems, like the GIEK model (Guarantee Institute for Export Credits) as used in Norway or the establishment of similar incentives, e.g. financial mechanisms made available to companies for the execution of piloting. If the technology becomes a success, the support is paid back while it is deductible in case of failure. This could reduce the risks, especially for small and medium-sized suppliers.

Another possibility is to establish a mechanism to stimulate piloting in the different licences like the R&D (FOT) in the licence accounting agreement or other mechanisms.

OG21 recommends that the different alternatives are further evaluated by the Government.

THE CURRENT PORTFOLIO OF MANY SMALL DISCOVERIES REQUIRES A NEW MODEL FOR TECHNOLOGY MATURATION. TECHNOLOGY DEVELOPMENT OUTSIDE LARGE DEVELOPMENT PROJECTS NEEDS TO BE STIMULATED BY USING PUBLIC INCENTIVES.

APPENDIX 1
OG21 MANDATE

FORMÅL MED OG21

Formålet med OG21 er å sikre en effektiv og miljøvennlig verdiskaping fra norske olje-og gassressurser gjennom et samordnet engasjement i petroleumsklyngen innenfor utdanning, forskning, utvikling, demonstrasjon og kommersialisering. OG21 skal inspirere til utvikling og bruk av bedre kompetanse og teknologi.

HOVEDOPPGAVE FOR STYRET

OG21-styret skal utarbeide en nasjonal teknologistrategi[3] som skal være retningsgivende for næringen og myndighetenes samlede teknologi- og forskningsinnsats. Strategien skal bidra til:

- effektiv og miljøvennlig verdiskaping på norsk sokkel i flere generasjoner
- kompetanse og industri i verdensklasse innenfor petroleum

Strategien skal skape en helhetlig tenkning rundt satsingen på mer effektiv petroleums-teknologi- og kunnskapsutvikling gjennom å koble myndigheter, næringsliv og forskningsmiljøer nærmere sammen.

Det er også et mål å bidra til økt nasjonal satsing på FoU for å kunne utvikle internasjonalt konkurransedyktig kompetanse og næringsliv innenfor petroleumsektoren.

STYRETS OPPGAVER FOR ØVRIG

- beskrive framtidens muligheter og utfordringer på norsk sokkel fra et økonomisk, miljømessig og samfunnsmessig perspektiv
- definere hvilke teknologiutfordringer og teknologi-gap norsk kontinentalsokkel står overfor
- identifisere virkemidler for å lukke teknologi-gapene og øke eksportverdien
- etablere arbeidsgrupper på de prioriterte innsatsområdene og følge opp at disse konkretiser, spisser og handlingsretter strategien, herunder utvikler delmål innenfor innsatsområdet
- kommunisere og forankre strategien hos relevante aktører og stimulere til samhandling i petroleumsklyngen
- bidra til operasjonalisering av strategien gjennom samarbeid med utførende organer som OLF, Norsk Industri, Innovasjon Norge, INTSOK og Forskningsrådet
- gi råd til OED i henhold til OG21-strategien og delstrategiene og peke på områder hvor offentlig finansiering er avgjørende
- profilere Norge som et internasjonalt senter for olje- og gassteknologi
- arrangere et seminar hvert annet år for å formidle OG21-strategien og de prioriterte innsatsområdene (OG21 Forum)
- revidere strategien hver 2-3 år og i den sammenheng evaluere oppnådde resultater i strategiarbeidet
- samarbeide med E21, bl.a. om en helhetlig strategi innen CO_2-fangst og -lagring.

3] Innenfor OG21s mandat ligger oppstrøm-, midtstrømaktiviteter – inklusive CO_2-transport og -lagring. Energieffektiviseringstiltak for disse verdikjedene ligger også innenfor mandatet til OG21. Alternativ energi slik som vind-, bølge-, tidevann, geotermisk-, biomasse-, saltvann og hydrokraft ligger ikke innenfor mandatet til OG21.

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