Biomass market and trade in Norway: Status and future prospects

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ABSTRACT

This paper gives an overview of bioenergy use, prices, markets and markets prospects in Norway. The current bioenergy production in Norway is about 60 PJ or 10% of the stationary energy consumption. About one half is produced and used in forest industries. The main share of bioenergy used by households consists of firewood in stoves. The use of refined, solid biofuels is hampered by low coverage of water-borne heating systems and historically low end-user prices of electricity.

Harvest levels in Norwegian forests are much below annual growth, implying that forest biomass resources steadily accumulate. Decreasing wood prices combined with rising prices of oil and electricity in recent year, have improved competitiveness of solid biofuels in the heat market.

Projections of future bioenergy use in Norway using a partial equilibrium forest sector model suggest that bioenergy use will increase in some market segments with the current price levels of electricity and oil. However, quite minor improvements of bioenergy competitiveness or increased energy prices may release substantially higher bioenergy use. A net increase in bioenergy use of 5 TWh by 2010 is realistic, but requires public awareness of the opportunities in bioenergy technologies. Wood stoves and replacement of oil-boilers in central heating systems show highest competitiveness, whereas district heating systems need higher energy prices or cost sharing systems for investments to be competitive. Biomass for combined heat and power projects or domestically produced liquid biofuels seems to have limited competitiveness in the short term. On the raw material side, wood residues, and roundwood from pine and non-coniferous species represent the main potential, whereas spruce continues to be consumed by the forest industries. According to the model projections, imported biomass will take a significant share of the possible increase of wood consumption, given that the forest industries maintain their current production level.

1 INTRODUCTION

The targets set by many independent countries and indeed by the European Union regarding use of bioenergy (European Commission, 1997; European Parliament and Council, 2001; European Parliament and the Council, 2003 and European Commission, 2005) indicate a substantial increase of biomass use for energy purposes in Europe. The Norwegian Government has defined a target of increasing the use of new renewable energy sources (i.e. renewable energy sources except hydro power) to 30 TWh (108 PJ) by 2016. The current level is just below 25 PJ. For liquid biofuels, the Government has stated that they intend to follow the EU directive on the promotion of the use of biofuels or other renewable fuels for transport (The European Parliament and the Council, 2003), implying that 5.75% of total liquid fuel should be based on biomass by 2010. The current share in Norway is less than 0.1%.

Traditionally, biofuels have mainly been traded within its country of origin. In recent years, however, international biofuel trade has grown in magnitude, at least in some regions. Achieving the political targets mentioned above in a cost efficient way implies further development of international biofuel markets[1]. One major obstacle for development of international biofuel markets is lack of information on market conditions (e.g. prices, production volumes, capacities, costs, and trade) of biofuels, relevant policies and market prospects in different regions. Knowledge of the market place and main characteristics of supply, demand and trade is also essential for developing efficient policies to reach the targets set by the government. The lack of market information is reflected by the international research and development efforts to increase knowledge and understanding on these issues (e.g. the EUBIONET II project, IEA bioenergy Task 40 and others).

The purpose of this paper is (i) to provide an overview of the current state of the Norwegian biomass and biofuel market and trade, and (ii) to assess the bioenergy and biomass market potential and likely development. The article is partly based on new data and analyses, but relies also strongly on previous work. For example, Risnes, Iversen, Klokk and Førde (2003) review the role of biomass in the Norwegian heat market and current policies deployed for bioenergy promotion. A recent study by Energidata, Institute of Transport of Economics and KEMA Consulting (2005) develop scenarios regarding future use of

[1] Risnes (2004) discusses main motivations for Norwegian energy authorities to stimulate development of international biofuel trade.

bioenergy in Norway and investigate cost structures of refined solid biofuel producers. Finally, Bolkesjø, Trømborg and Solberg (2006) analyses the economic potential of bioenergy given various scenarios for prices of alternative energy sources. A complete overview of the biofuel and bioenergy markets, market potentials and prospects is, however, lacking.

As we will elaborate below, the main short-term potential of biomass use in Norway lays within the heating sector. Therefore, when discussing market potentials and medium-term prospects, more focus is put on the heat market and less on biofuels in the transport sector and for electricity use. Also, as a result of the resources available in Norway, main attention is paid to woody biomass and solid biofuels.

The rest of the paper is organized as follows: First, we give a brief overview of the Norwegian energy system and relevant policies with respect to bioenergy use in Norway. Then, in section 3 the main market characteristics are presented – covering both the total domestic market, prices and direct and indirect biomass imports and exports. Section 4 discusses the potential for bioenergy implementation in Norway and presents results of a quantitative study projecting the bioenergy use in Norway and corresponding biomass import.

2 POLICY SETTING

2.1 More general energy policy

Since the 1970s, Norway has had a strong economic growth mainly as a result of rich oil reserves in the North Sea. In 2004, the Gross Domestic Product (GDP) was about 215 million Euro, or about 46 700 Euro per capita (including off-shore activities). Besides the petroleum sector, energy-intensive productions such as the metal and forest industries are significant economic sectors. The Kyoto target is a maximum 1 percent increase of the emissions from 1990-level.

