

Report 2008-055

**Facts and Figures on
the Use and Potential
of Biomass
Resources for
Bioenergy in the
Nordic Countries**

Facts and Figures on the Use and Potential of Biomass Resources for

Commissioned by
Nordic Energy Research

Econ Pöyry

Nansensgade 19, 6th floor, DK-1366 Copenhagen K, Denmark. Phone: + 45 33914045, Fax: + 45 33914046,
<http://www.econdenmark.dk>

Table of Contents:

1	BACKGROUND.....	1
2	THE USE OF BIOENERGY IN NORDIC ELECTRICITY GENERATION	2
2.1	Denmark.....	4
2.2	Finland.....	6
2.3	Iceland.....	7
2.4	Norway.....	7
2.5	Sweden.....	8
3	THE USE OF BIOENERGY IN NORDIC HEAT GENERATION	10
3.1	Denmark.....	12
3.2	Finland	13
3.3	Iceland.....	14
3.4	Norway.....	14
3.5	Sweden.....	16
4	THE USE OF BIOENERGY IN NORDIC TRANSPORTATION	18
4.1	Denmark.....	18
4.2	Finland	18
4.3	Iceland.....	19
4.4	Norway.....	20
4.5	Sweden.....	21
5	SUMMARY	23

Tables & Figures:

Figure 1.1	Sources of electricity-production in the Nordic Countries, 2006	2
Figure 1.2	Development of bioenergy in electricity production in the Nordic countries, 1992-2004	4
Figure 1.3	Gross electricity production from bioenergy in Denmark, 1990-2005	5
Figure 1.4	Gross electricity production from bioenergy in Finland, 1992-2005	6
Figure 1.5	Gross electricity production from bioenergy in Norway, 1990-2005	8
Figure 1.6	Gross electricity production from bioenergy in Sweden, 1990-2006	9
Figure 2.1	Sources of gross heat-production in the Nordic countries, 2004 ...	10
Figure 2.2	Development of bioenergy in the heat-production in the Nordic countries, 1992-2004/2006	11
Figure 2.3	Gross heat production from bioenergy in Denmark, 1990-2005 ...	12
Figure 2.4	Gross heat production from bioenergy in Finland, 1992-2005.....	14
Figure 2.5	Gross heat production from bioenergy in Norway, 1990-2005	15
Figure 2.6	Gross heat production from bioenergy in Sweden, 1990-2006	16
Figure 3.1	Consumption of methane in the transportation sector 1999-2007, Iceland	20
Table 3.1	Fuels Consumption in Road Transport 2000-2004, Finland.....	19
Table 3.2	Final energy use of renewable motor fuels 2000-2005 (TWh).....	21
Table 3.3	Bioethanol Production Capacity in Sweden, 2007	21

1 Background

This report is part of a collection of smaller reports under the Nordic Bioenergy Project "*Opportunities and Consequences of an Expanding Bioenergy Market in the Nordic Countries*", which aims to provide factual background information on the status of bioenergy in the Nordic countries. These factual reports cover the following themes:

Econ Pöyry-Report no. 2008-057: Status and Potentials of Bioenergy in the Nordic Countries - Summary

Econ Pöyry-Report no. 2008-054: Facts and Figures on the Use of Bioenergy in the Nordic Countries

Econ Pöyry-Report no. 2008-055: Facts and Figures on the Use and Potential of Biomass Resources for Bioenergy in the Nordic Countries

Econ Pöyry-Report no. 2008-052: Current Bioenergy Application and Conversion Technologies in the Nordic Countries

Econ Pöyry-Report no. 2008-0563 Current Bioenergy Policies and Measures in the Nordic Countries

Econ Pöyry-Report no. 2008-056: Global Aspects of Bioenergy Imports

The Nordic Bioenergy Project was launched in May 2007 by the Nordic Council of Ministers with the aim to help coordinate bioenergy activities in the Nordic countries and improve the visibility of existing and future Nordic solutions in the complex field of bioenergy, energy security, competing uses of resources and land, regional development and environmental impacts.

In addition to the collection of smaller background reports, the Nordic Bioenergy Project has prepared the report "*Energy, Economic and Regional Perspectives in an Expanding Bioenergy Market in the Nordic Countries*". This report provides an overview and analysis of the issues at stake for the Nordic countries in terms of the role of bioenergy in meeting various energy, industrial and regional development policy objectives. The report raises a number of questions in this regard and offers a number of perspectives to inspire future Nordic framework conditions.

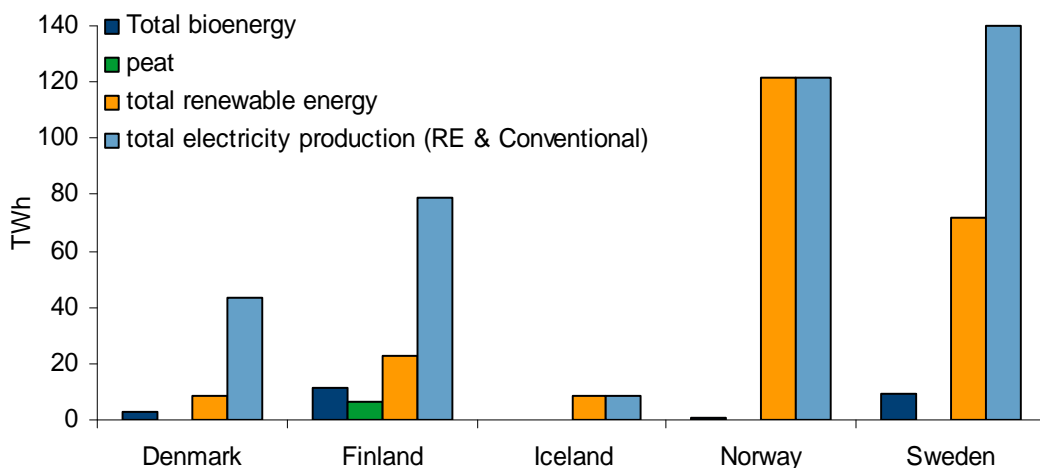
During the project, two workshops were held on the themes "*Bioenergy in the Nordic Countries: Status, Opportunities and Risks*" and "*Bioenergy in the Nordic Countries: Lessons & Future Framework Conditions*". Presentations and summaries from the workshops along with the above mentioned reports are published on the following website:

<http://www.nordicenergy.net/bioenergy>

2 The Use of Bioenergy in Nordic Electricity Generation

Large differences exist among the Nordic countries in terms of the level of renewable electricity generation and the role of bioenergy. While Iceland and Norway are leading in terms of the share of total renewable energy thanks to the extensive use of geothermal energy and hydropower, bioenergy finds little or no application in the electricity generation. Finland is at the top of the heap among IEA member countries with bioenergy representing 12.6 per cent (10.1 TWh) of total electricity production and peat contributing with 8.1 (6.5 TWh) in 2003. In Denmark, bioenergy represents 5.5 per cent of electricity generation (2003) and in Sweden the level was 3.7 per cent in 2003. In 2006 the level in Sweden was 7.7 per cent. Figure 2.1 shows the different use of bioenergy resources for electricity generation across the Nordic countries.

