Research and development

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8.1 Research and development

The energy sector is characterised by a series of challenges related to safe supply, power and energy balance and greenhouse emissions. Public research efforts are necessary in all these fields to ensure satisfactory developments and value creation for the sector through technological and organizational solutions. In addition, research and development are also of critical importance for business development within this sector.

With limited resources available, both financial and in terms of researcher capacity, priorities must be set for the research effort. Norway focuses in particular on areas in which Norwegian research environments have specialist expertise and standing, in which Norwegian businesses and other user environments have special competencies to apply the research results, in which Norwegian energy resources provide us with a special standing in the long-term, and in which there are particular Norwegian research needs.

The Research Council of Norway is responsible for administering most of the public funding available for energy research. The funds are used for basic research, industrial research and societal research. Basic strategic research is intended to lay the basis for more market-related projects in cooperation with industry and other users. The commercially orientated research is user-managed to ensure that the results can be adopted if they are technically successful. Users also contribute the bulk of project financing. Societal research focuses more strongly on energy policy and international agreements.

Part of Norway's research effort in the energy sector is the responsibility of the Norwegian Water Resources and Energy Directorate (NVE). This primarily concerns activities relating to energy and watercourse administration.

In addition to the national research activities, Norway and Norwegian research environments participate actively in a series of international energy research collaborations.

The Ministry of Petroleum and Energy has appropriated about NOK 202 million for research in the energy field during 2006. Of this, NOK 175 million is allocated to the Research Council of Norway, NOK 16.9 million to NVE and 10.4 million to cover Norwegian commitments in international research collaborations within the energy sector. In addition, NOK 11 million is allocated for participation in EU projects.

8.2 Research programmes

8.2.1 Renergi – clean energy for the future

The major part of energy research is organised within the Research Council's program Renergi – Clean energy for the future. It had a 2006 budget of NOK 100 million from the Ministry of Petroleum and Energy. The total Renergi budget for 2006 is about NOK 145 million.

This programme covers a wide range, from basic research and expertise development focused on institutions and universities, through applied research and technological development with the main focus on industry, to social science research as a basis for policy formulation. It is thereby intended to facilitate research both for the long term – a 30-year perspective – and in the short term – over the next five to 10 years.

The main aim of Renergi is to develop knowledge and solutions as the basis for environment-friendly, economically rational and safe administration of Norway's energy resources, and internationally competitive industrial

development relating to the energy sector. Emphasis is placed on building up competent and robust R&D institutions which can serve the industry and the authorities in a satisfactory way.

The professional areas covered by Renergi are described below.

Renewable energy production

Norwegian energy companies, energy industry suppliers and research institutions are strongly placed in the hydropower sector. Expertise in this area should be further enhanced with a view to future operation and development of the system. At the same time, research should support export opportunities available to Norwegian industry.

Norway is also plentifully endowed with renewable energy resources, such as wind, solar, biological, and marine sources – including waves, salt gradients and tides. These resources are substantial, so the challenges will primarily to be through R&D to develop technology to produce at competitive costs.

Natural gas

Natural gas is an energy resource which puts Norway in a special position internationally through production solutions and exports. Very little domestic use is made of natural gas. Renergi will focus on new possibilities for energy production and business development in connection with increasing domestic use of natural gas, for example related to new technology for direct use of natural gas including fuel cells and decentralised cogeneration (combined heating and power production).

Hydrogen

Currently, there are extensive and increasing investments in hydrogen as the international energy carrier. This is being driven first and foremost by considerations of the security of energy supply, the environment and business development opportunities. This subject has also attracted increased attention in Norway. See chapter 8.4.

The visions described for hydrogen involve a very lengthy perspective. Consequently, the commitment in Renergi will be long term and place great emphasis on building up basic expertise.

Initially, the programme will give priority to projects which build on existing Norwegian knowledge. One important consideration will be to prioritise areas where research in Norway can contribute to broader international collaboration, for example within storage and production of hydrogen.

The energy system

Further development and integration of power system planning to embrace the energy system as a whole will be important. This includes better interaction between technical and economic planning models, and the inclusion of heat. Further progress also needs to be made on the interaction between energy planning and other physical and public planning at local and national level. Possible research topics could, for example, be within system analysis, security of supply, energy planning and power transmission.