The Norwegian energy system is strongly based upon hydroelectric power as a result of expansive public engagement for hydropower construction in the period 1960-1990 (Christiansen, 2002). Since 1990, policies have developed towards more focus on environmental objectives such as preservation of water falls and reduction of green house gas emissions. As a result, there has been very limited growth of hydropower capacity in recent years. And with a corresponding annual growth of domestic power consumption of 1-1.5 %, Norway is now a net importer of electricity in a so-called normal precipitation year. Gas-fired power plants, based on Norway's vast gas resources, are by many regarded as the main solution to the situation of excess power demand. High gas prices and environmental concerns related to CO_2 emissions, however, have delayed the commercialization of this technology. It seems clear, that with market conditions as of 2006, gas-power needs substantial policy support to be initiated in Norway. It also seems clear, that the future use of gas power plants in Norway will strongly affect the economic conditions for bioenergy via market mechanisms.

Besides the gas-power debate, Norwegian energy policy focuses quite strongly on increased production of new renewable energy sources (renewables except hydropower), reduced energy consumption and improved flexibility of the energy system. Enova SF, which is a public enterprise owned by the Ministry of Petroleum and Energy, was established in 2001 to promote and support the use of new renewable energy sources. Investment subsidies to heating centrals and heat distribution installations are the most important means used by Enova. In 2004, Enova's budget was NOK 796 Million[2] (≈ 100 Million EUR). This amount is likely to be doubled by 2009 as a consequence of a new energy program announced by the Norwegian government in June 2006. About 14% of Enova's 2004-budget was assigned to heating projects, while almost 50% were used for wind power projects. Enova covers up to 30% of the investment costs to heat distribution installations larger than 1 GWh/year, and up to 25% for heat production units producing more than 25 GWh/year (≈90 TJ/year). Besides Enova, Innovation Norway is responsible for financial support of small-scale bioenergy installations initiated by farmers. Innovation Norway's budget for bioenergy projects amounted to 18 mill NOK (≈ 2.3 Mill. EUR) in 2004. Innovation Norway covers up to 25% of investment costs (up to 50 percent for pilot projects). Moreover, Innovation Norway has recently started a new support scheme for all renewable energy sources. Innovation Norway also has an international perspective with 40 offices around the world supporting new Norwegian business development more generally abroad.

2.2 Taxes

Electricity and fossil fuel taxes are important parts of the energy policy in Norway affecting bioenergy competitiveness. Currently, the electricity tax is 96.7 NOK/MWh (≈ 26.9 EUR/GJ). Industrial sectors are exempted from this tax. The total tax on oil use for heating is approximately 100 NOK/MWh (≈ 3.4 EUR/GJ). Gas and diesel used in vehicles is also subject to taxation. Currently, the tax on gas is 0.59 EUR/liter (including a CO_2 tax of 0.10

[2] 1 NOK ≈ 1/8 EUR.

EUR/liter), while the corresponding tax on diesel is 0.44 EUR/liter (including a CO_2 tax of 0.07 EUR/liter) (www.np.no). Bio-ethanol and bio-diesel is not subject to these taxes. A consumption tax of 25% applies to energy consumption and is added after special taxes have been applied.

2.3 Research and development

Norway's total governmental budget for energy research and development was NOK 441 million (International Energy Agency, 2005), while the budget for 2005 was NOK 635 million. Almost 60% of the total budget is allocated to petroleum-related research, while about 7% is assigned to renewable energy sources. Research related to renewable energy sources organizes under the research program "RENERGI" (Clean energy for the future), administrated by the Norwegian Research Council and with an annual budget of about 20 mill EUR in 2006. The program prioritizes the following areas: Renewable energy production, natural gas, hydrogen, energy system, energy markets, energy use, energy policies and international agreements. In research fields related to renewable energy sources, the research council cooperates closely with Enova.

3 CURRENT STATE OF THE BIOMASS AND BIO-BASED HEAT MARKET

3.1 Bioenergy and biomass in the Norwegian energy system

3.1.1 Biomass production and consumption

The total stationary energy consumption in Norway was approximately 565 PJ in 2003 (Table 1 and Figure 1)[3], of which wood fuels and wood waste took a share of 9%. A major share of bioenergy production in Norway stems from forest industry residues such as saw dust, bark and black liquor used in the internal production process. According to Størdal (2003), the total bioenergy production for internal use in forest industries amounts to about 29 PJ.

[3] Regarding energy use, more reliable data is available for 2003 than 2004. Therefore, we partly refer to 2003 in this section.

Table 1. Stationary energy consumption in Norway 2003 (PJ)[1]

Energy source	Total stationary consumption	Heat market
Wood fuels and wood waste	54	25
Other waste	7	7
Fossil fuels	133	36
Electricity	371	112
Sum	565	180

[1] Sources: Statistics Norway (www.ssb.no), Enova (2003) and Størdal (2003).

The Norwegian heat market is characterised by extensive use of electricity for heating in private households and limited availability of water borne heat distribution. About 70% of all households use electricity as the main heating source, while only 5% have common central heating and less than 1% has access to district heating. Electricity is often used in combination with stoves for fire wood or fuel oil. Approximately 60% of the households have stoves for solid fuels and 16% have stoves/boilers for oil or kerosene. The low share of households with water borne heating (12%) and district heating systems (4.5%) represents a major barrier for increased use of bioenergy because of high investment costs.

