Renewable energy and energy efficiency
Recent developments and activities in Norway

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1 Renewable energy and energy end use / efficiency in Norway

1.1 Policies and priorities

During the 1990s, there were a number of changes in the basic framework for Norway's energy policy. A headline for current energy policy is that environmental objectives will determine the limits of energy production, and that active steps must be taken to limit energy use. There are two main driving forces behind this development: The increased awareness on climate issues, made more specific by the Kyoto Protocol, and the political decision to stop further development of large-scale hydropower capacity. Energy policy, in the short and medium term, focuses on new renewable energy sources such as wind and bio, reduced energy consumption, a more flexible energy system, distributed power production and gas-fired power plants with reduced or no emissions.

In the White Paper no. 15, 2001/02, the Government prescribed a more pro-active approach to the climate issue. It is suggested that initiatives will be taken to make progress in the period up to 2005, and proposes a domestic emissions trading system to be established from 2005. As a consequence, the Government did during the summer 2004 propose a new law for greenhouse gas emission allowance trading. The proposed emission trading system should also stimulate the industry which is not covered by the present CO_2-tax, to reduce their climate gas emissions. The concept is in line with the EU emission trading system. By this, the Norwegian industry will have the same conditions as their European competitors, and in the future it will be possible to connect the Norwegian system to the EU system to obtain a large European emission trade market. The trading system entered into force January 1., 2005 which is the same date as for the introduction of the EU trading system.

One of the Government's targets is to reduce the use of mineral oils for heating by 25 per cent in the first commitment period under the Kyoto Protocol (2008-2012) compared with the average for the period 1996-2000. One step in this direction will be to draw up a strategy for conversion from oil-fired heating to new renewable energy sources. The Government will also strengthen research into the development of environmentally-friendly energy technologies.

According to the White Paper no.47 (2003-04), the development of natural-gas-fired power plants with CO_2 reduction technology is an import part of the Government energy policy. A separate Government owned innovation centre, Gassnova, was established in January 2005. Gassnova is a public agency reporting to the Norwegian Ministry of Petroleum and Energy. Gassnova shall work proactively and market oriented providing stimuli for enhanced co-operation and joint development ventures among government agencies and industry. In a joint effort with the Norwegian Research Council, Gassnova manages the CLIMIT-programme which is designed to promote research, development and demonstration of technologies for natural gas power generation with capture and storage of CO_2.

In the White Paper no. 9, (2002-03), the Government presented a policy on increased domestic use of natural gas, increased efforts on hydrogen, provision of electricity from the mainland to installations on the Norwegian continental shelf and a policy on green certificates. It is proposed that Norway should contribute to an advanced development of an

international certificate market. In doing so, consideration must be given to environmental concerns, security of supply and an acceptable management of natural resources in Norway.

The Government is preparing the introduction of a mandatory market for green certificates for electricity from renewable energy. Originally, the market was planned operational in 2006, but in order to synchronize preparations with the Swedish government and develop a common market, the plans are postponed a year to 2007. A proposition for a law to regulate the market will be presented in spring 2006. The Swedish certificate market was established in 2003. This implies that there is a strong interest in developing the Norwegian regime in parallel with the Swedish, where i.e. all renewable sources, including hydro power, are legitimate. The regulations will also be set with an eye to the development of a future European market.

The present support schemes for renewable energy developments in the power sector will be phased out with the new certificate market. The Governmental institution Enova will thus need to reconsider their activity, and focus their support on new heat production and efficiency on the user side. The Norwegian Water Resources and Energy Directorate (NVE) is preparing to become the regulatory authority. Statnett SF, the Norwegian transmission system operator (TSO) will administer the certificate transactions etc.

New strategy on development of hydrogen as an energy carrier. In August 2005, the Norwegian authorities launched a new strategy in which all hydrogen related activities will be administered and financed on basis of a common platform. Such activities include R&D, demonstration projects, development of safety standards, regulatory framework etc. The new strategy focus on all aspects of the hydrogen chain; production, storage and use of hydrogen serving stationary purposes as well as within the transport sector. Coming into force from January 2006, The Norwegian Research Council will have the main responsibility for carrying out the new strategy. It is expected that the new strategy will enlarge Norwegian hydrogen activities in the near future.

In June 2004 the Government presented a White Paper no.18 (2003-04) on the security of power supply. This document shows that hydropower covers 50% of the total Nordic electricity production. The electricity system has become more vulnerable recent years. This is due to shortage of rain at the same time as the electricity demand continues to grow. The production capacity has increased much less than the demand of electricity. In the early 1990's the annual Norwegian electricity export was 10 TWh, but the present production is less than the demand and Norway has a net import of 5-6 TWh. The Government aims to develop a more robust energy system with focus on:

- increased use of district heating systems
- more energy flexible heating systems in buildings
- increase the installation of small scale hydro power
- increased domestic use of natural gas in an environmentally sound way
- secure an effective Nordic power market

Information on national policies and priorities: www.oed.dep.no

1.2 Administration of policy instruments

The most important public or Government owned institutions being responsible for the administration of policy instruments within renewable energy and energy efficiency are:

Norwegian Research Council plays a vital role in developing and implementing the country's national research strategy, acting as a government adviser, a funding agency and coordinator of research activities. The Research Council is responsible for the administration of most of the public funding available for R&D in the field of energy and water resource management. www.forskningsradet.no