Figure 2.1 Sources of electricity-production in the Nordic Countries, 2006

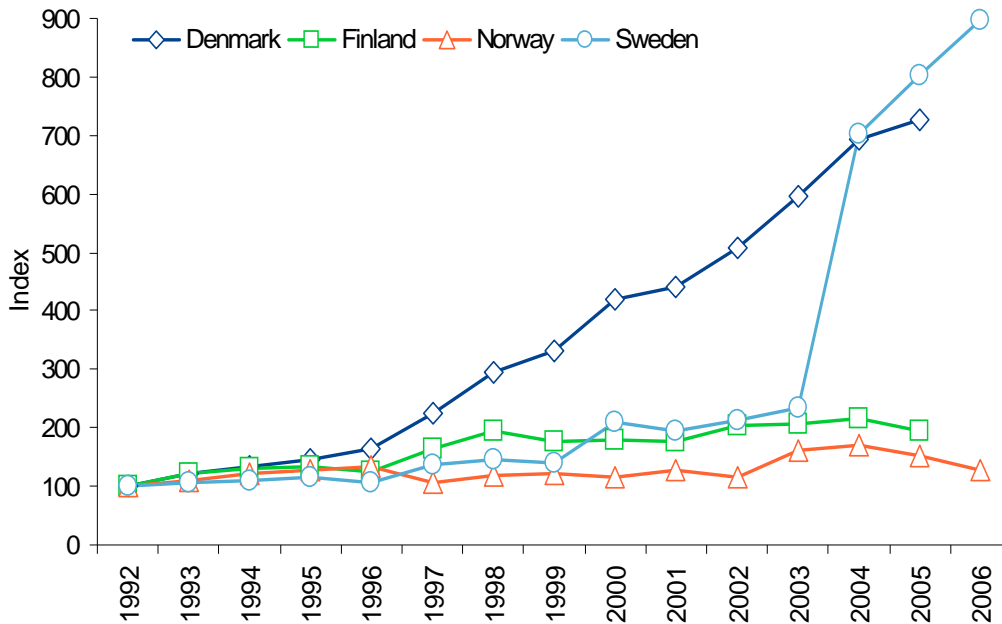


Source: Nordel (2006)

The development of the bioenergy sector in the Nordic electricity generation shows a strong positive trend. Between 1992 and 2004, bioenergy used in the electricity production in Denmark increased strongly by a factor 7; in Sweden bioenergy increased almost by a factor 9 between 1992 and 2006 and in Finland bioenergy more than doubled up to 2004. Bioenergy also increased significantly in Norway from 2002 on-wards.

Figure 2.2 shows the indexed development of bioenergy in the electricity production in the Nordic countries. The index base year is 1992.

Figure 2.2 *Development of bioenergy in electricity production in the Nordic countries, 1992-2004*



Source: IEA, Eurostat, UNECE (2006) Energy questionnaire, Renewables and Wastes, Denmark, Finland, Norway & Sweden

The following paragraphs and graphs describe the type of bioenergy sources used in the electricity generation by country since 1990. Iceland is not included in the following graphs as no bioenergy is used in the electricity generation.

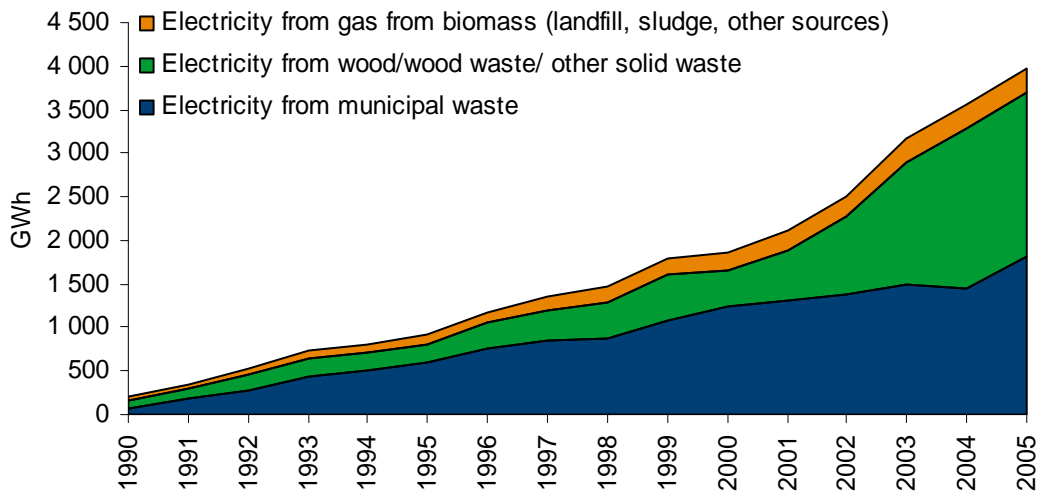
2.1 Denmark

The use of bioenergy for electricity production in Denmark increased by a factor 19 from 210 GWh to almost 4,000 GWh between 1990 and 2005. This is well above the overall growth rate of renewable energy sources which saw a 13 fold increase in absolute numbers. Today, bioenergy is responsible for 37per cent of renewable electricity.

Renewables in electricity production increased from 3per cent of total electricity to 29per cent over the same period.

Municipal waste used for electricity was the first bioenergy resource to be utilised for electricity at a large scale, increasing production from 62 GWh in 1994 to 1 810 GWh in 2005. The use of wood based bioenergy in electricity has increased steeply since 2001 and is today responsible for slightly more electricity generation than municipal waste (48per cent of bioenergy electricity compared to 45per cent of municipal waste).

Figure 2.3 *Gross electricity production from bioenergy in Denmark, 1990-2005*



Source: IEA, Eurostat, UNECE (2006) Energy questionnaire, Renewables and Wastes, Denmark.

The increased use of wood based bioenergy in electricity since the late 1990's is mainly due to political agreements and regulation. The political focus on biomass started much later in Denmark than in Sweden and Finland. After the oil crises in the 1970s, biomass was used for heat production in district heating plants and small heating installations in industries and households. The use of biomass for electricity generation started much later. However, since the 80's the use of biomass for power production has been a central part of the Danish energy planning.

In 1986 the Danish government and the large power producers entered into an agreement about renewable energy and decentralised combined heat and power (CHP), where 100 MW were conditioned to be based on biomass. This resulted in the first Danish biomass agreement (Energiministeriet (1986)). In 1990 came the energy plan Energi-2000 where biomass to CHP-production taken into consideration at the same level as wind and solar power.

In 1993 the Danish government passed the Biomass agreement (Biomasseaftalen 1993) for use of biomass in central and decentralised CHP-plants. The agreement included a mandatory obligation on large power producers to use at least 1.4 million tonnes biomass per year (1.2 million tons straw and 0.2 million tons woodchips) by no later than year 2000. As, it was economically infeasible to use biomass in small CHP units, the obligation was imposed on larger units. The background for the agreement was a prohibition of burning straws at the fields and lacking opportunities for extended use of biomass in decentralised CHP since these plants had to re-organise to use natural gas in accordance with the central natural gas net work planning.

The mandatory obligation on the large power producers spurred a Danish demonstration and research program was started for co-firing of straw in coal dust plants. Today, most biomass is used in conventional thermal processes with grate and dust firing. Co-firing and dust at central power plants is the most used technologies. At present, the Danish central power plants use approximately 21 PJ

biomass per year (mostly straw). However, also gasification of straw has been implemented in several demonstration plants.