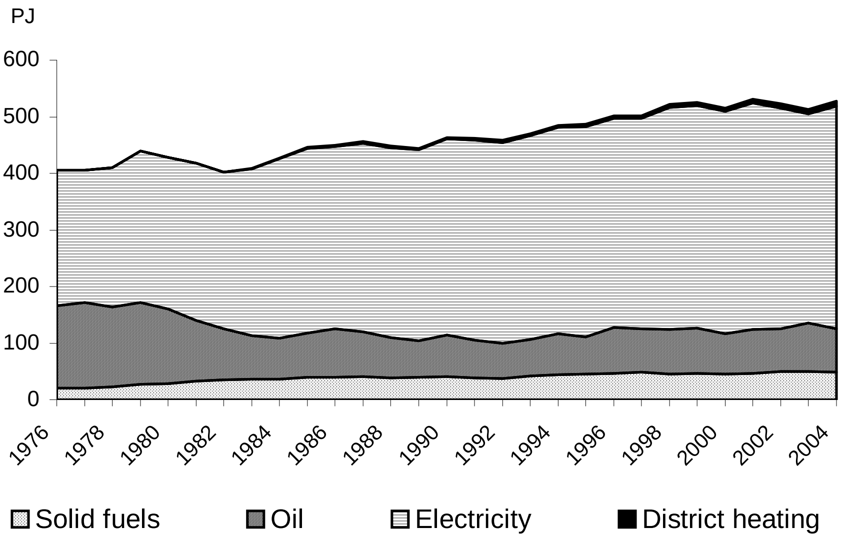

Figure 1. Historical development of stationary energy use (outside the energy sectors).

The total heat market volume was about 1806 PJ in 2003, of which more than 60% is based on electricity – mainly from domestic hydro power but also some import (Enova, 2003 and Størdal, 2003). Fossil fuels, mainly oil, take another 20% of the heat market, while about 25 PJ (14 percent) was based on firewood in stoves. In addition, about 5 PJ bioenergy is produced in district heating, mainly based on waste from households, but also some wood waste, chips, briquettes and pellets. The production and use of refined biofuels in micro-grids, central heating and stoves is currently very limited.

From this brief review it is clear that firewood used in stoves is the major biofuel type in Norway currently. The use of refined solid biofuels like pellets and briquettes is increasing, but still relatively minor. The exact figures for domestic biofuel production in 2004 are in table 2. In addition to these numbers comes a substantial production of fire wood, representing a net energy content of about 17 PJ. Although current market volumes are minor, it should be noted that in recent years, large industrial parties have taken strategic positions in the market, and the market may be characterized as emerging. Regarding liquid biofuels, about 4.2 million liters biofuels (mainly bioethanol and biodiesel) was used in the transport sector in 2004. This represents only 0.1% of the total market.

Table 2. Domestic biofuel production in 2004[1].

	Quantity for energy (1000 ton)	Assumed heat value (GJ/ton)	Energy content (GJ)
Logging residues	15.0	8.3	124.5
Demolition wood	4.0	13.7	54.7
Forest industry residues	3.0	13.7	41.0
Bark	14.0	8.3	116.2
Briquettes	27.7	16.9	468.0
Pellets	35.1	17.3	606.1
SUM	98.8		

Sources: Hovi (2005) and Norwegian Bioenergy Association (Nobio) (www.nobio.no).

3.1.2 Biomass resources

Only 3.5% of the land area of Norway is agricultural land, while 22% percent is productive forest land. Wood fiber therefore forms the main domestic biomass potential for energy purposes. Figure 2 shows historical harvest levels of sawlogs and pulpwood (used in sawmilling and pulp and paper making) and timber stock in Norwegian forest. While harvest levels have been quite stable around 7- 10 million m^3 (corresponding to 50-70 PJ), the standing stock of timber have increased substantially. The total standing timber stock is currently estimated to about 700 Million m^3. The development of the forest stock shows that there is a clear potential for increased forest biomass utilization in Norway. Annual growth of Norwegian forests approximates 24 Million m^3 ($\approx$ 173 PJ). Division of annual growth and total standing stock on species is in table 3. Additional potentials of other biofuels such as straw and waste is quite limited (Hole, 2001).

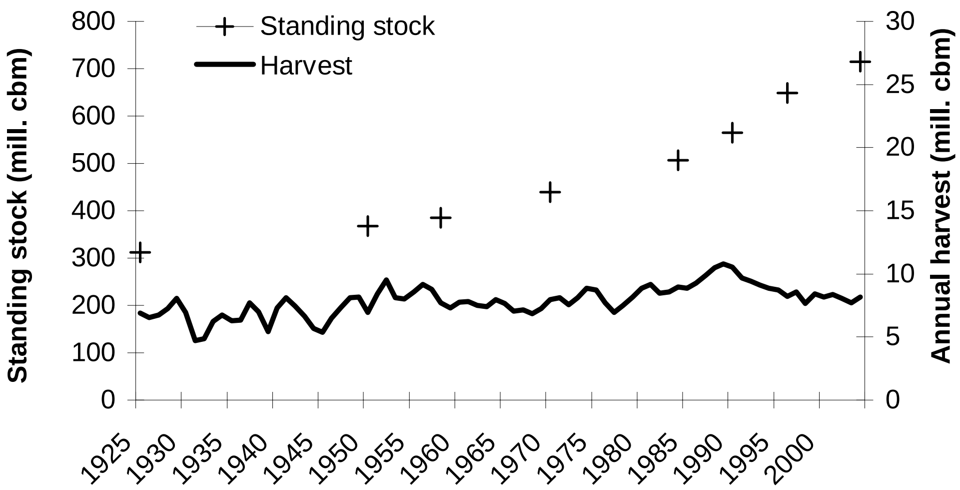

Figure 2. Standing timber stock and harvest levels in Norwegian forests 1925-2004. 1 Mm^3 ≈ 7.2 PJ (gross).