Enova SF became operational on January 1, 2002. Enova SF is a public enterprise owned by the Royal Norwegian Ministry of Petroleum and Energy. The main mission is to contribute to environmentally sound and rational use and production of energy, relying on financial instruments and incentives to stimulate market actors and mechanisms to achieve national energy policy goals. Stimulating construction of natural gas infrastructure, primarily as a measure to displace use of oil, is also among Enova's tasks. The establishment of Enova SF signals a shift in Norway`s organization and implementation of its energy efficiency and renewable energy policy. By gathering strategic policy responsibilities in a small, flexible and market oriented organization, Norway has wanted to create a pro-active agency that has the capacity to stimulate energy efficiency by motivating cost-effective and environmentally sound investment decisions. Enova SF enjoys considerable freedom regarding the choice and composition of its strategic foci and policy measures.
Enova SF advises the Ministry in questions relating to energy efficiency and new renewable energy. www.enova.no

Gassnova is the state centre for sustainable gas technologies. The purpose of the centre is to promote innovative, sustainable and cost effective gas technologies. Gassnova was put into operation on 1. January 2005. Gassnova is a public agency reporting to the Norwegian Ministry of Petroleum and Energy. www.gassnova.no

The Norwegian Water Resources and Energy Directorate (NVE) is a directorate under the Ministry of Petroleum and Energy, with responsibility for managing the country's water and non-fossil energy resources and for monitoring the energy market. NVE's mandate is to ensure integrated and environmentally sound management of the country's watercourses, to promote efficient energy markets and cost-effective energy systems and to work to achieve a more efficient use of energy. NVE also has the overall responsibility for maintaining national power supplies. NVE is involved in R&D and international development co-operation. www.nve.no

Statnett SF Statnett is responsible for co-ordinating supply and demand in the power system. Being a transmission system operator, Statnett owns and operates large sections of the main Norwegian power grid and the Norwegian section of power lines and subsea cables to other countries. www.statnett.no

The Norwegian State Housing Bank (The Housing Bank) is the main instrument of the Norwegian Parliament, the Norwegian government and the Ministry of Local Government and Regional Development for the implementation of national housing policy. Additional

loans at a modest interest rate may be granted for installations and efforts to reduce use of energy or use of flexible heating systems. www.husbanken.no

Innovation Norway. As of January 2004, the new state owned company Innovation Norway has replaced the following four organisations: The Norwegian Tourist Board, the Norwegian Trade Council, The Norwegian Industrial and Regional Development Fund, SND and the Government Consultative Office for Inventors, SVO.
The new organisation has no specific mandate in terms of promoting renewable energy and energy efficiency. However Innovation Norway promotes nationwide industrial development profitable to both the business economy and Norway's national economy, and helps release the potential of different districts and regions by contributing towards innovation, internationalisation and promotion. Innovation Norway has offices in all the Norwegian counties and in more than 30 countries world wide. The core group of clients are Norwegian companies, predominantly SMEs. www.invanor.no

1.3 Market situation

The energy situation in Norway is quite special compared to most other countries. Most other countries have to import a substantial part of their energy supply, and energy security is highly focused. In Norway, the annual production of energy is approximately 10 times the domestic use, and more than 99% of electricity production is hydropower. However, Norway is a part in the international energy market, and the energy costs in Norway reflect the international level.

In recent years, the growth rate in annual power consumption has been 1-1,5%. According to NVEs latest estimates, (June 2005) increased electricity prices compared to averages prices in the 1990'ies, will motivate investments in new generating capacity (mostly wind power, small hydro power and gas fired plants) as well as flattening in consumption in growth rate. Higher electricity costs are explained partly as a result of the 2003 winter price shock due to extraordinary low level of precipitation and cold weather, generally higher prices on fossil fuels and the introduction of CO2 quota market in the EU.
At the same time the electric power balance is moving in a more favourable way through realization of new transmission- and power plants in the Nordic region. Among these development is a new 700 MW cable connecting the Netherlands and Norway, expected operational in 2010.

1.4 R&D and innovation

The objective of research and development in the field of energy and water resource management is to strengthen economic growth, promote sound use of energy resources and ensure that environmental considerations are taken fully into account. About half of the overall research funding in the energy sector is provided by the public sector. For 2005, the Ministry of Petroleum and Energy has allocated NOK 160 million for energy research and development programs.

Most of the R&D funds are allocated to user-driven research programs. The Research Council also provides support for longer-term basic research and the development of expertise at research institutes and universities, which provides a basis for other, commercially promising projects in co-operation with industry and others. NVE is also responsible for some energy research, mainly applied research into water resource management within a budget of NOK18.5 million, the same amount as for 2004.

It is possible to apply for public funding to more market oriented activities from other government bodies, like Innovation Norway and Enova.

Some of the current research programs are:

- **The Clean Energy System of the Future (RENERGI).** The Research Council's Executive Board has decided to establish a new program entitled RENERGI (Clean energy = CLEANERGY). RENERGI will be one of a limited number of new major research programs in which the Research Council will deploy a wide range of instruments and resources. RENERGI represents a confluence of three existing programs: Energy for the future, SAMSTEMT and the Innovation Program Energy, Environment, Building and Construction (EMBa). The plans for these programs and the project portfolios contain important priorities that will be of relevance to the new program. The Research Council would also like RENERGI to reflect fresh thinking and create new opportunities under the auspices of a large-scale, highly visible program in an area of strategic importance for the country. The program is to facilitate research in both the long-term (30 years) and the short-term perspective (5 to 10 years). The program started in 2004 and will endure for 10 years. RENERGI will be limited to energy production and transmission, and to stationary and mobile energy use. Offshore petroleum activities will continue to be addressed under separate programs. It will be important to establish clear boundaries in relation to petroleum research and climate change research CLIMIT (NORKLIMA); importance will be attached to co-operation between the programs. The following fields will form the basis for ranking priorities within RENERGI:
  - Renewable energy production
  - Natural gas and gas-fired power plants with CO_2 management
  - Hydrogen
  - Energy systems
  - Energy markets
  - Energy use
  - Energy policy and international agreements

  Many issues for research will cover several of the areas mentioned above, or must be considered vertical in the energy value chain from primary production to end user, with the focus on the role of the authorities and private players. As an example; new renewable energy production may require public participation of different types. Phasing new production capacity into existing energy systems will call for investments in network infrastructure, new marketing and sales schemes must be adapted, and the operation of the other system will have to be adapted to the new situation. RENERGI will attach importance to accommodating projects that address such interdisciplinary issues between the areas.