The energy market

Norwegian specialists and institutions have a strong position in the energy market and in its development. Further improvements in knowledge and analysis of experience in areas such as market integration and market regulation will allow that position to be retained. Ensuring that the signals sent by the power market are sufficient to provoke long-term decisions on constructing new generating capacity is important. So is ensuring that the market stimulates efficient energy use.

Efficient energy use
An increased focus on end use and on reducing energy consumption, both for households and industry, is important in reducing environmental impacts and ensuring an acceptable security of energy supply. The goal for developing new technologies is that they must be competitive in the market. Research will be directed on the one hand at possible suppliers of such products and services. On the other hand, both the authorities and the public at large will need to possess good expertise, both on framing efficient instrument and on their own investments.

Energy policy and international agreements
Extensive energy policy changes have occurred in most countries over the past decade. The growing attention being paid to such issues as environmental problems, primarily climate change, competitive conditions and a focus on the market have stimulated international agreements and directives designed to identify suitable tools for regulating such conditions. Environmental and other international agreements have significantly altered the framework conditions for developing energy systems. Developing the regimes established by international pacts creates a big demand for multidisciplinary expertise in such areas as framing agreements and determining their impact.

More information on the energy research programmes pursued by the Research Council of Norway and the NVE can be found on their respective web sites at www.forskningsradet.no and www.nve.no.

8.2.2 Other strategic research

In addition to the Renergi program, the MPE provides support to smaller, strategic research programs under the Research council. These have as their goal to build up expertise within areas of strategic importance for the energy sector. In 2006, this support will amount to about NOK 21 million.

The largest program is Catalysis and Organic Synthetic Chemistry. This program is intended to provide increased expertise within processing natural gas, and to contribute to value creation within the Norwegian chemical industry. Basic research within the catalyst sector, which is the part of the program supported by the MPE, shall primarily target catalytic processors for processing natural gas to more valuable chemicals such as methanol, fuels and other chemicals.

The MPE also supports strategic institute and university programs. Institutes and universities use these programs to strategically build up their competencies in areas that have a market for research projects related to added-value creation and resource management within the energy sector.

8.2.3 Climit – eco-friendly gas-fired power technology

Generating electricity from natural gas with minimum CO_2 emissions is one area where Norwegian research institutions have acquired an international position over several years. A number of avenues are being explored, but commercially attractive solutions remain a long way off.

The Climit program was established on 1 January 2005 to support research, development and testing/demonstration of technology for gas-fired power with CO_2 management. Gassnova's contribution is financed through earnings from the Gas Technology Fund, and primarily targets demonstration and development (NOK 92 million in 2006). The Research Council contributes with funding to the program linked to research-related activities within technologies for gas-fired

power stations with CO_2 management (NOK 55 million in 2006).

Climit is intended to stimulate and support R&D projects that can provide the know-how and technology development that is needed to enable commercial realization of gas-fired power production with CO_2 management, within the framework conditions set by the authorities. The project portfolio will, to a large extent, target technology solutions for CO_2 capture using a cost-optimised method. A further priority is the development of knowledge and solutions for storing CO_2 in geology formations, whether purely for storage or use in increased oil production.

8.2.4 Administration-related energy and watercourse research

Administration-related energy and watercourse research management is under NVE. NOK 16.9 million has been allocated from the MPE budget for 2006. These activities are intended to support the directorate's work and help it to develop and disseminate knowledge which improves the basis for its regulatory activities. The work supplements programmes pursued by the Research Council of Norway, and is coordinated with the latter. In addition, the NVE collaborates closely with the Norwegian Electricity Industry Association (EBL), the Directorate for Nature Management (DN) and Enova SF.

Within the energy and market sector, attention is being paid to mapping energy potential. This mapping is to be expanded to include ocean currents, saline power and geothermal heat. With respect to hydropower, further development of technology and methods for small power plants, as well as refurbishment and upgrading of larger hydropower stations, are being reviewed. The consequences of the effects of climate change on wind power and hydropower production are also being studied. Costs and profitability development related to gas-fired power production with CO_2 management, as well as various aspects of energy consumption in Norway, are also central issues.