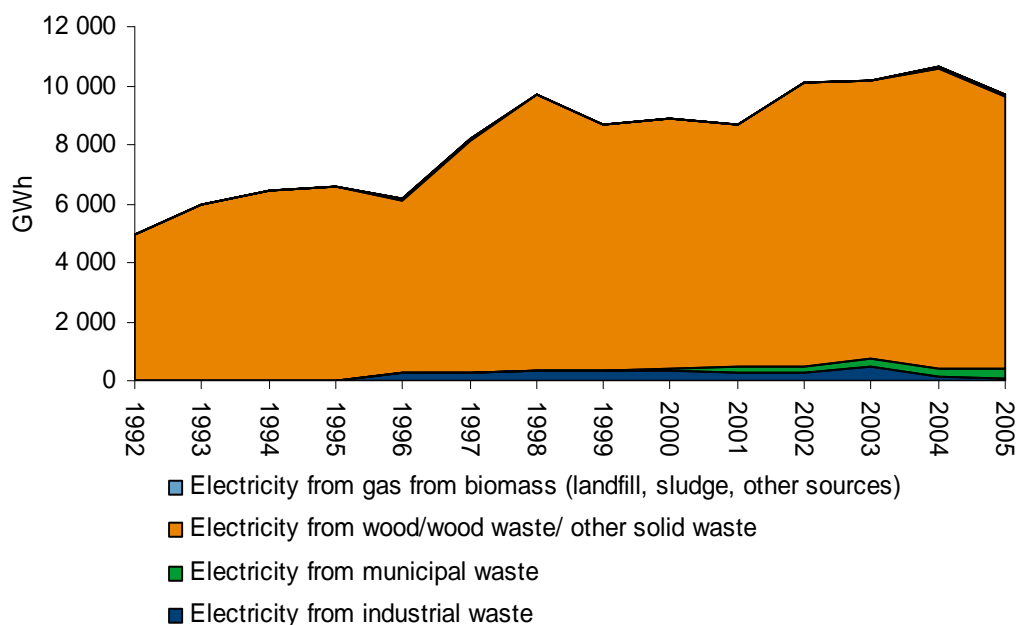
The political focus on straw in large power plants has driven a fast development in the use of biomass in Denmark during the last decade. However, in other areas of the bioenergy field, Denmark has been very modest, such as the promotion of biofuels in the transport sector or in the development of biogas plants. Denmark only accepted a target above 0per cent for biofuel after pressure from the EU. The political opinion in Denmark has been that the use of biomass in the CHP plants is more energy efficient and that due to limited national biomass resources, the use should be the power sector rather than in the transportation sector.

2.2 Finland

National statistics (Statistics Finland) for heat from bioenergy are not fully comparable with the statistics provided by Eurostats. Statistics from Eurostat are used here to provide comparative analysis between Nordic countries.

Finland is the country among the IEA member states with the highest level of electricity from bioenergy feedstock representing ca. 12per cent of total electricity generation. Between 1992 and 2002-2005, the use of bioenergy doubled from ca. 5,000 GWh to ca. 10,000 GWh with wood being the primary source (>94per cent). Bioenergy is responsible for the majority of the absolute growth in renewables used for electricity generation since 1992 and is producing 41per cent of renewable electricity in Finland in 2005. For comparison, hydropower produced 58per cent of renewable electricity in the same year.

Figure 2.4 Gross electricity production from bioenergy in Finland, 1992-2005



Source: IEA, Eurostat, UNECE (2006) Energy questionnaire, Renewables and Wastes, Finland.

During the period of 1999-2003, Finland implemented a Wood Energy Technology Programme focusing on large-scale production of forest fuels for use

by heating and power plants. The Programme included technologies for bundling and chipping at the roadside. There has also been eco-labelled electricity available in Finland since 1998. Eco-labelled electricity accounted for 2.3 TWh of the electricity production in 2004 while sales amounted to 0.4 TWh. A total of 17 companies offered the product in 2005. There are requirements with regards to the collection and use of landfill gas, which has helped increase the use of biogas. Biogas is mainly used for electricity and heat production although a small part has been used for biofuels.

The main driver behind the increase in the use of wood fuels and fuel peat during the past decades in Finland has been the growth in forest industry production. Heinimö and Alakangas report that more than 100 district heating plants and 500 MWe of new electricity production capacity based on wood fuels and peat fuels have been commissioned over the past 10 years. A separate company usually manages the power production also in connection with mills, buying fuel both from the mill and from others, and then selling heat back to the mill and to district heating networks. Excess power is sold to the grid.¹ This creates a strong link between the forest industry and the markets for wood based fuels.

2.3 Iceland

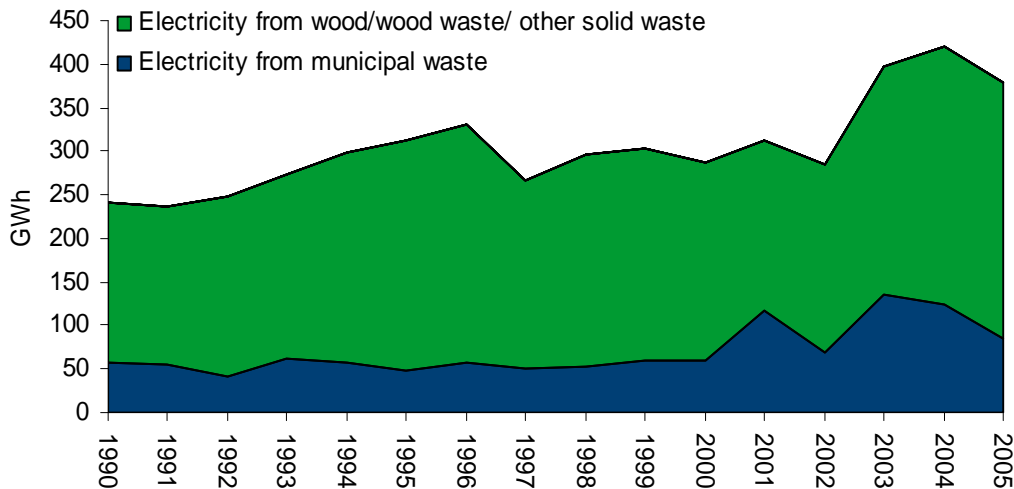
The biogas from Iceland's largest landfill has to be collected and burnt to reduce its greenhouse effect. It is most conveniently used as fuel, since hydro and geothermal electricity is ample and relatively cheap. However, there have not been enough methane vehicles to take advantage of all the biogas collected, so the remainder has been burnt for electricity production since 2003, producing on average about 2,6 GWh/y.

2.4 Norway

Electricity production based on biomass is almost non-existent in Norway. There has been a negligible increase in the period from 1994 to 2005. Of total electricity generation, this is less than 1per cent. Wood based bioenergy dominates with ca. 75per cent of bioenergy electricity. Municipal waste is responsible for the remainder.

¹VTT, 2003; Finnish Forest Industries Federation, 2005 as reported in Heinimö, Jussi & Alakangas Eija

Figure 2.5 *Gross electricity production from bioenergy in Norway, 1990-2005*



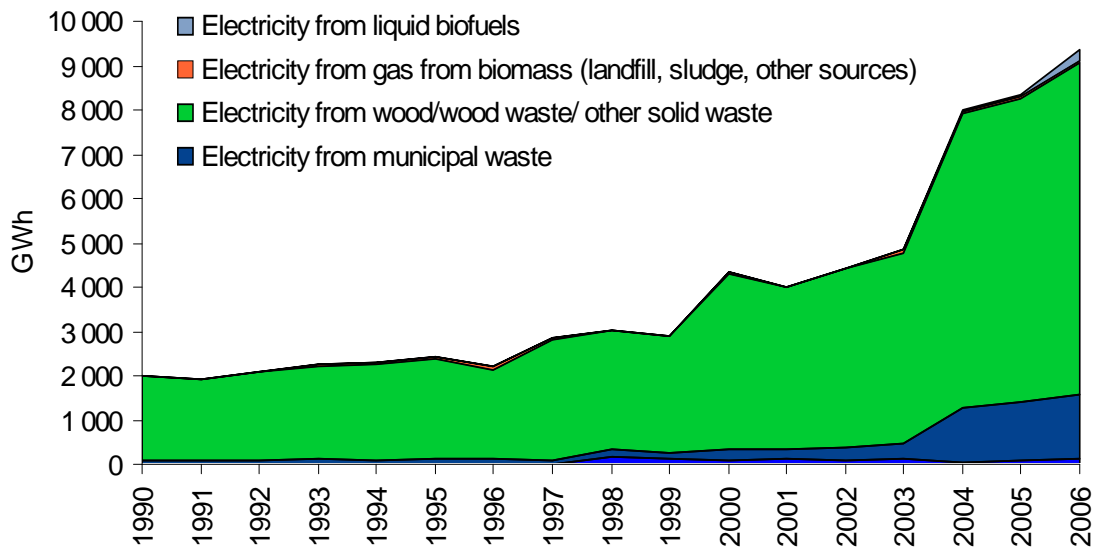
Source: IEA, Eurostat, UNECE (2006) Energy questionnaire, Renewables and Wastes, Norway

The insignificant share of electricity production from biomass can be found in the use of abundant hydro power with cheap electricity prices for end-consumers making bioenergy in electricity generation negligible. The trends in Figure 2.5 are due to capacities of individual plants. Further reasons for the low heat production in Norway are given in Econ Pöyry (2008a).