The program's project portfolio in 2004, featuring contributions from several programs and including earmarked funding for high-priority fields, breaks down roughly as follows among RENERGI's target areas:

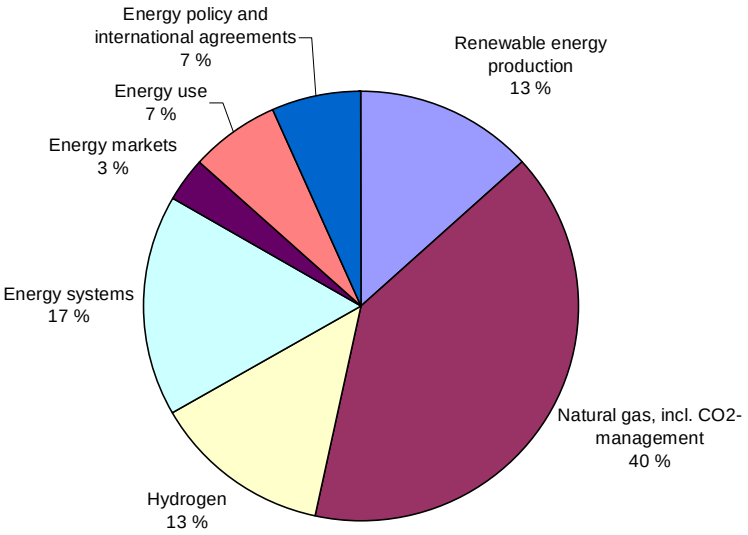

Figure 1 2004 project portfolio of R&D program Renergi

The 2005 budget contains an allocation of NOK 160 millions for RENERGI. In addition, the Ministry of Transport and Communications has granted NOK 22,6 million to promote the development of environmental technologies, hydrogen and alternative fuels in the transport sector.

- **Strategic programs at research institutions**. The Research Council supports a number of strategic research programs at universities and research institutions. Programs should focus on topics of fundamental importance related to the production and use of energy.

- **Applied research on energy and water resource management** is administered by NVE. These activities are a supplement to, and are coordinated with, the activities of the Research Council. Some important programs in 2002 were applied R&D on energy, environmental flows, and micro, mini and small power plants.

1.5 International cooperation

Participation in international cooperation on renewable energy and energy efficiency is given high priority and is an important supplement to national research efforts. One of the reasons is the new challenges that have arisen in the energy and environmental fields. Norway is primarily involved in cooperation within the EU system and the International Energy Agency (IEA) and at Nordic level. Some of the co-operation arenas and programs are:

- **The IEA** has established a number of research programs on various energy-related topics through Implementing Agreements. Norway is taking part in 21 such cooperation programs in areas including end-use technologies, renewable energy technologies and the dissemination of information. A Norwegian IEA portal was introduced summer 2005. www.iea.no
- **The European Commission** has started a new energy program, called "Intelligent Energy for Europe – (IEE)" (2003-2006). With a budget of €215 million, the intention is to implement the strategy outlined in the Green Paper on security of energy supply, founded on renewable energy sources and energy saving. Norway has been participating in the earlier programs SAVE and ALTENER since 1996 and is also a full member in IEE.

  Under the EEA Agreement, Norway has taken part as a full member of the EU's Fifth and Sixth Framework Programs for research, technological development and demonstration.
- **The Economic Commission for Europe (ECE)** is one of the UN's five regional commissions. Norway is one of the members of its Committee for Sustainable Energy. This committee functions as a meeting place for 55 countries, among them the USA, Canada and European countries. It has working groups for energy efficiency, gas and coal.
- **The Baltic Sea Region Energy Cooperation (BASREC)**. This is organized as part of the cooperation under the Council of the Baltic Sea States (CBSS). Eleven countries and the EU Commission are involved. BASREC has established ad hoc groups in the areas of climate change, energy efficiency, gas markets and electricity markets. In 2002, it was decided to make the region a testing ground for Joint Implementation projects for reducing greenhouse gas emissions in the energy sector.
- **Nordic Energy Research Program (NEFP)** has continued the activities of the former Nordic Energy Research Program. Its long-term objective is the development of expertise relevant to cost-effective reduction of energy use and the development of new renewable energy sources and environmentally-sound energy technology. This is to be achieved by strengthening basic expertise at universities, colleges and other research institutions, and by developing active research networks at various levels.
- **International Partnership for a Hydrogen Economy – IPHE** is a partnership with representatives from government authorities, R&D institutions and industry. A total of 14 countries and the European Commission take part in this partnership with the aim to coordinate, organize and establish international R&D and demonstration within the fields of hydrogen and fuel cells.
- **Carbon Sequestration Leadership Forum – CSLF**. Norway together with 13 other countries and the European Commission were invited by the US Government to take part in this forum with the aim to reduce the greenhouse gas emissions. CSLF was established in June 2003, and will work for the development of technologies to manage CO_2 from production as well as systems that will facilitate the sequestration of CO_2
- **The Norwegian-Russian energy forum** includes a working group on energy. This group is, among other things, following up projects in Russia that are financed through the Central and Eastern European Action Program, mainly training programs and programs on bio energy.
- **Bilateral R&D agreement between Norway and Japan** was signed in May 2003. This is a general R&D agreement which also includes energy and environment..

