Jussi Heinimö

IEA BIOENERGY TASK 40
"Sustainable International Bioenergy Trade: Securing supply and demand"
Country report of Finland 2008

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ABSTRACT

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This study considered the current situation of biofuels markets in Finland. The fact that industry consumes more than half of the total primary energy, widely applied combined heat and power production and a high share of solid biomass fuels in the total energy consumption are specific to the Finnish energy system. Wood is the most important source of bioenergy in Finland, representing 21% of the total energy consumption in 2006. Almost 80% of the wood-based energy is recovered from industrial by-products and residues.

Finland has commitment itself to maintaining its greenhouse gas emissions at the 1990 level, at the highest, during the period 2008–2012. The energy and climate policy carried out in recent years has been based on the National Energy and Climate introduced in 2005. The Finnish energy policy aims to achieve the target, and a variety of measures are taken to promote the use of renewable energy sources and especially wood fuels. In 2007, the government started to prepare a new long-term (up to the year 2050) climate and energy strategy that will meet EU’s new targets for the reduction of green house gas emissions and the promotion of renewable energy sources. The new strategy will be introduced during 2008.

The international biofuels trade has a substantial importance for the utilisation of bioenergy in Finland. In 2006, the total international trading of solid and liquid biofuels was approximately 64 PJ of which import was 61 PJ. Most of the import is indirect and takes place within the forest industry’s raw wood imports. In 2006, as much as 24% of wood energy was based on foreign-origin wood. Wood pellets and tall oil form the majority of export streams of biofuels. The indirect import of wood fuels increased almost 10% in 2004–2006, while the direct trade of solid and liquid biofuels has been almost constant.

FOREWORD

The objective of IEA Bioenergy Task 40 “Sustainable International Bioenergy Trade: securing supply and demand” is to support the development of sustainable international trade of bioenergy, recognising the diversity in resources and biomass applications. The Task aims to provide an outstanding international platform to make inventories of available information and experience, provide new analyses and set the agenda and initiate a host of new activities relevant for developing sustainable biomass markets and trade worldwide.

In the year 2008, the countries participating in Task 40 collaboration were Austria, Belgium, Brazil, Canada, Finland, Japan, Norway, Sweden, the Netherlands, the United Kingdom and the USA. In addition, several industrial parties and international organizations (such as FAO) are involved in the Task, providing a platform for its effective implementation.

One of the key elements of the Task’s work programme is to improve the understanding of biomass and bioenergy markets. For that purpose, country reports mapping the development of biomass markets and trade are prepared in the participating countries. This report studies and summarises the current status of biofuels markets in Finland, being an update of the previous Task 40 Finnish country report published in 2006.

Varkaus, August 2008

Jussi Heinimö

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APPENDICES

1 INTRODUCTION

Strivings to mitigate climate change and reduce CO_2 emissions are the most important factors driving the utilisation of renewable energy sources in energy production. Most industrialised countries have committed themselves to a significant decrease in green house gas emissions under the Kyoto Protocol. As renewable energy is not always competitive against fossil energy, renewable energy is commonly promoted by means of energy policy measures such as energy taxation and subsidies. Globally, biomass[1] is the most important source of renewable energy, covering currently about 10% of the total primary energy consumption [2]. Often, biomass is the most competitive option to increase the use of renewable energy sources. During the coming decades, biomass has the option to become a more important source of energy in many parts of the world. In several areas, existing biomass resources are underutilised and in many areas have the potential for a remarkable increase in the production of biomass for energy purposes. Biomass has traditionally been utilised at a local level close to the production area. The situation has begun to change, as biomass consumption has been on the increase in industrial applications within the heat, power and road transport sectors. The markets of industrially used biomass for energy purposes are developing towards international commodity markets – wood pellets and fuel ethanol being examples.