2.5 Sweden

Bioenergy represents the main source of non-hydro renewables in electricity generation in Sweden. Bioenergy is also the renewable energy source with the highest absolute growth. Electricity from bioenergy quadrupled from 2,005 GWh to 8,001 GWh between 1990 and 2004, of which wood and wood wastes compose the bulk. From 1996 onwards, other types of bioenergy sources have emerged, especially municipal waste, which reached a production of 1,233 GWh or 15 per cent of bioenergy electricity in 2004. Bioenergy increased its share of renewable electricity generation from 3 per cent in 1994 to 12 per cent in 2004.

Figure 2.6 *Gross electricity production from bioenergy in Sweden, 1990-2006*



Source: IEA, Eurostat, UNECE (2007) Energy questionnaire, Renewables and Wastes, Sweden

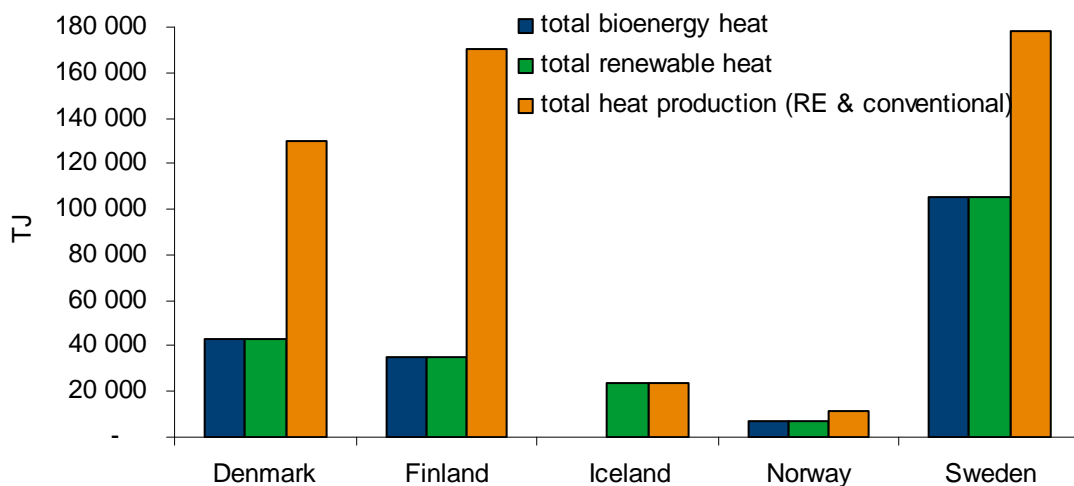
Since 2003 Sweden has a system of green certificates which encompass bioenergy. Today electricity generated with bioenergy makes up the largest share of the electricity in the system for green certificates in Sweden.

According to the Swedish Budget Bill (prop. 2007/08:1) the implementation of the green certificates in 2003 and the reduction of CHP taxation in 2004 has largely had the intended effect of increasing the production of electricity and heat while the production increasingly is based on renewable bioenergy. The Bill quotes the Swedish Energy Agency saying that the production of renewable electricity has increased by 4 TWh since the introduction of the green certificates. Fuel switching and increased production in existing bioenergy fuelled plants make up 3.1 TWh.

According to the Swedish Energy Agency's report 'Elcertifikatsystemet 2007' electricity produced from renewable energy within the system for green certificates accounted for 11.6 TWh in 2006, an increase by 5.1 TWh compared to 2002. Bioenergy provided the main share (70per cent in 2006) of renewable energy being generated or used to increase capacity in existing plants using bioenergy.

3 The Use of Bioenergy in Nordic Heat Generation

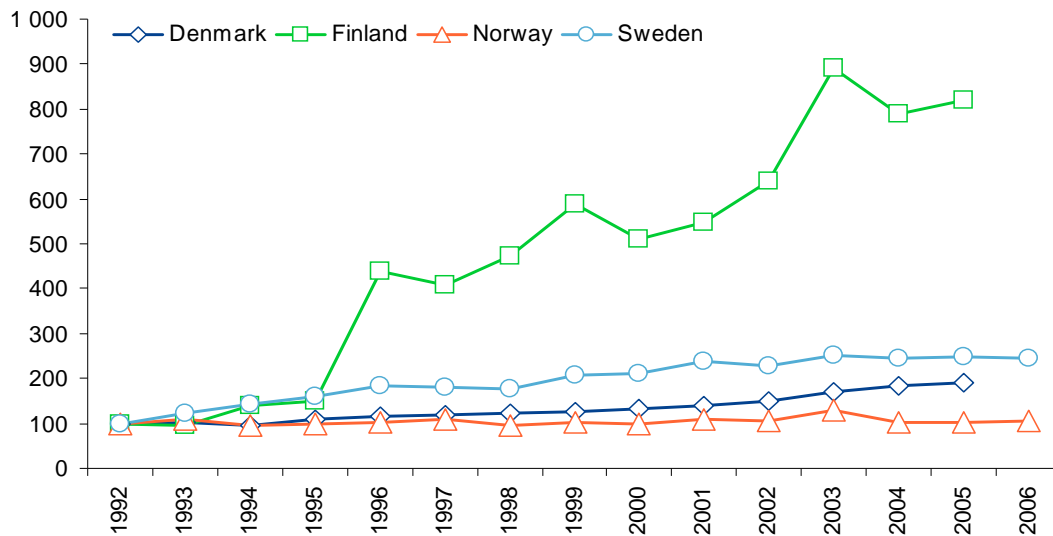
Figure 3.1 Sources of gross heat-production in the Nordic countries, 2004



Source: IEA, Eurostat, UNECE (2006) Energy questionnaire, Renewables and Wastes, Denmark, Finland, Norway & Sweden

Bioenergy provides 37 per cent of gross heat production in the Nordic countries and represents the primary renewable energy source in the production of heat in Denmark, Finland, Norway and Sweden. The shares of bioenergy gross heat production in overall heat production vary across the countries. Sweden leads in terms of absolute application of bioenergy in heating. In terms of district heating, bioenergy represented 48 per cent of district heating in Sweden, 15 per cent in Finland, 11 per cent in Denmark and 7.6 per cent in Norway (2002). The use of biomass for heating in Iceland is limited to municipal solid waste, with a total heat supply of 50-60 TJ/year.

Figure 3.2 Development of bioenergy in the heat-production in the Nordic countries, 1992-2004/2006



Source: IEA, Eurostat, UNECE (2006/2007) Energy questionnaire, Renewables and Wastes, Denmark,

Comparing the development of bioenergy in the national heat production, Finland stands out with a steep increase since 1995 in the use of heat bioenergy up to 9 times the level in 1992. Also Denmark and Sweden have markedly increased bioenergy in the heat generation.