- **Bilateral R&D agreement between Norway and the US** will cover fossil fuels including CO_2 management and hydrogen as well as energy efficiency and renewables.

2 Renewable energy

2.1 National strategies and goals

2.1.1 National goals

According to the White Paper No. 29 (1998/99) which deals with Norway's energy policy, growth in energy production must to a greater extent be based on new, renewable energy sources. A set of national goals were approved by the Parliament in the spring 2000:

- An additional of 4 TWh/year of water-borne heat to be produced by 2010. This shall reduce the dominance of electricity for household heating. The heat is to be produced from new renewable energy sources, heat pumps or waste heat.
- To establish wind farms that will produce at least 3 TWh/year of electricity by 2010.

2.1.2 Policy instruments

Financial support and subsidies

Enova is the responsible body for achieving the above quantified targets by 2010. The activities of Enova are financed by the Energy Fund, which receives the revenues from a levy on the electricity distribution tariff (NOK 0.01 per kWh) and from state budget grants. In 2005 the Fund will receive a total of about NOK 660 millions which is an increase of 17 % from 2004. Enova uses this Fund to promote energy savings, to reduce the use of electricity for heating purposes and to promote new environmentally friendly forms of energy production. Enova also provides information and educational measures to the public.

Several programs have been introduced to support production on renewable energy. In all programs, financial support is given on an individual basis. In general, projects are ranked based on maximizing estimated production (output) per NOK granted. Another general criterion is that financial support should be deemed necessary for realization of the project. In 2005 Enova supports the following types of projects involving production of renewable energy:

- **Wind production investment grant**. Projects involving the actual construction of wind power plants may receive a grant of up to 25 % of project costs. The proposed wind power projects are evaluated and compared, and grants are given to the projects considered most cost efficient The increase is expected to prevent a possible delay of wind power installations until the green certificate system is implemented. The grant is limited to wind turbines larger than 1,5 MW rated output power. When a green certificate market has been established, the wind farm owners can decide to enter into this market if they repay the grant from Enova.
- **Heat – processing of biomass**. The program is aimed at the entire chain, from harvesting and transportation to processing and trade with biofuels. The target group

is market actors working to develop long term business throughout the value chain. Examples of activities could be new capacity for harvesting, transportation, processing and trade, all on an industrial scale. To qualify for this program, the projects must be based on forestry products or by-products. Maximum share of grant is 40 % of the investments.

- **Heat** The Heat program grants investment support to heat production plants and infrastructure for waterborne heating. The heat production must be based on bio energy, waste, heat pumps or industrial spill heat. Project support from Enova is adjusted to ensure the project a profit level typical for the heat production industry. Project categories qualifying for support through the heat program can be new district heating plants, expansion of existing district heating plants, local energy production plants, thermal production of electricity based on solid fuels, land fill gas and biogas.

- **Introduction of new energy technologies**. Support is granted to new energy technology full-scale projects. The program aims at promoting technologies that have only been tested in laboratories or small-scale pilots or does not exist in today's market, or technologies for which adaptations are necessary to function under Norwegian conditions. The program targets all relevant energy technologies, like production of renewable energy or technologies for efficiency improvements leading to reduction of energy consumption

- **Pilot program - innovative energy technologies**. In order to support new and innovative energy technologies, Enova SF and the Research Council of Norway have jointly established a program for technology introduction. Applications will be evaluated by both organizations The program is aimed at two technology areas: Production of heat from sun and biomass, and energy efficiency (except transport sector). Public support can amount to maximum 30 % of documented project cost. Projects with a high degree of innovation (although not R&D), good potential for business development and that are market based will be prioritized. In 2005, the program has NOK 10 millions at its disposal. Continuation of the program If the pilot program is successful.

- **Municipal energy and environment planning.** The program grants support to the preparation of energy and environment plans in municipalities. It also supports feasibility studies for district heating and heat production plants.

In addition to the programs, Enova SF prepares and disseminates information material concerning renewable energy.

Taxes

Electricity consumption is subject to a tax. All business activities were exempted from the electricity tax with effect from 1 January 2004, but from the 1st of July 2004, the electricity tax for the business sector was changed again to conform to EU regulations. Private consumers, all businesses except industry and administration buildings in the industry pay NOK 0.0988 per kWh in 2005. All consumers and businesses (including some parts of the industry) in the county of Finnmark and the northern parts of the county of Troms are exempted from this tax. The industry pays 0.045 NOK/kWh, which corresponds to the minimum rates specified in the energy tax directive of the EU.

With effect from 1 January 2004, the grid companies took over responsibility for collecting the tax. It had previously been collected by the electricity suppliers through their invoices.

Total tax on end use of fuel oils includes:

- a heating oil tax of 0,0414 NOK/liter heating oil, or approximately 0.0545 NOK/kWh
- CO_2 tax of 0,052 NOK/liter mineral oil
- sulfur tax (17 NOK/kg SO_2)

To prevent a switch from electricity to oil as a source for heating, the heating oil tax should be analogous to the electricity tax per kWh. The figure below shows the development of the electricity tax ("Elektrisitet") and the heating oil tax ("Fyringsolje grunnavgift"), the latter with and without CO_2-tax and sulfur-tax, in 0.01 NOK/kWh (2005-level).