Finland has long-standing traditions in the utilisation of biomass in energy production, and bioenergy[2] plays an important role in the Finnish energy system. The country is one of the world's largest importers of raw wood; consequently a significant proportion of biofuels[3] produced and consumed in the forest industry physically originates from abroad. Finland is also a significant exporter of wood pellets. The export and import volumes of biofuels in Finland have previously been investigated in 1999 within the AFB-net project [3]. In 2005-2006, an extensive study for determining import and export volumes of biofuels and investigating the challenges related to the issue was carried out, [4, 5]. In this paper, the previous analysis of the Finnish situation regarding markets and international trade of biofuels is updated. The most recent data that was available dates back to halfway through the year 2008. The report is a part of the Finnish contribution to Task 40 collaboration and EUBIONET II.

The structure of this paper is as follows. In Section 2, an overview about the role of bioenergy in the Finnish energy system is given. In Section 3, the Finnish energy policy and policy measures on bioenergy are described. In Section 4, the production potential of biomass for energy is discussed. Section 5 focuses on the prices of biofuels. The most important biofuels import and export streams are reviewed in Section 6. The summary and conclusions of the paper are presented in Section 7.

[1] This refers to the biodegradable fraction of products, wastes, and residues from agriculture (including vegetable and animal substances) and forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste.
[2] This refers to energy derived from biofuel.
[3] Fuels produced directly or indirectly from biomass. The biofuel may have undergone mechanical, chemical, or biological processing or conversion or may have had a previous use. The term refers to solid, gaseous, and liquid biomass-derived fuels.

2 BIOMASS FUELS IN THE FINNISH ENERGY SYSTEM

2.1 Energy demand and energy sources

Finland is large and sparsely populated state: with a total area of 33.8 Mha, it is the fifth largest country in Europe and is located between 60 and 70 degrees northern latitude (Figure 1). Finland has a population of 5.2 million, i.e. 17 people per square kilometre. Forestry land covers 87% of the country's land area (30.4 Mha), only 9% (2.8 Mha) is used for agriculture and the remaining 4% consists of housing and urban development and transport routes. The relatively cold climate, low population density, structure of industry and natural resources of the country are factors that have affected the development of the Finnish energy system. These factors, caused mainly by natural conditions, are increasing the energy demand.

Figure 1. Location of Finland.

Imported fossil fuels – oil, coal, and natural gas – have a major role as a primary energy source in the Finnish energy system, accounting for almost 50% of the total primary energy supply (Figure 2) [6]. The only significant indigenous energy resources in the country are wood, peat[4], hydropower, and wind energy. In 2006, renewable energy sources accounted for 24% (365 PJ) of all energy consumption (1,492 PJ), which was the third highest proportion in the EU [6, 8].

[4] In Finland, peat has been defined as slowly renewing biomass fuel[7]. It is not considered a renewable energy source in official statistics and in greenhouse gas accounting.