Table 3. Standing stock and annual growth[1]

	Standing stock Mill m^3 (PJ)	Annual growth Mill m^3 (PJ)
Spruce	321 2094)	13.7 (89.1)
Pine	236 (1784)	6.1 (46.0)
Non-coniferous	158 (968)	5.6 (47.1)

[1] Converted from Mm^3 to PJ by assuming that 1m^3 spurce = 6522 GJ, 1m^3 pine = 7554 GJ and 1 m^3 non coniferous specifies = 8392 GJ.

3.2 Energy and fuel prices

3.2.1 Solid biofuels - production costs and market prices

Hovi (2005) analyzed cost of production and delivery of solid biofuels in Norway, based on a survey among Norwegian producers. Production and logistic costs of wood chips from pine pulpwood, including transport of chips and sales, are estimated to about 100 EUR/ton dry wood (about 6.1 EUR/GJ) for annual production volumes above 10 000 ton and transport distances of 50 km for the raw material and the chips. Biomass costs represent almost 50% of the total costs. Corresponding production and logistic costs of pellets are estimated to 200-220 EUR/ton (11.7 –12.8 EUR/GJ), when assuming transport distances of 50 km for roundwood and 150 km for pellets. In pellets production, biomass takes about 30% of the total costs, while pelleting takes 15%. Transport of pellets, storage, packing and sales are other significant cost components. Hovi (2005) stresses that it is hard to map production costs in this sector since it consist of relatively few producers, and high variation of technologies.

Since the main cost component in wood biofuels is the raw material, it is interesting to study the historical price development of wood fiber. And as mentioned, wood prices in Norway have decreased substantially the last decades. Since 1980, prices of pulpwood delivered at road side are reduced by one half (Figure 3). Prices of non-coniferous species are currently at approximately the same level as spruce.

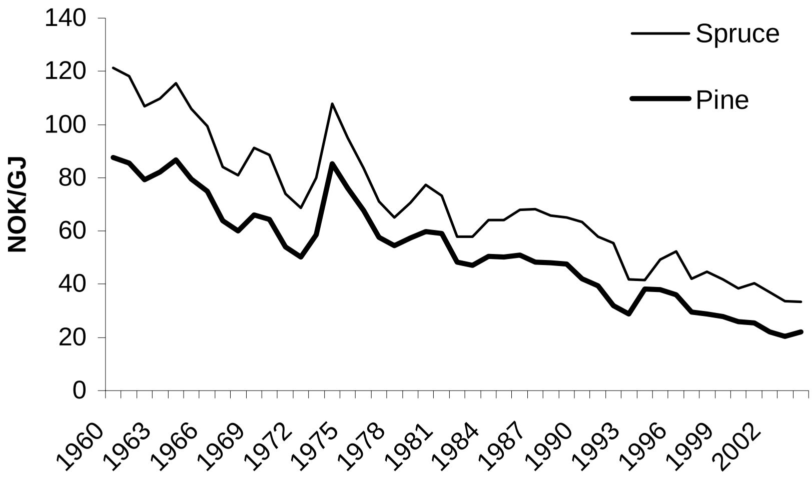

Figure. 3. Real (2004) prices of spruce and pine pulpwood 1970-2004 (converted from NOK/m^3 to NOK/GJ).

Norway is a high cost country having relatively high price levels both for wood fiber and labor. As a result, prices of biofuels are relatively high compared to other countries. Table 4 reports prices of different refined solid biofuels in 2004, delivered at production unit in Norway (www.nobio.no; Enviro Energi, 2004; Hovi,2005). The reported market prices of pellets are lower than production costs for pellets based on pine roundwood estimated by Hovi (2005). This may be caused by some bias in the study by Hovi (2005), but may also reflect that a large share of current pellets production in Norway is based on various types of wood waste, instead of virgin fiber, or based on cheap energy from waste burning having no other alternative use. The potential for further utilization of wood waste seems limited and increased biofuel production levels will thus require use of virgin wood fiber or import of wood waste.

Table 4. Market prices (in EUR/GJ) of various biofuel types in 2004, excluding transport costs and VAT. Source: www.nobio.no [1].

	2004	Jan-Jun 2005	Jul-Des 2005
Pellets, small bags	11.1	11.1	10.9
Pellets, large bags	9.5	9.5	9.5
Pellets, bulk	8.3	8.1	8.1
Briquettes, small bags	15.9	14.6	15.4
Briquettes, large bags	10.8	9.3	9.8
Briquettes, bulk	5.2	5.1	5.2
Bark	0.0	1.9	1.9
Logging residues*	6.2	5.6	5.6
Demolition wood	3.2	3.1	3.1

[1] The exchange rate 1 € = 0 8 NOK has been used.