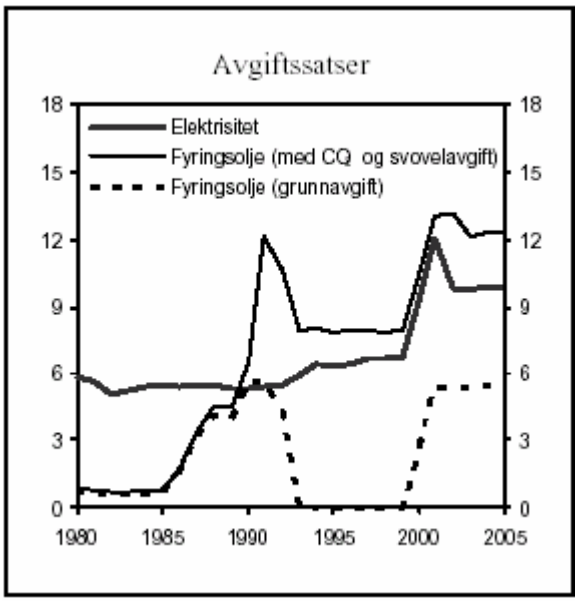

Figure 2 Energy taxes on oil and electricity, 0.01 NOK/kWh. Source: Ministry of Finance

In order to reduce methane emissions, a tax on final disposal of waste to landfills and incineration plants was introduced in 1999. In addition, it prohibited the disposal of wet organic waste in landfills and required that it be used for animal feed, composted or incinerated. In 2003, the tax on disposal of waste to landfills was differentiated; today the tax varies from 409 NOK/ton to 533 NOK/ton, depending of the environmental standard of the landfill. The incineration tax was changed in 2004 to reflect the emissions rather than the amount of waste incinerated. Unlike the previous incineration taxation system, the emission tax is not differentiated to reflect energy utilization.

Several taxes are imposed on producers of large scale hydro power. The tax level is relatively high, compared to other countries.

Concession and legal framework

Wind power plants and hydro power plants and district heat installations with a capacity of more than 10 MW need a concession. Applications for licenses may also be submitted for smaller district heat installations. Concession is necessary for local authorities to impose mandatory connection for new buildings in the concession area.

Several legal acts and regulations impose restrictions and requirements on market actors and installations. Plants for renewable energy production are treated in the same way as any other energy production plants in this respect.

In October 2004 the Government decided to adopt the EU Renewable Energy Directive. The directive was included in the EEA agreement on July 8th 2005, and will come into force as soon as the EEA countries have made the necessary amendments to the law, with deadline January 2006. According to this directive each EU member state must set an indicative target for the share of renewable electricity in 2010. Norway has a higher share of renewable electricity than any other EU member states, and the Ministry of Petroleum and Energy has indicated a target for Norway of 90 percent renewable by 2010. The renewables directive also requires each country to offer guarantees of origin to producers of renewable electricity. The guarantees of origin are proof that the electricity produced is renewable, and can be traded between countries.

Planned and future renewable energy incentives

Currently, much attention is directed at the green certificates issue. The intention is to integrate a new Norwegian certificates market with the existing Swedish certificates market. The framework for the common Norwegian-Swedish certificates market is under development and will be concluded during the last half of 2006. Certificates will be issued for production of wind power, solar power, geothermal energy, bio energy, wave energy, small hydro power, increased production in existing hydro power plants and new hydro power.

2.2 Renewable-based energy capacity and production

During the 90's, power consumption increased with an annual rate of about 1.0 – 1.5 % per year, while hardly any new production capacity was built.

	Installed capacity (MW)
Smal hydro power (<10 MW)	1042
Large hydro power (>10 MW)	26 875
Wind power	160
Thermal power	260
Total installed	**28 337**

Table 1 Installed capacity for renewable-based electricity (by January 2005)

There are approximately 140 000 PV-installations in Norway, mainly in cabins not connected to the grid. At th e end of 2004, the the total installed capacity was estimated to 6,9 MW. The corresponding annual energy production capacity would be in the order of 5 GWh.

The table below shows the energy production in Norway in 2004:

2004	**TWh**
Oil (stationary combustion)	1 875
Gas	770
Hydro power	110
Bioenergy	14
Heat pumps	4.5
Waste derived heat	1.1
Wind power	0.26
Solar energy	0.01
Geothermal energy	0

Table 2 Energy production in Norway (2004)

Hydro power is the dominant source of renewable energy produced in Norway, accounting for 99.3 % of electricity production.

Annual hydro power production fluctuates heavily from year to year, mainly dependent on reservoir inflow. The average production capability of Norway's hydropower plants is estimated to be about 118 TWh/year. The production span, however, is estimated to be between 90 and 150 TWh/year.

The table below presents figures on electricity production.

	1980	**1985**	**1990**	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**
Hydro power	83 962	102 946	121 382	122 487	142 289	121 800	129 837	106101	109280
Wind power				9	32	30	75	220	260
Thermal power	137	346	466	515	495	502	561	952	887
Total	**84 099**	**103 292**	**121 848**	**123 011**	**142 816**	**121 608**	**130 597**	107 273	110427

Table 3 Electricity production in Norway, 1980-2004 (GWh) ***Source: NVE "Energi i Norge"***

The development of district heating has increased over the last years. End use based on district heating was 9.1 PJ (2,3 TWh) in 2003. Production of district heating in 2004 was 2,5 TWh. Waste incineration constituted half of this production (source: Statistics Norway, SSB).

As can be seen from table 2.2, the wind power production has increased substantially over the last years. In January 2004, Norway had 55 wind turbines with an installed capacity of about 100 MW. At the end of 2004, the number of wind turbines had increased to 85, with a total capacity of 160 MW.

The present market for biofuel in Norway is very limited. Two buses in the town of Fredrikstad are running on fuel from landfill gas and about 1,4 million liters of biodiesel is used in the transport sector. Pure biodiesel can be obtained from two local fuel stations, and about 75 ordinary fuel-stations can provide auto diesel with 2-5 percent mix of biodiesel.

