OIL AND GAS FOR THE 21ST CENTURY - OG$_{21}$

Compatibility between Norwegian petroleum activities and environmental stewardship

A case for boosting mainstream petroleum research funding

Brochure

OG_{21} – OIL AND GAS FOR THE 21ST CENTURY

The OG_{21} Task Force is an advisory body established by the Norwegian Ministry of Petroleum and Energy. Its task is to formulate a national technology strategy to help the Norwegian petroleum industry add value, gain competitive advantages, and promote a co-ordinated and focused approach to research and development (R&D). The largest petroleum technology programmes – **PETROMAKS** and **DEMO 2000** – are funded by the Ministry according to OG_{21} recommendations and are administered by the Research Council of Norway (RCN).

ABOUT THIS BROCHURE

This brochure is a condensed version of a more comprehensive booklet commissioned by OG_{21}. The latter contains more detailed arguments and fuller examples of each technology. The author takes no responsibility for any controversial statements.

COMMON ABBREVIATIONS

CO_2 – Carbon dioxide
NCS – Norwegian continental shelf
NOK – Norwegian kroner
R&D – Research and development
RCN – Research Council of Norway

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PETROMAKS

The main objective of the **PETROMAKS** R&D programme is to help facilitate the sustainable production of oil and gas from the Norwegian continental shelf (NCS) far into this century. Emphasis is placed on basic research and innovative technology development for the benefit of the service and supplier industry, whilst ensuring sound management of Norway's natural resources. The programme supports an extremely wide variety of research initiatives organized within:

- Environmental technology for the future
- Exploration and reservoir characterization
- Enhanced recovery
- Cost effective drilling and intervention
- Integrated operations and real time reservoir management
- Subsea processing and transportation
- Deepwater, subsea and arctic production
- Gas technology
- Health, safety and environment

DEMO 2000

The main objectives of **DEMO 2000** are to ensure long-term competitiveness and continued profitable development of NCS petroleum resources, and to develop industrial products, systems and processes for the global offshore market. Emphasis is placed on demonstrating the commercial viability of new technologies. The programme also attracts supplementary funding from oil companies and contractors within:

- Subsurface technology
- Drilling and well technology
- Multiphase flow
- Deepwater technology
- Gas utilization
- System integration
- E-field development
- Arctic technology
- Technology upgrades

Both the industry and the Norwegian authorities recognize that innovative technology is the single most important factor for sustaining the nation's oil and gas activities in an energy-efficient and environmentally acceptable fashion.

MAKING THE CASE

A boost to innovative petroleum research funding is needed to pursue Norway's oil and gas activities in a sustainable manner and provide the capital to accelerate alternative energy solutions

Petroleum industry revenue has contributed greatly to the country's economic growth, development of the welfare state, and the Government Pension Fund – Global. Moreover, it is believed that only 38 per cent of the expected total oil and gas resources beneath the NCS have been produced so far.

The potential for further wealth creation is thus considerable, assuming that the necessary knowledge, skills and technology are forthcoming.

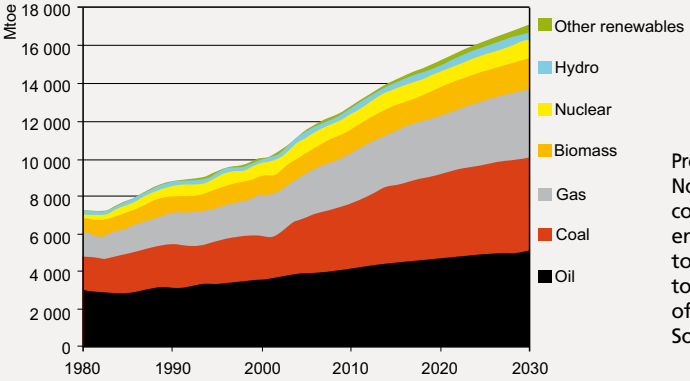
It is therefore a cause for concern that the 2009 funds allocated to the RCN to support its main petroleum R&D programmes – PETROMAKS and DEMO 2000 – have been reduced by about 20 per cent. This makes it difficult to meet present technological challenges, let alone address those of the more distant future.

There is also a widespread perception that the Norwegian petroleum industry is a major environmental offender, at odds with the nation's wish to be at the forefront of clean energy alternatives and de-carbonization solutions.

Nevertheless, it is felt that government funding of the main petroleum programmes is underdimensioned, considering the country's future economic wellbeing and the petroleum industry's drive towards sustainable energy production. Moreover, some 80 per cent of the world's energy demand may still have to be met by fossil fuels for several decades to come, even though alternative energy will undoubtedly make a greater impact.