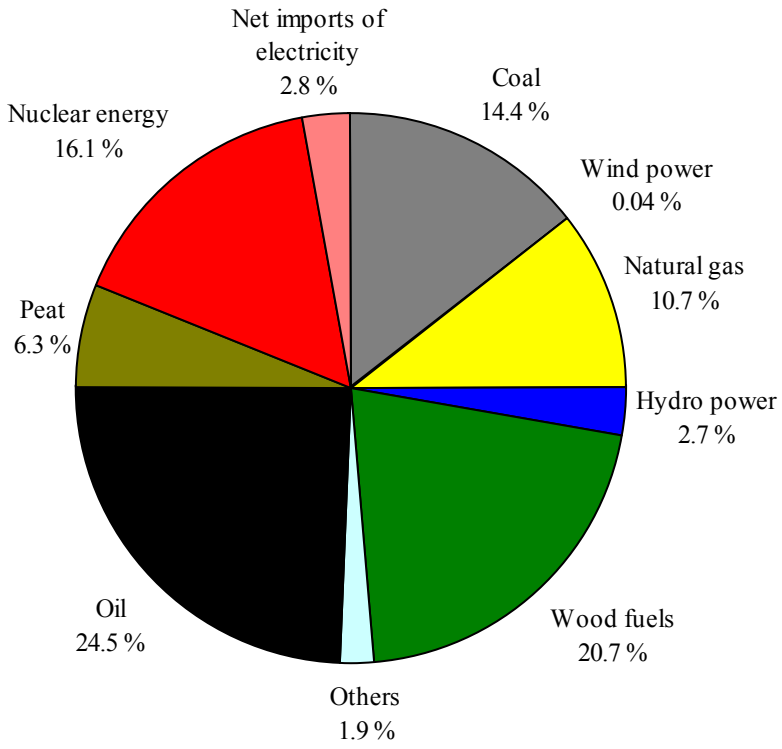

Figure 2. Primary energy sources in Finland in 2006. (The total use of primary energy in 2006 was 1 492 PJ). [6]

In Finland, primary energy consumption per capita is high, 275 MJ/capita in 2005 [6]. This is due to the severe climate, long distances, high standard of living and energy intensive structure of industry. Industry consumes nearly half of all energy (Figure 3), which is the highest proportion among the OECD countries [9].

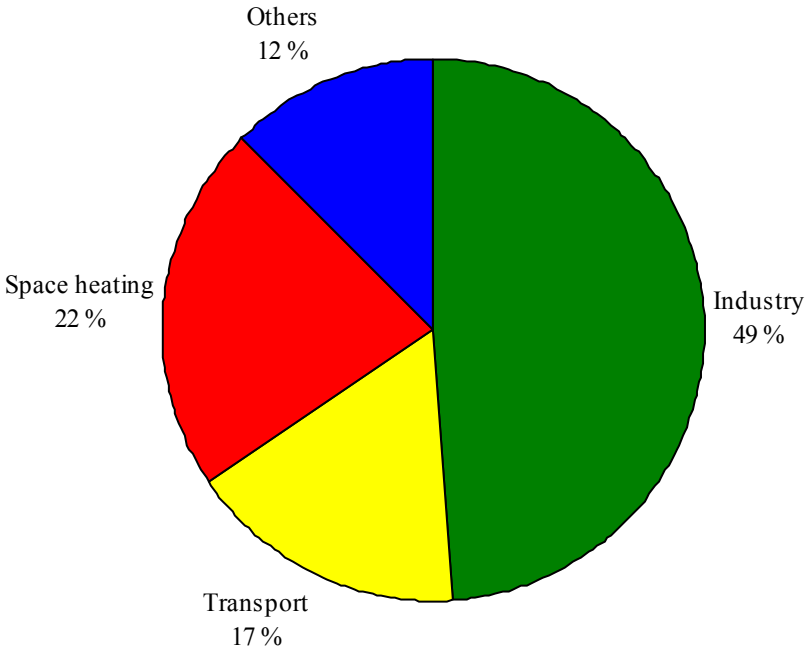

Figure 3. Final energy consumption by sector in Finland in 2005. (Total 1,066 PJ) [6].

Wood together with energy peat are the most important sources of bioenergy in Finland. The use of other biofuels, including agrobiomass, biogas, the bio-fraction of recovered fuels and liquid biofuels in the road transportation sector, is negligible compared to wood and peat use (Table 1) [6].

Table 1. The consumption of solid and liquid biofuels in Finland in 2006 [6].

Fuel	Use in 2006 [PJ]	Share
Black liquor [a]	156.0	38.2%
Solid processing industry by-products and residues [b]	81.5	19.9%
Forest fuels (forest chips)	24.6	6.0%
Firewood	45.3	11.1%
Wood pellets	1.5	0.4%
Biogas	1.7	0.4%
Recovered fuels (biodegradable part)	3.8	0.9%
Other bioenergy [c]	0.9	0.2%
Bio liquid fuel in traffic	0.0	0.0%
Peat	93.6	22.9%
In total	408.9	100.0%

[a] Black liquor is a by-product from the wood pulp making process and contains non-fibrous wood matter and cooking chemicals. Energy production from black liquor is a solid part of the pulp making process.
[b] Includes bark, sawdust and wood residues chips.
[c] Includes plant-derived and animal derived products (e.g. field biomass and liquid biofuels).