Figure 3.2 shows the indexed development of bioenergy in the heat generation in the Nordic countries. The index base year is 1992.

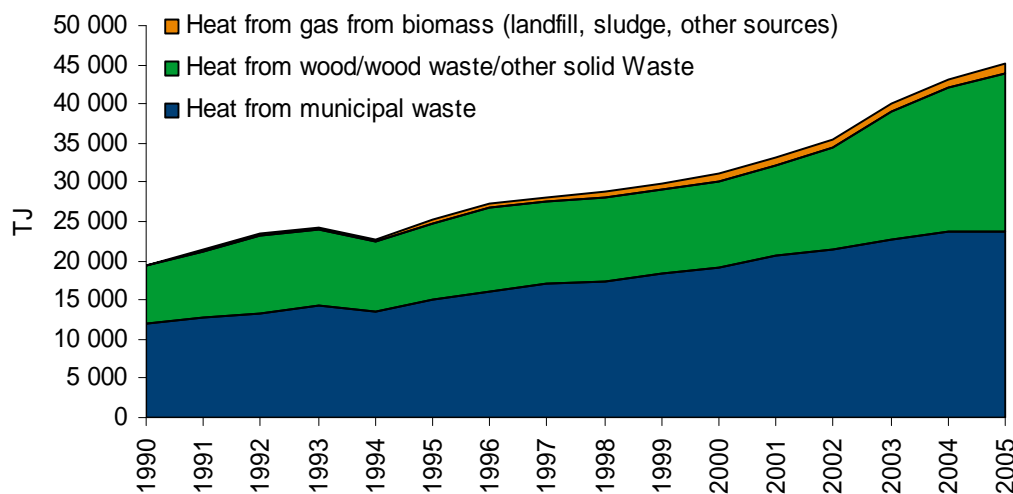
The following paragraphs and graphs describe the type of bioenergy sources used in the heat generation by country since 1990. Iceland is not included in the following graphs as no bioenergy is used in the electricity generation.

The graphs are based on data collected by Eurostat, IEA and ECE from national energy agencies and may differ on the data published in national statistics in a given country. National statistics in each country report statistics with different categories and calculation methods and therefore they are not directly comparable with each other. Eurostat statistics are used here so that the comparison between the countries is possible.

3.1 Denmark

Heat generated from bioenergy more than doubled between 1990 and 2005 from 19,464 TJ in 1990 to 45,040 TJ in 2005. Especially municipal waste and wood biomass contributed to the increase. Heat generated from municipal waste increased from ca. 12,000 TJ to 23 600 TJ and wood biomass from ca. 7,400 TJ to ca. 20,300 TJ over the period. Heat from biogas increased significantly, but from a low level from 127 TJ in 1990 to 1 154 TJ in 2005.

Figure 3.3 Gross heat production from bioenergy in Denmark, 1990-2005



Source: IEA, Eurostat, UNECE (2006) Energy questionnaire, Renewables and Wastes, Denmark

Denmark has a long tradition in district heating. The first combined heat and power plant (CHP) was built in 1903, which was also a waste combustion plant. The first large collective district heating system was developed in Copenhagen in the 1930's.

Due to increasing problems with waste handling and depositing, the use of waste combustion plants became common in the 1970s. Several municipalities constructed large common waste combustion plants for district heating.

The oil crises in the 1970s started the formulations of Danish energy plans. In 1979, Denmark got its first Heat Supply Law. The law laid down framework and

content of heat planning in Denmark and represented the start of an era of central energy planning. An extension plan for the natural gas and district heating networks was made for all dense population areas. The building of the natural gas and district heating networks required massive investments and in order to ensure that a sufficient amount of households would be connected to the grids, the planning was made central for Denmark. The natural gas and district heating grids were planned in such a way that they did not overlap while ensuring a combined coverage of densely populated areas. This meant that most households should have access to natural gas or district heating, but no households would have access to both, hence with no possibility for substitutions between the two energy sources.

The Heat Supply Law gave the municipalities the authority to enforce a mandatory connection obligation to the public supply on new and existing households - either to the natural gas or to the district heating networks.

The mandatory connection to the grids in the large supply areas had a transition period of 8-10 years for existing installations – allowing households time to face out their existing boilers.

Since 1988, electric heating as primary space heating energy has not been allowed in new houses with access to public energy supply (natural gas or district heating), and from 1994 existing houses were no longer allowed to use electric heating.

Environmental concerns in the 80'ies resulted in fuel taxed on the heat production. Biomass and biogas were exempted from the fuel taxes.

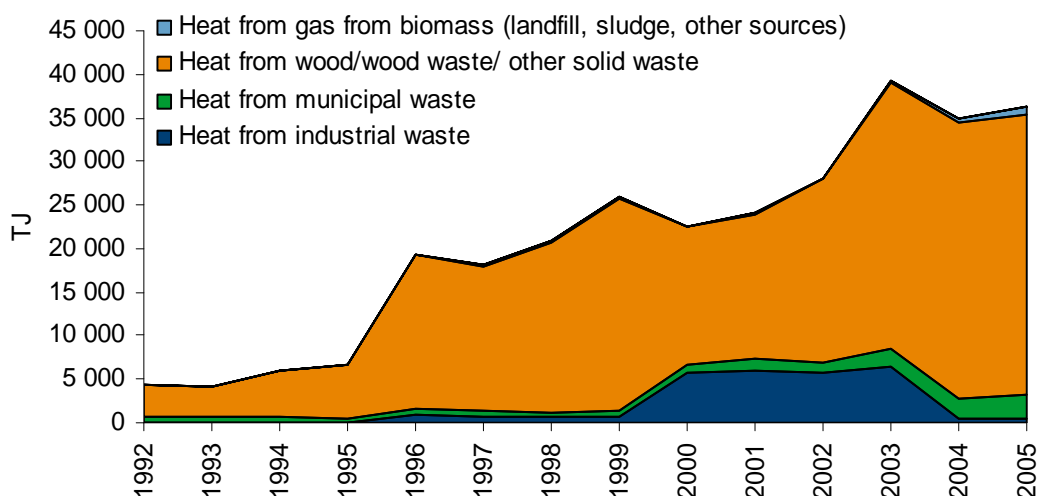
In 1993, the Danish government passed the Biomass Agreement for use of biomass in central and decentralised CHP-plants. The agreement included a mandatory obligation on large CHP and power producers to use at least 1.4 million tonnes biomass per year (1.2 million tons straw and 0.2 million tons woodchips) no later than by year 2000. The large spread of district heating and the Biomass Agreement have been the main drivers for the development of heat production from bio-energy in Denmark.

Where there is no public supply of district heating or natural gas, primarily in rural areas, oil boilers are still the main space heating installations in households. Use of firewood, wood pellets and other alternative installations only count for a small share of the total consumption and are often installed as a supplement to the main installations.

3.2 Finland

Heat from bioenergy increased in Finland by a factor 8 from ca. 4,400 TJ in 1992 to ca. 36,200 TJ in 2005 with the bulk coming from an increased use of wood and wood wastes, including black liquor in industry for heating. Up to 25per cent of bioenergy heat was generated from industrial waste between 2000 and 2003. Municipal waste is gaining pace especially since 2000 up from ca. 550 TJ to 2776 TJ in 2005. Biogas for heating was introduced from 1996 and has since seen a steep increase in the application of especially landfill gas. Gas from biomass used in heating augmented from 30 TJ in 1996 to 927 TJ in 2005.