Surely the massive investment needed to realize alternative energy solutions and their infrastructures must lie in the continued wealth generated by the Norwegian petroleum industry.

The aim of this brochure is to suggest that: (i) the pursuit of 'cleaner and more energy-efficient petroleum production' can be compatible with and complementary to the pursuit of 'alternative energy solutions'; and (ii) that both endeavours deserve more even-handed treatment in terms of government support and funding.



Projected world energy demand. Note that by 2030 the predicted contribution from alternative energy sources still amounts to less than 15%, as it does today. Mtoe - million tonnes of oil equivalent.
Source: © OEDC/IEA.

National petroleum industry contributions

- To date, the petroleum sector has generated net revenues to the State of about NOK 3750 billion
- The value of the Government Pension Fund (Global) at the end of 2008 was NOK 2275 billion
- The petroleum sector's share of state revenues in 2008 was about one third; its share of the Gross National Product (GPD) was about one quarter; and its share of total exports was one half
- Norway is the world's fifth largest oil exporter and is vying with Canada to be the world's second largest gas exporter

Technological challenges ahead

Improve oil recovery from producing fields (average recovery is about 46 per cent)

Discover new accumulations (including those close to existing infrastructure)

Conquer frontier areas (e.g. ultra deep-water margins and those in northern waters)

Address more complex geology and reservoir characteristics

Continually improve upon today's best environment protection practices

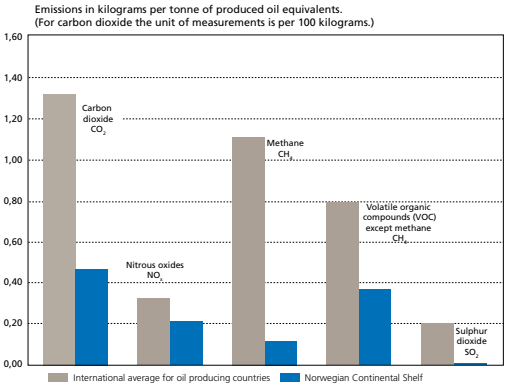
Increase energy efficiency

Remain competitive in the international petroleum arena

ENVIRONMENTAL TECHNOLOGY TODAY

Norway's peerless leadership in petroleum-related environmental technology provides a solid foundation for the cleaner production of fossil fuels – at least until alternative energy solutions are sufficiently mature to play a more dominant role

Norway's excellent standing is partly demonstrable by comparing emissions to air on the NCS versus averages for other producing countries. The most impressive result concerns carbon dioxide (CO_2) – the chief offender in strengthening the greenhouse effect. Note that CO_2 emissions from NCS activities are far less than the international average.



A comparison of emissions to air between the NCS and other producing lands. The emissions largely comprise exhaust gases from gas combustion in turbines and motors, gas flaring (burning off non-producible gas) and diesel consumption by various facilities. Source: NPF/OLF.

Some of this success is attributable to pioneering technology at the North Sea Sleipner gas field, where CO_2 is stripped from the gas and injected into a deeply-buried saline aquifer for indefinite underground storage. About 1 million tonnes of compressed CO_2 have been injected annually since 1996 without any detectable leakage.

The entire process - known as Carbon Capture and Storage (CCS) – has attracted considerable international interest. In 2005 the IPCC (Intergovernmental Panel on Climate Change) suggested that CCS holds considerable potential as a part of the world's climate protection measures.

Other environmental breakthroughs have come from the desire to eliminate marine pollution in conformance with the Norwegian authorities' 'zero-harmful discharge to sea' policy. There has also been a dramatic drop in the use of potentially hazardous chemicals, and much progress has been made in oil-spill preparedness, detection and response. Energy consumption has been reduced by improving energy efficiency, an area in which the Norwegian petroleum industry is at the very forefront.