2.3 Future growth projections for renewable energy technologies

In an official study from 1998 (NOU 1998:11), 4 possible scenarios on energy production and use in the years up to 2020 were described. The expected electricity production in 2020 was assumed to be 141 TWh in the "Climate scenario", and 181 TWh in the "Growth scenario", being the most extreme scenarios. In the same study, the growth potentials for renewable energy with an energy price to the consumer below 70 øre/kWh (EUR 0.09/kWh) (before value added tax) was estimated:

	2001 (TWh)	***2020 (TWh)***
Hydro power	122	126
Wind power	0.03	6
Bioenergy/Energy from waste	15	22
Heat pumps	4.5	10
Solar energy	0.01	8
Geothermal energy	0	0.1
Wave/Tidal	0	0.5

Table 4: 1998 estimates for future energy production in Norway

Another estimate for future wind and hydro power production was published by the Norwegian Water and Energy Directorate (NVE) in 2005. NVE has developed three scenarios, depending on quota levels in a green certificate regime. The table below reflects the lowest and highest estimates:

Production, average years	***2005 (TWh)***	***2020 (TWh)***
Hydro power	119	123,5 - 127
Wind power	0,3	7,3 – 10,8
Production, average years	2005 (TWh)	2020 (TWh)

Table 5: 2005 estimates for future hydro and wind power production in Norway

Trade associations and other sources operate with more optimistic expectations:

	2020 (TWh)
Hydro power	133
Bio energy	35
Wind power	10

Table 6: Trade organizations have more optimistic expectations. Sources: EBL, NOBIO.

Within the current policy of the Government, there is still some potential for further development of hydro power capacity. Per January 2005, this potential has been estimated to 41,9 TWh/year. Production capacity equivalent to 1,2 TWh is under construction. Concession has been granted for another 1,5 TWh. In addition, increased capacity can be expected from mini scale hydro power (< 10 MW). During 2004, concessions were granted to 27 new small-scale hydro power plants, the expected total energy production from these plants is 270 GWh/year.

In addition to the wind power facilities built and put into operation by the end of 2004, 110 MW of new capacity was added to the wind power plant at Smøla in September 2005. The plant at Smøla is the largest onshore wind power plant in Europe, with a total installed capacity of 150 MW and an expected annual production of 450 GWh. Furthermore, eleven new wind power projects have been given concession by the Norwegian Energy Directorate (NVE). These could generate about 3 TWh/year if they are all erected. More information about these plans can be found on the directorate's web site at www.nve.no. Technological developments and longer production series have contributed to a substantial reduction in the investment cost of wind power. Current generation costs are estimated to be about NOK 0.25–0.30 per kWh at sites with good wind conditions and moderate development costs. Costs may even be below this level for certain projects where these factors are particularly favorable.

A continued increase in the contribution from bio energy, waste material and district heating is expected.

2.4 Industry capacity and key companies

A large number of companies are engaged in the renewable energy sector. This section contains a brief presentation of some of the most important industrial manufacturing companies in the renewable energy sector.

Bio energy

- ***EnviroArc Technologies AS*** has developed a process for incineration of all kinds of waste by a gasification process called PyroArc. The metallic fractions of the waste are melted and collected, while all the other fractions are gasified in a plasma generator. The gas is used for production of electricity or damp. www.enviroarc.com

- ***Energos*** has developed a technology for low emission incineration plants for municipal- and some industrial waste. The concept is designed for local energy production with short transport distances for both fuel and energy. The business and assets of Energos ASA has been purchased by the UK-based company ENERG-G www.energos.com

In addition, there is a steadily increasing number of production plants for biomass pellets.

Photovoltaic

- ***Elkem AS*** is developing alternative processes for manufacturing of solar grade silicon for PV cells. www.elkem.no

- ***Norwegian Silicon Refinery AS (NSR)*** is a new company working with the commercialization of a new production method for solar grade silicon production. The inventor received in 2004 a prestigious Norwegian prize on behalf of NSR for its innovative process for producing solar grade silicon . Several years of research is the basis for this new solid state/liquid process which differs from the more complicated and commonly used gas state process. The NSR-process has many similarities to the electrolysis process for producing aluminum; however, the NSR-process might be more profitable as the product has a much higher prize than aluminum.

- ***Renewable Energy Corporation AS (REC)*** covers the whole value chain of solar photovoltaic systems - from the manufacturing of solar grade polysilicon feedstock to the marketing of photovoltaic systems to the consumer. REC has over the last years had an annual growth in revenues of 50-60 per cent. The sales revenue in 2004 was NOK 1.4 billion, more than double than that of 2003. The plant's capacities are sold out for 2005 and, to a large degree, for subsequent years. REC (www.rec-pv.no) is the parent company of the following companies

    - ***ScanWafer AS*** has become a significant producer and supplier of multicrystalline silicon wafers for the word solar cell industry. Established in 1994 the company started to produce in 1997in Glomfjord and since then has been continuously increasing its production. With a production volume of 162 MW at the end of 2004 ScanWafer held more than 17% of the global market for solar wafers. Expected run rate at end of 2005 is 240 MW.

    - The new Herøya plant produced its first wafers in April 2003. ScanWafer has 277 permanent employees. www.scanwafer.no
    - ***ScanCell AS*** is a manufacturer of quality polycrystalline silicon solar cells from wafers produced by ScanWafer. In January 2003 normal production of 125 x 125 mm solar cells was started at the Narvik plant. www.scancell.no
    - ***ScanModule AS*** is producing solar modules in Sweden.
    - ***Silicon Technology AS*** is 100% owned by REC and was established in 2001 to work on technology and business development in the feedstock area. Silicon Technology is producing granular polysilicon feedstock through a joint venture with ASiMI in the USA. The production of polysilicon started at the beginning of 2004.