Figure 3.4 Gross heat production from bioenergy in Finland, 1992-2005



Source: IEA, Eurostat, UNECE (2006) Energy questionnaire, Renewables and Wastes, Finland

The 1999-2003 Wood Energy Technology Programme focusing on large-scale production of forest fuels for use by heating and power plants has played a central role in the development of heat production from bioenergy. The forest industry is the largest consumer of heat in Finland and the growth in this industry has been one of the main drivers of the increased use of bioenergy for heat production. Fossil fuels and tall oil are taxed for heat production. Government decisions require the collection and use of landfill gas which has increased the use of biogas. Biogas is mainly used for electricity and heat production.

Wood and peat made up 30 percent of fuel provided to the district heating sector in 2004. CHP based heat production made up 76 percent of the heat produced for district heating. Most big CHP plants use fluidised bed combustion (FBC) and operate within the forest industry. FBC technology has been developed by Finnish boiler makers and is suitable for fuels which are more difficult to use. It is the main technology in new larger biomass fired plants, and a number of older boilers are being converted to this technology.

The Finnish production of wood pellets was started in 1998 and was primarily based on exports as pellets have not been competitive against other heating fuels in Finland. The Finnish government considered subsidies to the private sector investments in wood pellet heating systems in 2006. Exports of pellets and tall oil have been economically viable due to domestic levels of taxation on fossil fuel or subsidies for the production of electricity from biomass in other countries.

3.3 Iceland

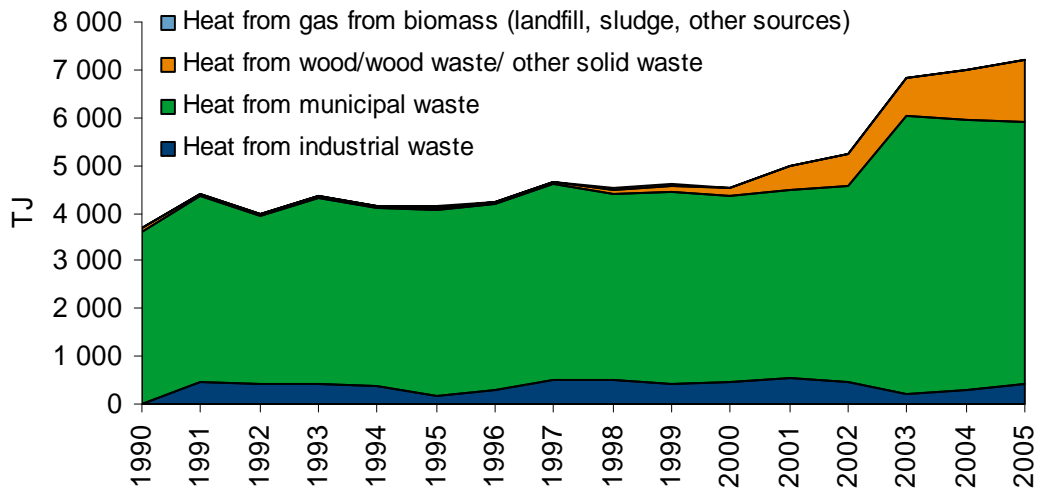
Several municipal waste district heating utilities are in operation in Iceland, with total production around 65TJ/y. (2005)

3.4 Norway

Municipal waste produces the bulk of bioenergy heat in Norway, increasing by 52per cent over the period from ca. 3,600 TJ in 1990 to ca. 5,500 TJ in 2005.

Industrial waste and heat generated from biogas represent a stable minor share of overall bioenergy heat production. Heat generated from wood and wood waste has increased since 2000 and represents today 18per cent (1,316 TJ) of bioenergy heat produced in Norway.

Figure 3.5 Gross heat production from bioenergy in Norway, 1990-2005



Source: IEA, Eurostat, UNECE (2006) Energy questionnaire, Renewables and Wastes, Norway

Due to low prices of alternative heating sources (low electricity prices) combined with relative high investment costs for district heating, electric space heating and not district heating dominates the heat market in Norway. The country has a very limited use of thermal based furnaces for heating in the households unlike what is seen in the other Nordic countries.

Since 1997, the Authorities have provided subsidies to use bio-energy for heat production (district heating). District heating only makes up 2per cent of the energy supply for heating in Norway unlike in the rest of the Nordic countries. District heating is mostly used in Oslo, Fredikstad and Trondheim. The district heating Oslo is the largest and produces almost half of the total district heating in Norway.

The district heating system in Oslo has been in use since 1937. However, it was not until the 1980'ies the development gathered speed, in order to use the exhaust heat from the waste combustion plants (Brobekk and Klemetsrud). These are still the main suppliers of district heating and cover today around 15per cent of the heat demand in Oslo.

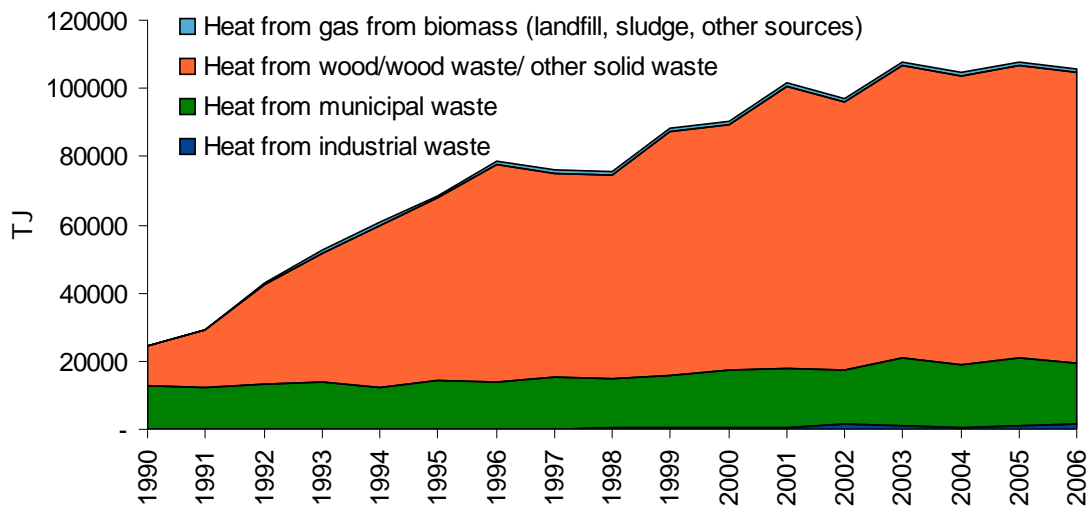
Heat based on industrial waste wood resources is mainly used in wood industries as process heat. 1/3 of the final biomass use is based on industrial waste wood. The other 2/3 is for heat in households.

For the period 2002-2006, Enova managed to contract 2 TWh of energy through its support programmes ofr bioenergy. Grants and supports for heat generation make out ca. 20per cent. This indicates that of the 2TWh contracted energy, only 0.4 TWH heat have been realised. Previously, Enova provided generous fund to the support of the production of briquettes and pellets with the result that the Norwegian market experiences an overproduction.

3.5 Sweden

The overall use of bioenergy for heating quadrupled between 1990 and 2004. Wood based heating increased significantly, especially during the 1990s, and over the full period by a factor 7 from ca. 12,000 TJ to ca. 85,000 TJ². The use of municipal waste for heating purposes was relatively stable over the period with production increasing from ca. 12,550 TJ in 1990 to ca 18,000 TJ in 2004. Less than 1per cent heat from industrial waste was reported since 1998.