The North Sea Sleipner gas field. The Sleipner T gas treatment installation (right) is linked by a bridge to the Sleipner A platform (left). Source: Dag Myrestrand/StatoilHydro

FIELDS	ENERGY EFFICIENCY
Ekofisk II	Changes made in the Ekofisk II development include turbine upgrades, which resulted in an annual carbon cut of 980 000 tonnes (1998)
Balder	Improved compressor regularity and flaring procedures reduced the annual carbon cut by 100 000 tonnes (2000)
Gjøa	Partial power supply from shore for a floating installation avoids an annual emission of 250 000 tonnes of carbon dioxide
Kvitebjørn	Exceptionally high pressures in the Kvitebjørn field are being used to separate oil from gas and transport the gas to shore
Ormen Lange	The introduction of electric, variable speed drives for gas turbine compressors allows them to run at optimum conditions; this results in significant energy savings as well as zero emissions of CO_2 or nitrous oxides (NO_x) (e.g. pipelining untreated wellstream gas from the Ormen Lange field to the Nyhamna gas processing plant)
Snøhvit	Snøhvit's liquefied natural gas (LNG) plant is the most energy efficient in the world and the first to introduce CCS from the start of production, thereby avoiding emissions of 700 000 tonnes of carbon dioxide per year when at full capacity
Tordis	Subsea compression and the separation of produced water from a wellstream makes production more energy efficient, especially when the water is disposed of by pumping it into a suitable, underground saline aquifer (e.g. at the Tordis field)
Valhall	Full power supply from shore avoids 250 000 tonnes of carbon dioxide per year
Åsgard	The Åsgard B-platform has become 30% more energy efficient during the last decade and has an annual carbon cut of 30 000 tonnes through improved compressor efficiency

ENVIRONMENTAL TECHNOLOGY TOMORROW

Imagine the day when sustainable petroleum activities have no visual impact; when the probability of marine pollution is almost zero; when greenhouse gas emissions are largely stored below ground or used to improve oil recovery: this day may be closer than you think with the advent of new technology

The present transition from sea-surface to seabed oil and gas processing could eventually culminate in fully-fledged subsea field centres capable of reproducing most platform-based operations.

This would also facilitate ultra-deep water field developments and pave the way to Arctic sub-ice production, when coupled to ultra long-distance wellstream transport and pressure boosting stations.

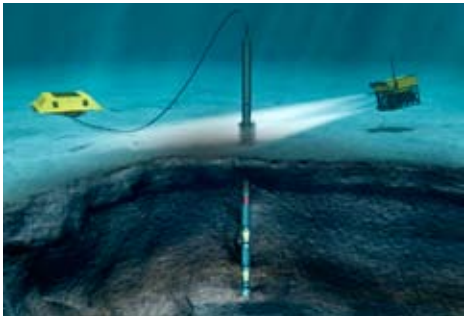
Specific major developments are anticipated in local power supply, downhole sand and water management to facilitate seabed processing, and satellite-based wireless communication.

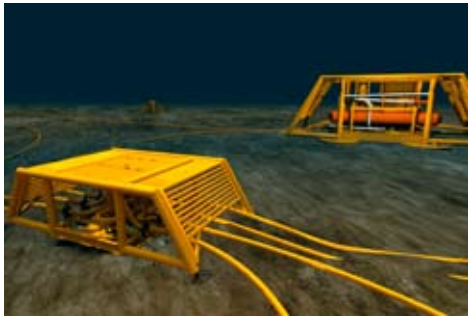
The day may also come when permanent communities of subsurface robots will supersede today's requirements for subsea well intervention, maintenance and repair, as well as gathering new information for improving recovery and enabling unmanned operations in challenging geographical areas. Indeed, total subsea operations, field development and long-distance well-stream transport may become the hallmarks of harmless, inconspicuous exploitation.

Accidental leaks and spills could almost become a thing of the past or will be detectable by sophisticated sensors, prompting immediate and effective remedial action.

Carbon dioxide will be seen as a potential creator of wealth rather than a major air pollutant. This goal is best realized by developing a complete commercial CO_2 value chain, where the CO_2 ends up in underground saline aquifers or is injected into suitable oil fields to improve recovery.

Some of this may never be fully realized, but many of the RCN's PETROMAKS and DEMO 2000 projects are headed this way.





Left: Badger Explorer. Source: Badger Explorer AS. Right: Subsea separation, boosting and injection system (background) and well template (foreground) at the Tordis field. Source: FMC Kongsberg Subsea/StatoilHydro.