2.2 Past development of biomass fuels' use

The consumption of wood fuels and energy peat has been on the increase during the past three decades (Figure 4). Until the second half of the 1970s, traditional firewood was the most important wood fuel. Since then the use of wood fuels in heating and power plants has increased. The oil price shocks in the 1970s were a significant incentive for developing the energy use of peat. Finland is currently one of the leading countries together with Sweden and Ireland in the utilisation of fuel peat [10]. The main reason for the success of biofuels has been the positive development of the forest industry sector. During the past decades, there has been an increasing trend in the production of the forest industry, but the volumes of black liquor and solid by-products (bark, sawdust, industrial chips) vary annually according to the rate of forest industry production. E.g. in 2005, a several weeks' stoppage in the pulp and paper industry resulting from an industrial auction decreased the production of the forest industry and affected the use of biomass fuels. Biomass has become a more popular fuel in the district heating sector. It was estimated that during the years 1997-2010 more than 100 heating and CHP plants including 860 MW_e of new additional capacity for electricity production from solid wood and peat fuels will be introduced [11]. In almost every case, peat and solid wood are burnt in multi-fuel boilers designed for moist and varying quality biofuels.

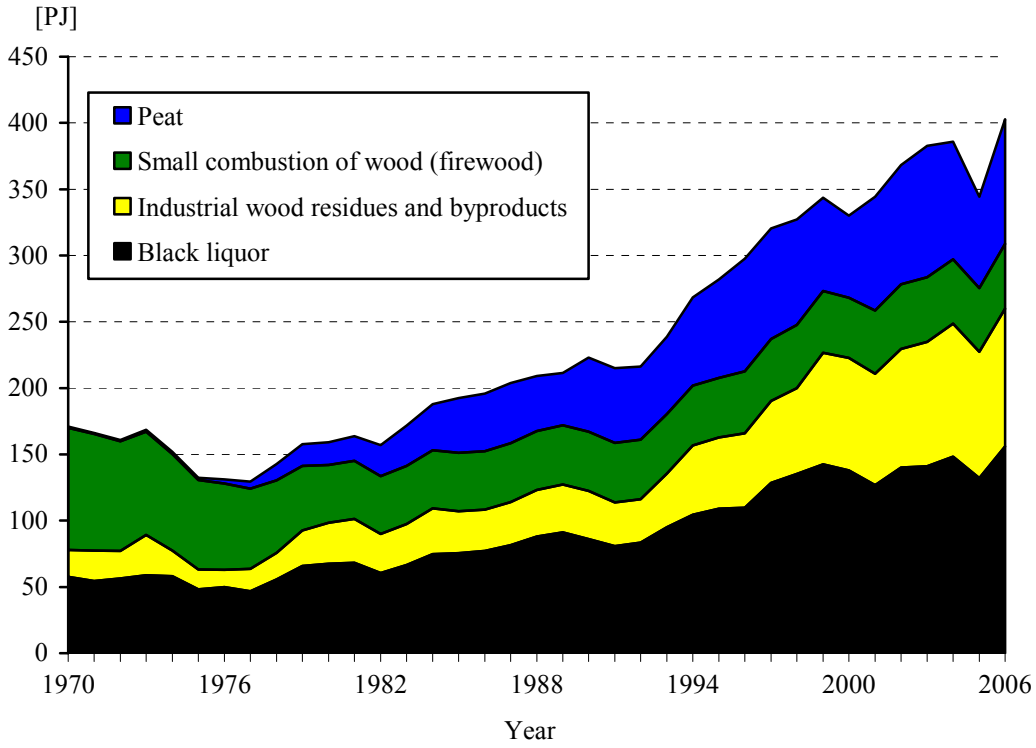

Figure 4. Consumption of wood fuels and peat in Finland in 1970–2006. Forest fuels consumed in heating and power plants are included in industrial wood residues and by-products[6]