3.2.2 Energy prices

Figure 4 shows historical development of net energy prices, including taxes, for fire wood, light fuel oil, kerosene and electricity. Oil, electricity and kerosene prices are from Statistics Norway, whereas the price development of fire wood is based on historical timber prices and processing costs according to Hole (2001). The data includes all costs except capital costs of heating equipment. The historical price figures explain a large portion of the relatively minor use of bioenergy in Norway, compared to neighboring countries like Sweden and Finland. Until about 2000, fossil fuels and electricity have been cheaper than fire wood and other solid biofuels in Norway. After 2000, the rising prices of oil and electricity internationally, and corresponding decline of Norwegian timber prices, have made solid biofuels like fire wood economically competitive towards electricity, light fuel oil and kerosene (the main competitors). It should be stressed though, that high investment costs hamper the substitution of bioenergy for electricity and oil in existing buildings, although fuel prices are substantially lower.

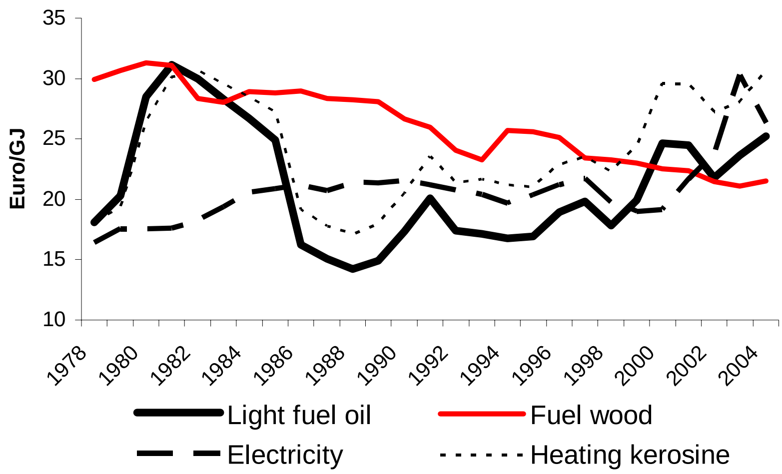

Figure 4. Real (1998) prices of net energy (including all taxes) for oil, electricity and fire wood (Sources: Statistics Norway (www.ssb.no) and Hole, 2001).

3.3 Import and export of biofuels

International biomass trade is commonly divided in direct and indirect trade. Direct trade comprises biomass to be used directly for energy purposes, while indirect trade consists of flows of raw materials that end up as energy fuel after a prior production process. In Norway, direct trade of biofuels is currently limited, and consists mainly of firewood from Estonia, Latvia and Sweden. Norway is a net exporter of refined solid biofuels, but the quantities are quite minor. The overcapacity of refined biofuel production units does presumably reflect expectations of a growing market for bioenergy domestically.

Indirect trade of biofuels is far more substantial than the direct trade. Norway has been a net importer of timber for decades as a result of relatively high, and growing, production levels in the pulp and paper industry. In recent years, pulpwood import have approximated 1.5-2 Million m^3, corresponding to about 11-14 PJ (Figure 5). In addition, there are also import and export of sawlogs (used in producing sawnwood). Sawnwood production implies by-products like chips, saw dust and bark. Chips is usually sold to pulp and paper mills for pulping, whereas sawdust and bark most often are used for drying purposes at the sawmill. In recent years, the net import of sawlogs has been about 0.5 Million m^3, representing an energy content of about 3.6 PJ (Figure 6).

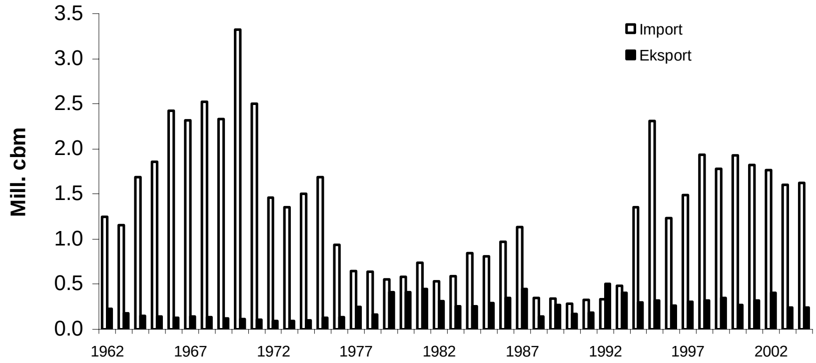

Figure 5. Import and export of pulpwood 1962-2004 (based on Nyrud, 2002).

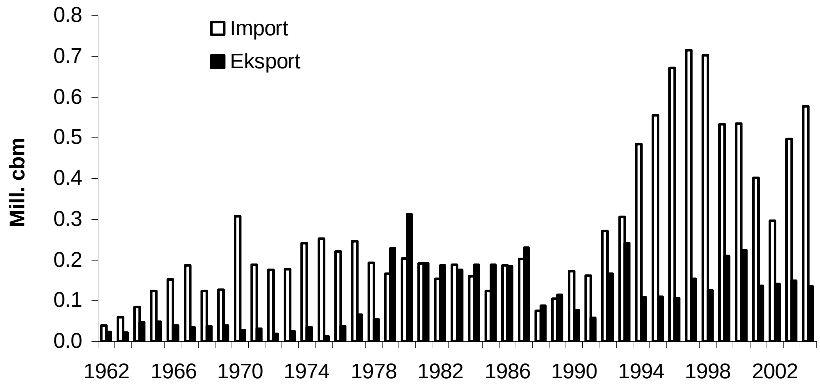

Figure 6. Import and export of sawlogs 1962-2004 (based on Nyrud, 2002).