RCN EXAMPLES	AIM AND (ENVIRONMENTAL BENEFITS)
Rig-less drilling (Badger Explorer)	A disposable, autonomous rig-less exploration tool (phasing out large drilling rigs; no discharge to sea; potentially no emissions to air if power is supplied by onshore renewable energy)
Seabed drilling rig	A robotized, remotely-controlled seabed drilling rig (marine ecosystems protected from surface water and ice cover pollution; surface vessels minimized; no surface rigs)
Seabed production	Seabed production, processing and long distance wellstream transport (underground disposal of produced water; reduction in chemicals; greater energy efficiency)
Subsea electrification	Increasing onshore-to-offshore electrical power via seabed cables (facilitating new, environment-friendly subsea fields far from land and eliminating polluting gas turbines)
'Natural' environmental monitoring	Combining physical, chemical and biological sensors (organisms) (for real-time offshore pollution monitoring – the Biota Guard system)
Oil spill detection	Mapping oil spills using ship-borne infra-red cameras capable of functioning in dark, rough seas – the SECurus system (oil thickness data transferred in real-time to an on-screen map enabling counter measures to be directed to the most critical locations)
Oil spill remediation	A new NorLense system for oil spill recovery in bad weather, near coastlines, and where there are difficult currents (innovations include a boom designed to function with a separator and a skimmer to handle oil that has been mixed with seawater by breaking waves)
$C0_2$-based IOR	Development of CO_2-based improved oil recovery (IOR) methods for depleted fields requiring gas-based solutions

TECHNOLOGY SYNERGY

Despite what the sceptics may say, the petroleum industry is a significant player in developing alternative energy solutions, many of which are in areas where the transfer and adaptation of skills and technology are most natural and desirable

From what has been said so far, future Norwegian petroleum activities show considerable promise of being carried out in an increasingly energy-efficient and environmentally acceptable fashion, thus blurring the boundary between what today is deemed polluting versus non-polluting energy sourcing. And despite the taunts of 'green-washing', many oil companies are investing heavily in alternative energy to meet projected demand and to conform to challenging environmental regulations.

What's more, the two approaches are beginning to converge in areas where skills and technology are inter-changeable or readily adaptable. The following, limited examples are pertinent to Norway, highlighting alternative energy capture which is closely linked to offshore petroleum engineering and downstream refining capabilities.

Offshore wind, wave and tidal power

StatoilHydro has interests in the world's first tidal power turbine which delivers electricity to the onshore grid, and has constructed the world's first full-scale floating wind turbine *(Hywind)*. Hywind contains a 2.3 MW wind turbine attached to the top of a Spar buoy and is designed to operate in deep water where the wind strengths are greatest and hindrance to coastal shipping is least. StatoilHydro also invests in the first commercial wave power plant – *Pelamis*, which is now in operation off the coast of Portugal.

In the realm of offshore *hybrids*, Ormonde Energy is developing an offshore wind farm to be run in conjunction with two nearby depleted gas fields: the remaining gas in these fields will serve as a back-up energy source for electricity generation when the wind dies down. Shell's hybrids are offshore, zero-emission gas production platforms powered entirely by wind and solar electricity. These *monotowers* enable the production of small, standalone gas fields in the southern North Sea whose exploitation would otherwise be uneconomical.

Geothermal energy

Norway's interest in geothermal energy is rather modest. However, it may increase with the possible discovery of additional high-pressure/high-temperature reservoirs and the country's proximity to Iceland. The technology for producing geothermal energy from underground sources is very similar to that used in oil and gas operations. Norway's leadership in innovative drilling technology could prove to be extremely beneficial.

Clean fuels of the future

The petroleum industry has taken the lead in the production of biofuels by exploiting its vast experience in gas processing and conversion, refining, and transport fuel distribution. Accepting the criticism that 1st generation biofuels compete with food stuffs, the answer may eventually lie in the development of 2nd generation biofuels, which include the production of ligno-cellulosic ethanol and bio-butanol using biomass waste products; and Biomass-to-Liquids conversion (BtL), where non-food materials such as wood chips are gasified and converted into a synthetic fuel which can be blended with diesel. The BtL process is similar to the petroleum industry's Gas-to-Liquids (GTL) conversion process, which largely produces clean-burning synthetic diesel.

The industry is also exploiting its downstream expertise in the quest for the 'ultimate fuel'. *Hydrogen**, for example, produces zero-harmful emissions when used in fuel cells that generate electricity for automotive transport. It is primarily produced from oil or natural gas by partial oxidation or steam reforming, by methanol reforming, and by the electrolysis of water. Hydrogen can also be produced from renewable energy sources, including biomass. Detractors apart, the use of hydrogen is still potentially very attractive for reducing greenhouse gas emissions, albeit in the somewhat distant future.

(*Note that hydrogen, *sensu stricto*, is an energy carrier – not an energy source.)

Photo collage: Upper left – Pelamis, source StatoilHydro; lower left, tidal turbine, source StatoilHydro; lower centre, Hywind, source StatoilHydro; right, Shell monotower powered by electricity generated by wind turbines and solar panels, source, Shell Graphic Services.