3 ENERGY POLICY TARGETS AND MEASURES

3.1 Commitments and goals

One of the goals of the Finnish energy and climate policy is to fulfil international climate and environment commitments. In the Kyoto Protocol, as an EU member state Finland has committed itself to maintain greenhouse gas emissions at the 1990 level, at the highest, during the period 2008-2012. In recent years, the actual emissions have exceeded the Kyoto commitment and reducing emissions to the target level will need an active energy policy (Figure 5).

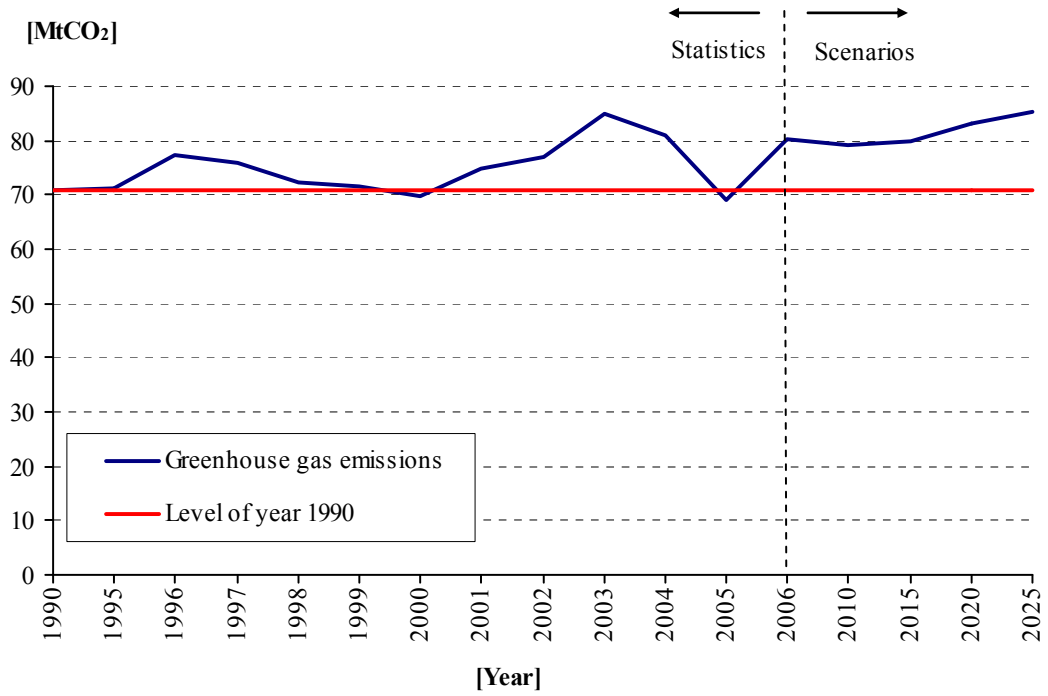

Figure 5. The targeted emission reduction in Finland and scenario until the year 2025. The carbon sinks are not included in the figures. The scenario was compiled in 2005 and shows the trend with no new measures taken. [12, 13]

The energy and climate policy carried out in recent years has been based on the National Climate Strategy approved by the government in 2001. After completion of the strategy, however, the operation environment of the energy and climate policy has undergone several changes, and in 2003 the revision of the strategy was started. The revised National Energy and Climate strategy was finished in November 2005.