Solar heating

- ***SolarNor AS*** develops solar heating systems in collaboration with General Electric Plastics. Building on more than 20 years of research and development, the company supplies integrated solar heating systems in terms of roof or façade covers which may substitute conventional

building materials. The company also offers controllers for solar heating systems. www.solarnor.no

Wind power

- ***ScanWind AS*** is producing large wind power turbines (3 MW) and complete wind farms especially fitted for Nordic conditions. A 3 MW prototype turbine with direct driven generator was erected in March 2003 in the Trøndelag region. Two new 3 MW turbines will be erected at the same location during 2005. www.scanwind.com

- ***Umoe Ryving AS*** produces wind turbine blades for the global wind power market. www.umoe-blades.com

Wave/tidal/salt gradients

- ***Hammerfest Strøm AS*** has built a 300 kW tidal water pilot plant at Kvalsundet. The plant consists of an under water turbine. The "under water mill" has a radius on the rotor blades of 15 meters. This is the world's first tidal water plant to be connected to the electricity transmission grid, and it was installed in autumn 2003. www.tidevannsenergi.com

- **Statkraft** is planning another tidal pilot installation in the same Kvalsundet. This is a floating device of 1 MW anchored to the seabed which is expected to produce 3,6 GWh/year. The manufacturing will take place in 2005 and the installation in the Kvalsundet is expected during the spring 2006. In cooperation with the research organization SINTEF, Statkraft is also active in the development of osmosis technologies. The concept is patent pending. www.statkraft.no

Small scale hydro power

- ***Small Turbine Partner AS*** produces turbines for small scale hydro power plants (250 kW – 10 MW). Each turbine is tailor-made for each hydro power installation. . www.turbinepartner.no

3 Energy end-use and efficiency

3.1 Energy consumption and prices

3.1.1 Current situation

The energy consumption per capita is higher in Norway than the average of OECD countries, but about the same as other countries with corresponding climate conditions like Finland and Sweden. The electricity consumption in Norway is higher than in other countries.
Net domestic energy use[1] in Norway in 2004 was 226 TWh. Net energy use for stationary purposes[2] was 168 TWh.

	1985	1990	1995	2000	2003	2004
Coal and coke	15.0	13.6	15.8	15.7	12.4	12.8
Wood and black liquor	9.2	10.6	11.7	14.3	14.4	14.4
Gases	0.6	1.1	3.3	5.6	6.1	4.2
Petroleum products	72.8	69.4	71.4	82.3	81.3	76.6
Electricity	91.4	96.9	103.9	110.0	104.2	110
District heating	0.3	0.8	1.1	1.7	2.0	2.2
Total	189.2	192.5	207.2	229.6	220.4	220.2

Table 7: Net domestic energy consumption[1] 1985-2004 (TWh). ***Source:*** ***www.ssb.no***

In the past 20 years, the greatest increase in energy use has been in the household and service sectors. Energy use in the service sector has increased by 70 % since 1980, while energy use in households has increased by 25 % in the same period.

Net electricity consumption in 2004 was 109 TWh, representing close to half of net domestic energy use. All electricity consumption was used for stationary purposes. The main reasons for the high proportion of electricity use are the access to rich supplies of relatively cheap hydropower, and that government policy over several decades was focused on hydropower development. A large electricity-intensive industrial sector has developed as a result. Furthermore, electricity is widely used for space and water heating in buildings.

The electricity consumption increased with 3,7 % from 2003 to 2004. The electricity consumption in 2003 was the lowest since 1996, due to a warmer climate than normal as well as high electricity prices. In 2004, the electricity price decreased whereas the oil price increased and this lead to a switch from oil to electricity. The average price to households reached a peak with 0,90 NOK/kWh in 2003 incl. taxes and distribution costs. This can be compared with an average price of 0,60 NOK/kWh in 2001 and 2002 and down to 0,50 NOK/kWh as an average the previous 5 years. In 2004, the average electricity price including taxes was about 0,75 NOK/kWh.

[1] Net domestic energy use is gross energy use minus energy utilized to convert and transport energy ready for the end user, energy carriers used as raw materials, and minus losses during transmission.

[2] Stationary energy use is net domestic use minus energy for transport purposes, international maritime transport and the energy sector itself.

Hydropower covers more than 99% of the domestic electricity production. Wind power has increased from 39 GWh in 2002 to 220 GWh in 2004. It is expected that the national goal of 3 TWh wind power by 2010 will be reached with good margin.

The market for heat pumps is steadily increasing. The number of heat pumps sold in 2001 was more than 6000, an increase of 90 % compared to 2000. The increase has continued in 2002 and in 2003, due to the market situation and immediate Government initiative in early 2003. This initiative resulted in more than 50.000 heat pumps sold in 2003. Most of these are air to air heat pumps.

3.1.2 Expected increase in energy consumption

In an official study from 1998 (NOU 1998:11), 4 possible scenarios on energy production and use in the years up to 2020 were described. The expected consumption of electricity in 2020 is assumed to be 125 TWh in the "Climate scenario", and 173 TWh in the "Growth scenario", being the most extreme scenarios.

In a Government White Paper (no. 37, 2000/01), annual increase in electricity consumption is expected to be 1.4 % in the period 1999-2005. The resulting net electricity consumption in 2005 is expected to be 122 TWh.

The current market situation has demonstrated that there are significant potentials for energy savings in Norway, and that energy prices can have a strong influence on market behaviour. As an example, a current analysis financed by Enova reveals a significant potential for profitable energy efficiency in the processing industry.