THE WAY FORWARD

A boost in mainstream petroleum R&D funding is advocated to help realize the government's vision of a sustainable petroleum industry and to generate sufficient petroleum revenue to support the transition to alternative energy

Gathering all of this together, it is suggested that:

- The potential for further wealth creation on the NCS is immense, especially if new prospective areas are quickly opened up in the north and efforts are intensified to increase recovery from fields already in production.
- The Norwegian petroleum industry is already an international role model for environmental stewardship.
- The industry's environmental achievements augur well for the production of increasingly energy-efficient, sustainable fossil fuel, which may eventually compete favourably with alternative sources of energy until the latter are mature enough and sufficiently cost-effective to take over.
- The petroleum industry is also contributing to the development of renewable energy by synergistically combining appropriate knowledge and technology with 'new energy' initiatives.
- All of this can only be fully realized by boosting government-sponsored *petroleum technology* R&D alongside more specific initiatives to stabilize climate change.

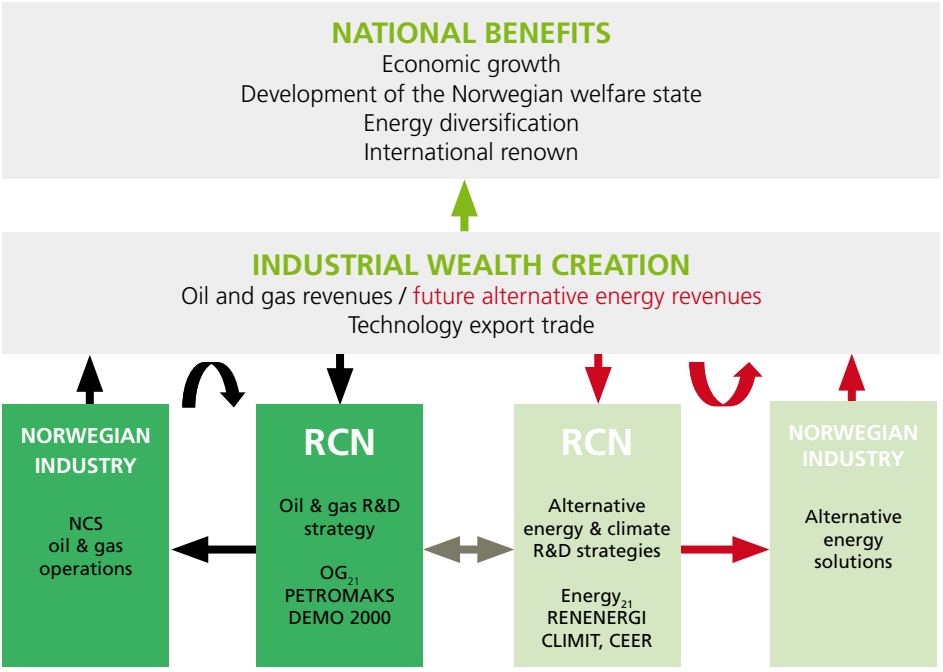
The key questions are: how is this best achieved in practice; and from where is the money coming?

A simplified dual model approach is offered as a solution.

The black arrow loop: Research advances made through the RCN's OG_{21} PETROMAKS and DEMO 2000 programmes will help the petroleum industry to produce more oil and gas while using less energy and protecting the environment. This, in turn, will help to generate substantial oil, gas and export revenues to sustain Norway's economic interests and to support further petroleum research.

The red arrow loop: A generous proportion of this oil wealth can also be used to offset the massive cost of accelerating alternative energy solutions, stabilizing greenhouse gas concentrations, and building a strong alternative energy supplier industry. In the longer-term, research advances made through the RCN's RENERGI (Clean energy for the future) and CLIMIT (CCS) portfolios will also help to generate significant revenue.

In this way, alternative energy solutions may reduce the country's economic dependence on fossil fuels and even supersede the petroleum industry in the far distant future.



Dual model approach. The double-headed arrow depicts synergy. $Energy_{21}$ ($Energi_{21}$) – Energy for the 21st century; RENENERGI – Clean energy for the future; CLIMIT – Carbon capture and storage (CCS); CEER – Centres for environment-friendly energy.

In conclusion, the fast-track development of an even stronger petroleum industry is deemed the best foundation for developing a balanced, multi-faceted energy cluster, until the day comes when alternative energy may predominate. This is a potential win-win situation for Norway.

Increased government expenditure on the main RCN petroleum technology programmes will help to achieve this ambitious goal.

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