Within the water resources sector, the cost efficiency of various preventative measures and the impact on vegetation and the environment of small hydropower stations are being studied. A key activity is follow-up of the EU Water Framework Directive. NVE has main responsibility for ICT development within the Directorates' cooperation. Work is also ongoing to achieve a better scientific basis for determining water flow in developed watercourses, as well as the challenges associated with flooding vulnerable areas.

Within hydrology research particular attention is being paid to three core areas; climate change impact on hydrology, hydrology models and hydrology methodology development. Work is also underway on methodology for flood prediction, documentation and knowledge of ice conditions and environment conditions in watercourses.

Within concessions and monitoring, risk related to landslide-generated waves in reservoirs, impact of wind power development on birdlife and what drives new investment in power production are being examined.

8.3 International research and development

Participation in international R&D collaboration in the energy field has a high priority and represents an important supplement to national research. Collaboration across national boundaries is crucial not only for maintaining a high scientific standard at Norwegian

research institutions but also for strategic reasons in establishing contacts and alliances with other countries. Participating in international projects builds expertise and provides both scientific and economic assistance for solving key research tasks. International cooperation also helps to showcase Norwegian technology and knowledge suppliers. Norway collaborates in the energy area primarily in the EU system, with the International Energy Agency (IEA) and at Nordic level.

8.3.1 The EU 6th Framework Program for Research

Through the European Economic Area (EEA) agreement, Norway participates as a full member in the EU's sixth framework programme for research, technological development and demonstration (2002–06). This programme has an overall budget of EUR 17.5 billion. One of its priority subjects is sustainable energy systems, which has a financial framework over the programme's lifetime of EUR 810 million. The energy programme can deploy a variety of instruments, which range from support for thematic networks and coordinatory activities to support for R&D and demonstration projects. The Research Council of Norway is coordinator for the Norwegian activities.

The energy programme in the 6th framework program is divided into two sections:

- short to medium term activities – renewable energy sources, energy saving/efficiency and alternative motor fuels
- medium to long term activities – fuel cells, hydrogen, new renewable energy sources, CO_2 management and socio-economic conditions.

To ensure strong participation by Norwegian institutions in the framework program, Norway's Research Council has implemented a scheme with partial financing of the institutions' own contribution if allocated projects by the EU. The institutions come under the sector responsibility of several Ministries. From 2006, the MPE has allocated NOK 11 million to this scheme.

8.3.2 The International Energy Bureau

A number of research programmes relating to various energy topics have been established by the IEA through implementing agreements. Norway belongs to 21 of these, including ones in the fields of end-user technologies, renewable energy technologies and dissemination of information. Norwegian participants are drawn from industry, research institutions or the authorities, depending on the activities covered by a programme. The Research Council of Norway is coordinator for the Norwegian activities.

8.3.3 Nordic Energy Research

Nordic Energy Research is an institution under the Nordic Council of Ministers which aims to promote and extend regional cooperation in the field of energy research. It is intended to strengthen national energy research programmes and institutions in the Nordic area and to contribute to a joint strategy for research and development in those parts of the energy sector which are of common Nordic interest. The institution also pursues strategy work and provides advice on projects under the Nordic Council of Ministers. Its annual budget of NOK 27.5 million is contributed jointly by the Nordic countries in accordance with a specified formula.

In the current NEFP activity period (2003-2006), thematic research activities have concentrated on areas which support the key areas designated by the energy ministers in the Nordic energy cooperation. These are Nordic

electricity cooperation, climate issues and regional cooperation. On the basis of this, five scientific programmes have been defined:

- energy market integration
- renewable energy sources
- energy efficiency
- the hydrogen society
- consequences of climate change in the energy sector.