3.2 Policies and priorities

Energy efficiency plays an important role both in achieving Norway's reduction target of greenhouse gas emissions as well as securing a more rational use of natural resources. National climate policy is based on a situation where the Kyoto Protocol enters into force.

The White Paper No. 29 (1998/99) suggested that energy efficiency activities in Norway were fragmented and, for this reason, should be more purposefully organized. Consequently, with Enova being established, the reorganization of national activities in this field has now been carried out.

Currently, much attention is directed at the green certificates issue. The intention is to integrate the Norwegian certificates market with the existing Swedish certificates market. In Sweden, certificates are issued to producers of renewable energy, and all end-users are obliged to buy certificates equivalent to 7.4 % of their electricity use in the first year, increasing to 16.9 % in 2010. In Sweden, electricity prices (for households) are expected to increase by SEK 0.01 – 0.015 per kWh due to the introduction of the certificates market.

Total installed capacity in the Norwegian power system is approx. 28 GW. The actual capacity at peak load hours during the winter season is considerably less, due to power plants

without reservoirs, maintenance etc. The actual maximum available capacity during the winter 2001/02 and 2002/03 was 24,5 GW. Peak load hours during the last few winter seasons have revealed that the system is vulnerable. The Government is expected to stimulate the further development of two-way communication, which can be an important tool in demand side management.

3.2.1 Political goals

The Government's goal, established in the White Paper No. 29 (1998/99), is to limit the energy use considerably more than would be the case if developments were allowed to continue in a business as usual scenario. The Paper also stated goals with regard to energy production:

- increase annual use of central heating based on new renewable energy sources, heat pumps and waste heat by 4 TWh/year by the year 2010
- to install wind power capacity of 3 TWh/year by the year 2010

Norway has decided to implement EU directive energy in buildings. The objective is primarily to enhance energy efficiency in private homes as well as commercial and public buildings. Formally, the directive will come into force in January 2006. The implementation process in Norway is not decided in detail yet, but NVE has already for some time carried out planning preparations. A main consequence of the directive implementation is that , over time, all buildings will be issued energy labels revealing energy performances, and also an energy certificate stating the nature of energy systems, efficiency measures etc.

3.2.2 Policy instruments

Financial support and subsidies

Except from the nationwide information and advisory services to promote efficient energy, Enova has now initiated several programs aimed at quantifiable reduction in the use of energy:

- **Energy consumption – existing buildings**. The program objective is to reduce energy consumption in private homes as well as private and public commercial buildings. In cases where electricity is used for heating, a switch to other, more environmentally friendly sources of energy will be registered in addition to the reduction target.
- **Energy consumption - industry.** To reduce energy use in energy intensive industry (using more than 50 GWh/year), Enova supports initiatives for more energy effective processes, heat recovery, conversion to renewable energy sources etc. A maximum of 20 % of project costs may be granted and the projects must result in a minimum of 0,5 GWh/year Energy data from these projects are collected in a database for benchmarking purposes (anonymous).
- **Energy management - SME Energy Networks**. The program target group is SMEs with annual energy consumption over 0.5 GWh. Members of the network can obtain

grants to analyze the potential for energy savings, to introduce energy management systems, etc. Benchmarking against other companies in the relevant business sector is undertaken.

- **Energy consumption – installations**. The aim of the program is more energy efficient installations like outdoor lighting, road lights greenhouses, sports centres etc. Potential for energy reduction should be more than 0.5 GWh/year in projects receiving grants.
- **Energy consumption – new buildings.** Flexible energy solutions and energy saving measures that are implemented during the building phase are both cheaper and more efficient than modifications of existing buildings. It is important that building owners, developers, architects, consultants and entrepreneurs choose the most energy efficient solutions in the planning phase. Enova SF can cover parts of additional costs for pre-engineering and planning of these solutions.

The Housing Bank administers various loan and grant schemes for residential energy efficiency measures. The bank offers an extra mortgage loan, and grant to house-builders who intend to invest in alternative forms of energy solution such as water-based central heating and heat pumps which may be combined with solar heating systems and use of bio fuel. The level of support will be based on the actual case. Development and pilot projects with high environmental ambitions, may receive grants and loans up to 80 – 90 % of the costs. The bank has stated a goal that half of all new houses built in 2010 shall have a reduced energy demand of 50% compared to the present standard.

Taxes

Taxes and exemptions influence the relative prices and costs of the various energy carriers. This, in turn, affects energy use. Electricity consumption is subject to a tax. Private consumers, all businesses except industry and administration buildings in the industry pay NOK 0.0988 per kWh in 2005. All consumers and businesses (including some parts of the industry) in the county of Finnmark and the northern parts of the county of Troms are exempted from this tax. The industry pays 0.045 NOK/kWh, which corresponds to the minimum rates specified in the energy tax directive of the EU. Heating oil is subjected to a CO_2- and a sulphur tax.

In general, there is a value added tax (VAT) on energy purchases. There are exemptions for the northern part of Norway, as is also true for the electricity tax.

Legal framework

The provisions of the Energy Act, the Planning and Building Act, labeling requirements and standards for electrical equipment represent some of the legal framework having an influence on energy consumption, and on how energy is used.

The National Office of Building Technology and Administration is responsible for administering the building regulations. The technical regulations pursuant to the Planning and Building Act contain rules governing energy use in buildings. New requirements relating to energy use and a new method of calculating energy use in new buildings are being reviewed.

Through the EEA Agreement, Norway takes part in international cooperation on energy labeling of a number of consumer products. Refrigerators, freezers, dishwashers, washing machines and tumble dryers and household lamps are all now labeled to show energy use. The labels are intended to help consumers select the appliances that use energy most efficiently.