The objective of the National Climate and Energy Strategy is that the total consumption of renewable energy sources will account for almost one third of the primary energy consumption in 2025, whereas in 2003[5] the share of renewable energy sources was 23%. Especially the use of forest chips, agrobiomass fuels, biogas and the small-scale use of wood are targeted to increase and will be promoted through energy policy measures. Small-scale use of wood will take place through the increased consumption of wood pellets [12]. The actions envisaged by the strategy increase the use of these energy sources by 65% from 2003 to 2015, and by about 80% by 2025

[5] The year 2003 was used as a reference year in the revised National Energy and Climate strategy.

[12]. In 2003, the consumption of forest chips, agrobiomass, biogas and firewood was in total about 63 PJ[6] [14]. The expected increase of 65% means approximately a 40 PJ increase in their consumption, while their total consumption will be about 100 PJ in 2015. Peat has an important role as a domestic fuel in the Finnish energy system. In the accounting of green house gas emissions, peat is defined as non-renewable energy and the CO_2 emissions include the use of peat in energy production in full, which decreases the competitiveness of peat in energy production. The strategy aims to secure peat utilisation in the energy sector. In addition, the government has prepared to procure a total of 10 Mt worth of emission reductions in 2008-2012 by using Kyoto flexibility mechanisms. [12]

In March 2007, a legally binding objective was agreed on in a meeting of the Council of the European Union to meet 20% of the Union's energy need with renewable energy sources by 2020 [15]. In January 2008, the European commission put forward a proposal for a new directive on renewable energy [16]. According to the proposal, each member state should increase the share of renewable energy to 20% by 2020. An increase in biofuels use in transport fuel consumption is included in the overall EU objective. To achieve the targets, each member state is required to increase its share of renewable energy by 5.5% from 2005 level, with the remaining increase calculated on the basis of the per capita gross domestic product (GDP). In Finland, the share of renewable energy in the final consumption of energy was 28.5% in 2005 and the target for the year 2020 set in the directive proposal is 38.5%. In 2007, the government started to prepare a new long-term (up to the year 2050) climate and energy strategy that will meet EU's new targets for the reduction of green house gas emissions and the promotion of renewable energy sources [1]. The new strategy will be introduced during 2008.

3.2 Measures to implement the energy policy

The Government employs funding of research and development projects, energy taxation, tax relief, production subsidies for electricity and forest chips and investment subsidies as financial measures to implement the energy policy. In addition, in the beginning of 2008 a new measure – the obligation to supply biofuels to the transport markets – was introduced.

Research and development

The competitiveness of renewable energy sources is promoted through investment in long-term technology research and development. Obstacles to getting the R&D findings and results onto the market will be lowered by supporting projects aimed at the commercialisation of new technologies.

The Finnish Funding Agency for Technology and Innovation (Tekes) is the main public financer of technology R&D. Renewable energy technologies, belonging to sustainable development solutions, are in the strategic focus of Tekes. Various national technology programmes and projects have involved RES technologies, the main focus being on bioenergy. Tekes funding for bioenergy R&D amounted to some € 15 million in 2006, which was € 5 million more than in the previous year [17]. The total funding for renewable energy and climate change technology has been € 60–70 million annually. In the Energy and Climate Change Strategy, technology development and respective financing remain the major means towards the attainment of energy and climate policy objectives. A strong investment will be made in innovations mitigating climate change, with a special focus on competence areas that are strong from the Finnish point

[6] In 2006, the corresponding figure was 72 PJ [6].

of view. The public funding appropriated to business-driven projects will be maintained at least at the previous years' level (about € 60 million annually) [18].