Table 5. Balance of international trade in year 2004 (1000 ton) (www.ssb.no)

	Import	Export
Direct trade		
Wood waste	34.4	14.0
Wood pellets	0.2	5.6
Briquettes	0.6	1.0
Firewood	80.8	0.8
Tall oil	42.9	8.0
Indirect trade		
Roundwood	2338.4	289.39
Chips	703.4	44.7
Sawdust	65.3	16.9
Total	3265.8	380.4

Norwegian biofuel prices (table 4) appear relatively high compared to international prices reported by Energidata et al. (2005) and Junginger and Faaij (2005). Development of a well functioning international fuel market would secure that domestic prices do not exceed European prices plus cost of transport from producer to the Norwegian market. As seen from Fig. 5 and 6, the Norwegian forest industry has a long tradition in importing roundwood and chips. Prices of imported and domestic wood fiber delivered at mill gate are in general at more or less the same level. For small volumes, transport costs per unit decrease with increasing volumes. Cost of imports will also differ according to size and location of bioenergy units. For example, cost of import will be low, relatively, for CHP plants located near suitable harbors.

To summarize, a growing market for biofuels in Norway will imply increased costs of domestic raw materials, and at the same time reduced per unit transport costs for imported fuels. These mechanisms will motivate market actors to consider international market possibilities. The forest and energy sector in Norway include strong international companies with long traditions in international trade of raw materials and energy. There may be short-term barriers for international biofuel trade, but in the long run it should be as natural to trade biofuels internationally as any other commodity. A substantial market in terms of volume is, however, required.

4 FUTURE PROSPECTS OF BIOMASS AS ENERGY SOURCE IN NORWAY

This section provides an appraisal of the future prospects for biomass markets in Norway, taking possible imports and exports into account. When assessing biomass markets and market prospects it is necessary to consider the end use market, which in the case of Norway currently primarily is the heat market[4]. Table 1 shows that oil and electricity take the major market shares of the Norwegian heat market, while bioenergy currently takes less than 20 percent.

4.1 Drivers and main barriers for biofuel use in Norway

Our point of departure in this assessment is, corresponding to the main barriers mentioned by Enova (2003), that bioenergy must be economically competitive to increase market shares.

[4] In addition to power and fuel for transport which are disregarded here.

That is, the end use price of bioenergy must be lower or equal to the alternatives. In the short-term, however, lack of well functioning markets, especially for biofuels, may hamper the development. Biofuel markets in Norway, and most of the rest of Europe, are relatively minor and immature. Markets are expected to grow in coming years, but a necessary condition for sustainable growth is that factor (biomass) and product (bioenergy) markets grow in fairly correspondence. Import and export may reduce potential problems of over- or under-capacities in domestic markets, but international markets for solid biofuels is not yet well developed. Moreover, as discusses above, a well functioning international biofuel market secures as competitive prices as possible. Political barriers may also apply, both regarding changes in legislations, policy support and taxes.

There exist certain barriers for increased bioenergy utilization, but in the long run, the development of bioenergy and biomass use will mainly depend on the market pull in terms of shifts of supply and demand affecting competitiveness. In a market context, long run competitiveness of bioenergy may improve in two ways: (i) reduced costs via reduced input prices or improved technology, or (ii) increased prices of alternative energy sources and carriers. The sector it self can mainly deal with (i), while energy consumers, but also policy makers, can affect (ii).

Regarding (i) - costs of biofuels - it is discussed above that raw materials is a major cost component in biofuel production. There are several major drivers affecting biomass prices. For wood fiber – which is most relevant in the case of Norway – the competition for fiber from forest industries is a main issue. Fiber demand from forest industries depends on a large set of factors. The most important mentioned by Solberg and Moiseyev (1997) is: Population development, economic growth, prices and price expectations, technology, institutional and political frame conditions, and substitution.

The decreasing trend of Norwegian timber prices shown in Figure 3 is partly due to increased availability of imported timber and partly related to a positive shift of domestic supply due to increased standing timber stock (Figure 2). Increasing use of wood fiber for energy purposes will *ceteris paribus* increase timber prices. As shown by Energidata (2005) improved efficiency of logistics in the biofuel value chain may help reduce costs. In particular improved conversion rates of boilers can substantially reduce costs. However, for a major share of the heat market in Norway, the lack of water-borne heating systems imply high investment costs for conversion to bioenergy based heating. Investment subsidy of bio-boilers is currently a deployed policy to improve competitiveness of bioenergy by reducing costs.

Regarding (ii) – prices of alternative energy sources – the economic environment internationally sets the main premises. It is beyond the scope of this paper to discuss international prices of electricity and fossil fuels. Also national policies affect end-use prices of electricity and oil. Relevant polices includes taxes, e.g. electricity taxes and GHG emission taxes, and different types of subsidies. Compared to other Scandinavian countries, taxes on electricity use have been low in Norway. The electricity tax is a sensitive political issue in Norway.

Legislations regarding use of water-borne heating systems are widely debated in Norway. Such legislations can exclude electricity as an alternative and thus improve bioenergy competitiveness. Green certificates in the power and heating sector will affect bioenergy demand in the same direction. Increased focus on positive environmental effects of bioenergy compared to the above mentioned alternatives may also increase demand.