Figure 3.6 Gross heat production from bioenergy in Sweden, 1990-2006



Source: IEA, Eurostat, UNECE (2007) Energy questionnaire, Renewables and Wastes, Sweden

The growth in bioenergy in Sweden is strong in the areas of bio-CHP, biofuels for transports and pellets. District heating and industry represent the largest users of bioenergy. Out of the current 270 Swedish municipalities with a district heating system in place, 250 use biomass fuels. About two thirds of energy in district heating is bioenergy in the form of wood fuels, peat and household waste. At the moment, several large projects involving bioenergy powered large CHP (combined heat and power) are planned in the Stockholm area. Fortum plans two in Värtan and Brista, Söderenergi plans one in Södertälje and E.on plans one in Järfälla. The project in Värtan could produce 800 GW of renewable electricity and replace the heat production in heat pumps to the equivalent of 250 GWh.

The Swedish pellet market developed early due to an active energy policy in combination with significant taxation of fossil energy. Sweden pioneered the use of pellets in CHP with the use of pellets in existing oil fired CHP, which meant that no major new investments were needed. Pellet production increases with 25-30 per cent per year totalling 1.5 million tonnes (7TWh). The amount of pellets sold to the single family home sector has increased by 72 percent from 2005 to

² This data is based on the Swedish energy statistics reported to Eurostat, IEA and ECE from the national energy agency. It may differ from reporting of national energy statistics.

2006. One major driver behind this development has been the tax on oil which led to increasing costs for the consumers. Other drivers have been a temporary programme aimed at promoting small scale bioenergy and the growing maturity of pellet based heating which has contributed to turning this into a credible alternative.

4 The Use of Bioenergy in Nordic Transportation

4.1 Denmark

Denmark has a growing production of biodiesel based on rape seed. Between 2001 and 2006, the production more than tripled from 25,000 tonnes to 80,000 tonnes. The totality of the production has been exported to primarily Germany and Sweden, where tax exemptions on the biofuel provides better market conditions. One producer in Denmark is responsible for the total production of biodiesel: Emmelev Mølle.

Statoil started in May 2005 as the only distributor in Denmark to sell 'bio95' from 205 out of 306 petrol stations in Denmark. Bio95 is 5 per cent ethanol added to octane 95 petrol, where the bio-ethanol is produced based on cereals, corn, sugar beets etc. using the 1st generation conversion technology. The sale of bioethanol in 2006 represented 0.2 PJ with a strong positive trend, amounting to 0.15 per cent of total sale of petrol and diesel for transportation purposes.

4.2 Finland

Finland has a small but rapidly growing market for bioethanol, increasing the imports of bioethanol from 1 143 tonnes in 2002 to 6 752 tonnes in 2004. The main use of biofuels originate from fixed term projects aimed at mixing bioethanol with gasoline or small scale trials with biodiesel and biogas.

Neste Oil has started the first domestic Biodiesel production on 31 May 2007 in Porvoo with a planned annual capacity of ca. 170,000 tonnes of biodiesel. The production will be based on vegetable oils and animal fats. Most of the vegetable oils will originate from imported palm oil. Neste Oil also produces bio-ETBE since 2004 with an annual capacity of 100,000 tonnes. The ethanol contained in ETBE is imported from Brazil and the end-product is mixed with petrol for export (Finnish Ministry of Trade and Industry (2007)).

Only a small share of the biogas used in Finland has so far been used for biofuel. From 2004 onwards, biogas for motor fuels became exempted from excise duty and gas driven vehicles were also exempted from the power output taxation, which is imposed on all motor vehicles using fuels taxed less heavily than petrol.

Table 4.1 Fuels Consumption in Road Transport 2000-2004, Finland

Year	Fuels in road transportation total [PJ]	Gasoline [PJ]	Diesel Fuel [PJ]	Liquid biofuels	
				PJ	per cent
2000	153	76	77	-	-
2001	156	77	78	-	-
2002	159	79	80	0.033	0.02
2003	161	79	82	0.176	0.1
2004	166	80	86	0.186	0.1

Source: Statistics Finland 2005

VTT and number of Finnish companies are developing a technology (Fisher-Tropsch) to refine gas from wood and peat where the gas can be used for producing 2nd generation biodiesel. VTT Technical Research Centre of Finland has already commissioned a small gasification plant and the first commercial plant is expected after 2010.

The first 2nd generation plant will probably be located in Varkaus as Neste Oil and forest industry company Stora Enso have signed an agreement to join forces in developing technology for producing next-generation biofuels from wood residues. The first phase will be the design and building of a demonstration plant at Stora Enso's Varkaus Mill, in Finland.

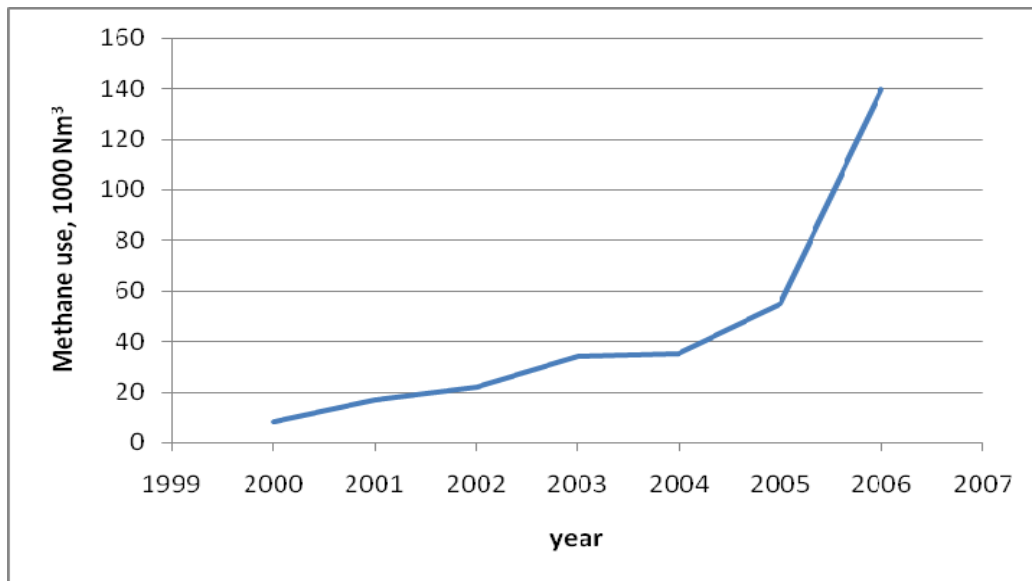
Forest industry company UPM and waste management and recycling company Lassila & Tikanoja (L&T) have also developed a new ethanol and energy production concept that makes use of commercial and industrial waste.

St1 Biofuels is planning to set up a bioethanol production plant in the Turku region. The company plans to produce ethanol from excess materials provided by grocery stores and bakeries. The facility would produce 1-2mn litres of 85per cent bioethanol initially. It would be concentrated in Hamina. In three years, the company hopes to have 20-30 plants in Finland producing 70mn litres of bioethanol.

4.3 Iceland

Transportation is the field where bioenergy is most promising for Iceland. So far, the only domestically produced biofuel is methane, and Figure 4.1 below shows the increase in use of methane over six years.

Figure 4.1 Consumption of methane in the transportation sector 1999-2007, Iceland



Source: Ministry of Industry, Energy Office, Iceland.

The increase in use of methane is indicative of the general increase of interest in biofuels in Iceland.

Other biofuels, such as B5 and E15 have been imported, with E85 import only beginning in 2007. Currently there is not much demand for biofuels, mainly because tax incentives have not yet been fully implemented, but it is expected that in the very near future they will be, see Econ Pöyry (2008b).

4.4 Norway

The development of biofuels in Norway is still in its infancy. For some years, biodiesel in Norway has been dominated by fish wastes, but a production of Biodiesel is taking off, primarily based on imported rape seed. In the statistics, the use of biofuels has been negligible, although several petrol companies now offer a low mixture with biodiesel.