8.3.4 Other international collaborations

Norway also participates in a number of other international research initiatives in the energy area. The most relevant are:

- the International Partnership for a Hydrogen Economy (IPHE), which aims to help organise, coordinate and initiate international R&D and demonstration projects relating to hydrogen as an energy carrier and to fuel cells
- the Carbon Sequestration Leadership Forum (CSLF), which helps to promote cooperation of research and further development of technologies relating to the separation, storage, transport and/or use of CO_2, and which aims to facilitate profitable utilisation of CO_2MoU (Memorandum of Understanding) between Norway and the USA, a bilateral research cooperation within energy related research and technology. Relevant topic areas are oil and gas production, CO_2 management, hydrogen research and new renewable energy sources.

8.4 More information on hydrogen as an energy carrier

Hydrogen is the simplest of the elements, and the most abundant in the universe. It is highly reactive and therefore does not exist on Earth in a free form, but only in compounds with other elements. If pure hydrogen is to be used for pure energy use, it must be produced from a compound containing hydrogen. Natural gas and water distinguish themselves as the most suitable sources for the production of hydrogen:

- it can be produced from all primary energy carriers, both fossil and renewable
- it can be stored
- greenhouse gas emissions from its end uses are very limited.

How far hydrogen is an environment-friendly energy carrier depends on the mode of production and the source of the primary energy. The carbon in the natural gas must be removed and processed before the hydrogen produced from natural gas can be called environment-friendly. If hydrogen is produced from water using electrolysis, the electricity required by electrolysis must be generated from renewable energy sources to ensure greenhouse gases and polluting releases are not generated in production.

The international transport sector is conducting research into both direct use of hydrogen as a motor fuel and its conversion to electricity in fuel cells for electrically-driven vehicles.

In a distributed energy supply system for stationary purposes, hydrogen or hydrogen rich gas can be used in small power plants based on fuel cells or turbines for combined heat and power generation.

Major and expensive technological challenges must be overcome before any significant commercial use can be made of this element.

Critical factors for hydrogen development relate to:

- cheaper production solutions
- satisfactory solutions for storage and distribution of pure hydrogen
- clear improvements in fuel cell technology for conversion to electricity.

8.4.1 Norwegian investments in hydrogen

Currently, Norway is investing substantial public funds on research, development and demonstration of hydrogen-related technology. The funding comes primarily from the Research Council, Gassnova and Enova. In 2006, this income will amount to about NOK 70 million.

A government-appointed commission presented a report on hydrogen as the energy carrier of the future (NOU 2004:11) in 2004. ('Hydrogen as the energy carrier of the future'). This inquiry identified three principal reasons for making a commitment to hydrogen in Norway:

- opportunities for environment-friendly production of hydrogen from Norwegian natural gas
- opportunities to reduce emissions of greenhouse gases, particularly in the transport sector
- opportunities for value creation in Norwegian industry with hydrogen-related expertise.

The commission concluded that hydrogen could be extensively used in the Norwegian transport sector. Using hydrogen in stationary energy supply could also be possible in certain niche areas. The report can be found at: http://www.odin.dep.no/oed/norsk/publ/utredninger/bn.html.

In 2005, the Ministry of Petroleum and Energy, and the Ministry of Transport and Communications submitted a strategy for investment in hydrogen as an energy carrier for transport and stationary energy supply, as follow-up to the Hydrogen Select Committee report. The primary objective of the strategy is to coordinate and make transparent current grant schemes and activities within the hydrogen sector. This report can be found, in Norwegian only, at http://odin.dep.no/oed/norsk/p30006318/energi_vassdrag/bn.html.

At the core of the hydrogen strategy is the establishment of a national hydrogen platform that will coordinate current grant schemes. The platform, which has an administration comprising the Norwegian Research Council, Gassnova, Enova and Innovation Norge, started up operations on 1 January 2006. The Research Council is responsible for daily operation. More information about the hydrogen platform can be found at www.hydrogen-plattformen.no.

As part of the hydrogen strategy, the Ministry of Petroleum and Energy, and the Ministry of Transport and Communications appointed a Strategic Council on 20 December 2005 dedicated to the government investment in hydrogen. The Council comprises representatives from universities and colleges, institutions, industry, environmental organisations and Directorates. The Council will provide professional advice and input for the government and will prepare a framework Action Plan that will form the basis for all work within the hydrogen platform. The Action Plan will be ready during the course of 2006.