4.2 Assessment of the demand side

To give an overview of market potentials and prospects of biofuels in Norway, we start with an assessment of the heat demand side. As discussed previously, the extensive use of electricity for heating hampers the possibility for increasing market shares of bioenergy, since investment costs of distribution systems and boilers are too high in existing buildings based on electricity. Replacement of oil and kerosene burners and boilers with bio-boilers is much more appealing economically. Also intensified use of wood stoves and other existing bioenergy installations may have a substantial potential within reasonable economic conditions for bioenergy.

Table 6. Technologies and corresponding demand side potential for bioenergy in the Norwegian heat market.

Technology	Description	Fuel	Efficiency	Potential for increased production
Wood stove	Traditional wood stoves in private households.	Firewood	60%	In households with wood stoves, limited to 7000 kWh for single houses and 3000 kWh for other. Min/max increase per county set to 25%/100%
Pellets stove	Stoves in private households using wood pellets.	Pellets	90%	Replacement of ovens for kerosene in private household with potential production set to 10 000 kWh. Replacement of 90% of the kerosene consumption in service sectors. Implies investment in pellet stoves.
Wood based central heating – single houses	Bio boilers in private households with water borne heat distribution.	Wood, pellets or briquettes	90%	Replacement of oil boilers. Potential production set to 90% of the net energy production based on “light oil” in private households and agriculture.
Wood based central heating	Bio boilers in industrial buildings, buildings in service sectors and multi-dwelling buildings with water borne heat distribution.	Wood, pellets or briquettes	90%	Replacement of oil boilers. Potential production set to 90% of the net energy production based on “light oil” in service sectors and multi-dwelling buildings, 75% in industrial buildings.
Wood based district heating	Water borne distribution to several buildings from a central bio boiler.	Wood chips, or forest fuel (waste)	90%	Substitution of up to 90% of the consumption of “light oil” in service sectors and multi-dwelling buildings in urban areas. Implies investments in bio boiler and infra structure to buildings.
Bioenergy in forest industries	Existing energy production for heating and drying in forest industries.	Bark and residues	85%	Closely linked to the production in the forest industries.

Based on data for heating systems in private households and energy consumption in different sectors on county and municipality levels from Statistics Norway (www.ssb.no), we have divided the heat market in five main technology types that suits different segments of the market (Table 6) (the bioenergy use in the forest industry is included for completeness). Table 6 also describes the content of each technology and how the potential for substitution of bioenergy for the alternatives is assessed. As seen from table 6, the estimated potential is based solely on intensified use of existing bioenergy installations, and substitution of bioenergy installations for existing installations based in fossil fuels and water borne heating. Based on the assumptions in Table 6 the energy production in 2003 and calculated potential for each technology at an aggregate national level are shown in Figure 7.

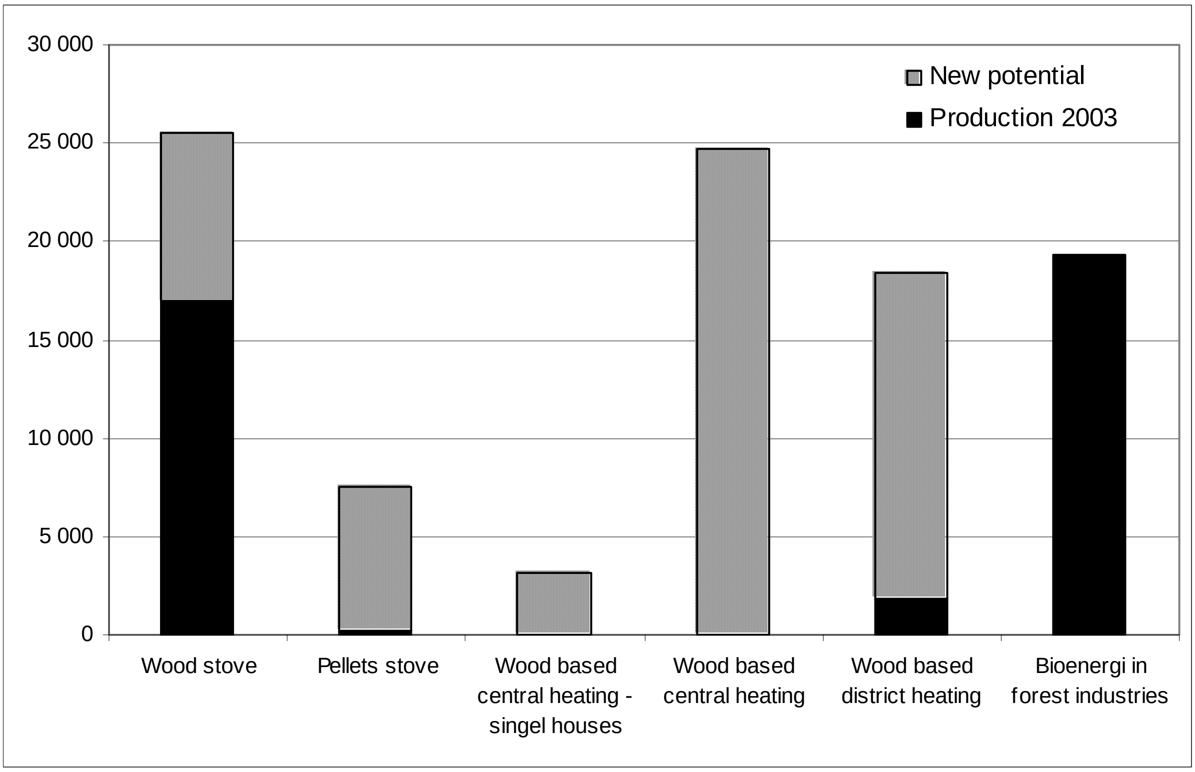

Figure 7. Net production (TJ) of bioenergy from forest fuels in 2003 and estimated potential for increased bioenergy production based on demand side assessments (by increased use of wood stoves and replacement of fossil fuels).