The company Estra in Trøndelag is the largest producer of Biodiesel in Norway that produced ca 10 million litres per year based on salmon oils from processing wastes. Due to a too high level of iodine according to the European Standard EN 14214 for biofuels, the salmon oil based biodiesel production has been stopped. The production is now based on imported rape seed oil from primarily Denmark.

Several large production plants are being constructed or planned around the Oslo Fjord. If the plans are realised, the production of 1st generation biodiesel will represent almost 20per cent of the current use of diesel in Norway. Given the limits to the application of biodiesel in the existing automobile park, Norway may in the near future become a net exporter of Biodiesel – based on imported bioenergy resources.

4.5 Sweden

Sweden is leading in terms of developing a commercial market for clean vehicles and biofuels for transportation in the Nordic countries. Today most petrol in Sweden contains 5 percent of ethanol. In 2006 biofuel made up approximately 3 percent of the total use of fuel for transport in Sweden. Sweden operates with several kinds of biofuels, e.g. E85 fuel which is a mixture of bioethanol with 15 percent of gasoline, a five-percent mixture of ethanol in all 95 octane gasoline, rapeseed oil based biofuel (RME) and biogas. RME can be mixed into diesel fuel creating a greener alternative.

Different customs duties exist depending on whether the imported ethanol is used for E85 or for the five-percent mixture. This demands separate storage of bioethanol. The present budget proposal envisages a change to these rules (see Econ Pöyry (2008a)). Approximately 85 percent of all petrol sold in Sweden consists of petrol mixed with 5 percent of ethanol. E85 can be bought at a number of petrol stations. Through mixing of RME (metyl ester of rape seed oil) into diesel, the use of biofuel for transport increases quickly. Price increases are looming if demand for bioethanol rise in countries such as the US, England and France.

Final energy use of renewable motor fuels increased from 0.26 TWh in 2000 to 1.94 TWh in 2005 of which the majority was based on bio-ethanol.

Table 4.2 Final energy use of renewable motor fuels 2000-2005 (TWh)

TWh	2000	2001	2002	2003	2004	2005
Ethanol	0.16	0.25	0.45	0.88	1.54	1.68
Biogas	0.05	0.06	0.09	0.11	0.13	0.16
FAME	0.06	0.03	0.04	0.05	0.09	0.1
Total	0.26	0.34	0.58	1.04	1.75	1.94

Source: Swedish Energy Agency (2006).

Sweden imports the majority of bioethanol (83 per cent in 2004) and produces the remainder based on cereals and wine alcohol. Of the 153 million litres produced domestically in 2005, 90 million litres were produced based on wine surplus production in France (90 million l). There are two main producers of bioethanol in Sweden, Agroetanol and SEKAB (See Table 4.3 below).

Table 4.3 Bioethanol Production Capacity in Sweden, 2007

Company	Production capacity (million litres)	Production capacity under construction (million litres)	Feedstock
Agroetanol	50	155	Cereals
Sekab	100	-	Wine Alcohol

Source: www.ebio.org

In 2006, the biodiesel production capacity under construction increased substantially, with a total of 19 companies being granted tax exemptions for biodiesel production. Among these was Lantmännen Karlshamn, which set up a

new plant for RME production. This plant will produce 45 million litres per year during the first years and after that the production is expected to double. Perstorp has also set up a new plant, which will produce 60 million litres RME per year. It is expected that a lot more biofuel in Sweden will be based on raw materials from the forest in the near future. By the year 2020 there could be 18 TWh/year. However, half of that – 9 TWh – is viewed as good³. Sweden had a small production of Biodiesel of 13,000 tonnes in 2006 (ca. 14.3 million litres) (Statistiska Centralbyrå, 2007)

According to reports in media in 2007 there have been problems with the supply of E85. Market participants foresee a strong growth in demand for E85 due to increasing sales of green cars.

In 2005, ethanol from Brazil accounted for 70 percent of the consumption. Most biofuels for transport are thus imported. The main sources for bio diesel are Denmark and Germany. The main sources for ethanol are Brazil, France, Spain, Italy and Norway. The rapid increase in use is attributed to various policy initiatives (Sandebring, 2004).

³ <http://www.nyteknik.se/art/46151>

<http://www2.sjv.se/nyhetsarkiv/nyheter/5.1737b9f10d11b6eae480003136.html>

<http://www.svenskraps.se>

5 Summary

In *electricity production*, Finland is a leading country in the application of bioenergy, not only among the Nordic countries but also among IEA member countries with bioenergy representing 12.6per cent (10.1 TWh) of total electricity production and peat contributing with 8.1 (6.5 TWh) in 2003. Denmark had a bioenergy share of electricity generation of 5.5per cent in 2003 while in Sweden 7.7per cent biomass contributed to electricity in 2006. According to statistics biomass contributed 3.7per cent to electricity in 2003. One reason for the relatively low number for 2003 was a tax rule which encouraged registering biomass with fossil fuels. The current level of bioenergy use in electricity is based on a strong positive trend, which in Denmark meant an increase by a factor 7 between 1990 and 2005, in Sweden an increase by a factor 4 (between 1990 and 2004) and in Finland by a factor 2 (between 1990 and 2005).

In *heat generation*, bioenergy represent the main renewable resource. Sweden leads in terms of absolute application of bioenergy in heating where ca. 250 municipalities apply bioenergy. Bioenergy represented 48per cent of district heating in Sweden, 15per cent in Finland, 11per cent in Denmark and 7.6per cent in Norway (2002). The use of biomass for heating in Iceland is limited to municipal solid waste, with a total heat supply of 50-60 TJ/year. Comparing the development of bioenergy in the national heat production, Finland stands out with a steep increase since 1995 in the use of heat bioenergy up to 9 times the level in 1992.

In transportation, Sweden is leading in the efforts to develop a commercial market for clean vehicles and biofuels, with currently a 3per cent share of biofuels of total transportation fuel, primarily based on bioethanol. Biofuel production is also in Finland and Norway experiencing a strong growth, mainly based on biodiesel. Denmark currently exports the large majority of Biodiesel produced to Germany and Sweden.

References

- Biomasseaftalen 1993: <http://www.ens.dk/sw13380.asp>
www.ebio.org
- Econ Pöyry (2008a): Current Bioenergy Policies and Measures in the Nordic Countries.
- Econ Pöyry (2008b): Global Aspects of Bioenergy Imports.
- Energiministeriet (1986), Aftale af 6. juni 1986 om den fremtidige eludbygning og en forstærket indsats på energibesparelsesområdet.
- Finnish Ministry of Industry and Trade, 2007. Report of the Finnish Ministry of Trade and Industry pursuant to Directive 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport in Finland. 36/020/2007.
- IEA, Eurostat, UNECE (2006) Energy questionnaire, Renewables and Wastes, Denmark
- IEA, Eurostat, UNECE (2006) Energy questionnaire, Renewables and Wastes, Finland
- IEA, Eurostat, UNECE (2006) Energy questionnaire, Renewables and Wastes, Norway
- IEA, Eurostat, UNECE (2007) Energy questionnaire, Renewables and Wastes, Sweden
- Ministry of Industry, Energy Office, Iceland.
- Nordel (2006), Annual Statistics 2006.
- Sandebring, H., (2004) Introduktion av förnybara fordonsbränslen – Slutbetänkande av utredningen om förnybara fordonsbränslen, SOU 2004:133 as quoted in Energimyndigheten's report "The future of bioenergy in Sweden – Background and a summary of outstanding issues".
- Swedish Energy Agency (2006), Energiläget i siffror. Energy in Sweden – Facts and figures.
- Swedish Energy Agency (2007) Elcertifikatsystemet 2007. ET 2007:26. Stockholm, Sweden.
- The Swedish Budget Bill for 2008: Putting Sweden to work - increasing opportunities, September 2007