The total net production of bioenergy based on wood is 38.1 PJ. In addition comes 6.5 PJ from waste in district heating systems. Based on the assumptions reviewed in Table 6, the total potential for bioenergy based on wood is estimated to 80.2 PJ (i.e. 42.1 PJ new capacity) or about twice the current production. If one also includes substitution of electricity for heating in urban areas, the potential increases with about 43 PJ. Table 6 focuses on the heat market. The market for fuels for transportation is massive, but in Norway, biofuels is currently not competitive in these segments. The same assessment applies to power generations and combined heat and power technologies based on biofuels.

Birkeland, Eide and Tveiten (2005) conducted a similar calculation and concluded that the potential for substitution of bioenergy for oil, plus electricity outside the industry sector was 33 PJ in Eastern Norway. In a foresight study by Energidata et al. (2005), three scenarios for the use of bioenergy in Eastern Norway in 2020 are in the range from about 22.7 PJ (most optimistic scenario) to 5.8 PJ (most pessimistic scenario). The latter study excludes the use of fire wood in stoves.

4.3 Projections

The previous section focuses on potentials from the point of view of total demand for heat and distribution of heating systems in Norway. Although cost competitiveness to some extent is considered by excluding the replacement of electric heating systems, the potentials are still upper edge estimates. As elaborated above, future use of bioenergy, and hence biofuel, depends on a complex set of relations and drivers. Of particular importance are the price developments of alternative energy and the prices of raw materials. Bolkesjø et al. (2006) projected future bioenergy and biomass use in the Norwegian energy system under three different scenarios regarding future prices of electricity and oil, taking these issues into account. The first scenario, called "*business as usual*" (*Bau*) assumed price levels to remain at 2003 levels. In the second scenario, called "low growth", prices of electricity and oil rose by 20 NOK/MWh (0.7 EUR/GJ) per year, while in the last scenario the same prices were assumed to grow by 40 NOK/MWh (1.4 EUR/GJ) annually.

Production, prices and trade was calculated for each scenario using a partial equilibrium model called NTM II. The model covers the forest and bioenergy sector and includes a relatively detailed description of Norwegian timber supply, forest industry production and heat market. A major advantage of this approach is that both competition for wood fiber and synergies between the forest industry and the bioenergy sector is included. Also, the model includes interregional and international trade of raw materials and end products. A thorough outline of the methodology is provided in Bolkesjø (2004).

Table 7 reports some of the results from the model analysis. As expected, total bioenergy use (production) grows substantially if electricity and oil prices continue to grow. The increased production is partly based on domestic wood fiber, but also imports increases substantially - from about 2.5 PJ for energy purposes in the "bau" scenario to 8.6 PJ in "low growth" and 10.1 PJ in "high growth". Corresponding to increasing demand, timber prices is projected to increase by approximately 20-30%. It is interesting that the timber price increase is about the same in the "low growth" and "high growth" scenarios.

Table 7. Projected net energy production (TJ), biomass import (TJ) and timber prices delivered at road side (NOK/TJ) in the three energy price scenarios in 2010.

	Bau	Low growth	High growth
Production (TJ)			
Stoves	15201	17000	18615
Micro-grid	939	5835	7011
District heating	1349	10446	11813
Total	*17489*	*33281*	*37439*
Import (TJ)[1]			
Pine	813	2374	3317
Non-coniferous	1615	6320	6932
Total	*2428*	*8694*	*10248*
Timber price (NOK/GJ)[1]			
Pine	30.1	34.9	35.6
Non-coniferous	33.0	39.7	40.6

[1] Assuming that 1 m^3 pine pulpwood = 2.2 MWh , 1 m^3 non-coniferous pulpwood = 2.4 MWh and 1NOK = 1/8 Euro

There are of course substantial uncertainties connected to the exact numbers in the projections presented above, but we regard the following conclusions from the study as plausible:

(i) Bioenergy based on biomass from the forest sector will be fairly competitive in some market segments with constant (2003) price levels of electricity and oil.

(ii) Minor, permanent, increases in prices of electricity and oil could release substantially increased levels of bioenergy production.

(iii) Cost effective expansion of the bioenergy sector in Norway will partly be based on domestic timber and forest industry residues and partly on imported woody biofuels (timber, chips or pellets).

(iv) Investors and policy makers must account for, *ceteris paribus*, increasing raw material costs as the bioenergy sector grows in volume.

Capacity changes in the pulp and paper industry is a key aspect for long term development of bioenergy. In 2005, Norwegian pulp and paper mills used 5-6 mill m^3 pulpwood and chips, corresponding to about 36-43 PJ. The investment rate has been low in the industry in recent years and a significant share of the production takes place in machinery that either needs upgrading or will be closed in a 10-15 year period. One likely scenario in this regard, is that bioenergy production will increase, causing reduced pulp and paper production levels.

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