Energy taxation and tax relief

Taxation is one of the main instruments related to climate change and environmental policy, Table 2. In Finland, a carbon based environment tax for fossil fuels have been imposed since 1990. In heat generation, solid biofuels are not taxed. Fossil fuels have a tax which is based on the carbon content of the fuel. Fuels used for electricity generation are not taxed, but an electricity tax is imposed on the consumption of electricity. In CHP, fuels used for heat generation are calculated by the amount of heat produced. The consumption of heat fuels is calculated by multiplying the heat amount generated by the factor 0.9. Unlike in some other countries, industry in Finland is not entitled to deduct the carbon/energy tax, but has lower electricity tax than private consumers and the public sector. In Finland, energy taxes have slightly risen in the beginning of 2008.[19, 20]

Table 2. Energy taxes as of 1 January 2008 [19, 20]

Product	Unit	Excise tax	Security of supply fee	Total Tax
Motor petrol [a]	€ c/l	62.02	0.68	62.70
Diesel oil [b]	€ c/l	36.05	0.35	36.40
Light fuel oil	€ c/l	8.35	0.35	8.70
Heavy fuel oil	€ c/l	6.42	0.28	6.70
Coal	€/t	49.32	1.18	50.50
Natural gas	€/MWh	2.016	0.084	2.10
Fuel peat	€/MWh	0	0	0
Tall oil	€ c/kg	6.7	0	6.7
Electricity				
- class I [c]	€ c/kWh	0.87	0.013	0.883
- class II [d]	€ c/kWh	0.25	0.013	0.263

[a] *Reformulated sulphur free*
[b] *Sulphur free*
[c] *Other consumers*
[d] *Industry*

Production subsidies for electricity

The production subsidies for renewable electricity were revised in 2006 because the start of emission trading has made the operating environment more favourable for renewable energy sources. Since the beginning of 2007, the aid for electricity produced from wood and fuel timber products was abolished, except for electricity produced from forest chips (Table 3).

Table 3. Subsidies for electricity production since the start of 2007 [19].

Source of energy	Production subsidy of electricity, [€ c/kWh]
Wind	0.69
Biogas	0.40
Forest chips	0.69
Recovered fuel	0.25

Generally, the Finnish financial incentives to utilise biomass in energy production are at quite a moderate level compared to some other EU countries that apply considerably stronger financial measures. In addition, the support system of bioenergy has been almost constant for several years.

Investments grants

Subsidies granted for energy investments, development projects and energy conservation constitute an important means of implementing the National Energy and Climate Change Strategy. A particularly important function of the subsidies is to promote the use of renewable energy sources, and to reduce the environmental impacts arising from energy generation and use. The Council of State's new decision (625/2002, EUVL C37/2001/) sets the following maximum percentages for the assistance granted to different types of renewable energy projects:

- Energy investment studies, 40/50%
- Wind and solar energy investments, 40%
- Other investments in renewable energy, conventional technology (renovation and modernisation projects) 30% and innovative projects 40%

Projects involving innovative technology have the priority when energy support is granted. Investment grants are allotted for companies and communities, not for private persons or state organisations. In 2006, in total € 34.1 million was available for energy supports and approximately 70% was granted to renewable energy investments. The figure includes € 3.8 million in grants from the European Regional Development Fund. [17]

Support for the forestry and agriculture sector

In the Act on the Financing of Sustainable Forestry, non-industrial, private forest owners are entitled to seek governmental grants for the afforestation of understocked areas, prescribed burning, the tending of young stands, the harvesting of energy wood, forest recovery, fertilisation etc. Loans can be granted for joint ventures involving improvement ditching and forest road construction [21]. The Ministry of Agriculture and Forestry pays support in accordance with the law on forestry financing for the harvesting and forestry transport of timber sold for fuel as part of the management of young plantations. The aid for harvesting fuel wood is €7 per solid cubic meter, Support may also be obtained for chipping fuel timber. In 2006, a total of €5.5 million was spent in 2006 on fuel timber harvesting and chipping support. [17]

Obligation to distribute biofuels to the transport market

For the year 2010, the Finnish Government has fixed a national target of 5.75% for biofuels used in power road traffic. This objective will be achieved by the distribution requirement laid down in a law that has entered into force on 1 January 2008. The law obliges distributors of transport fuels to supply a minimum volume of biofuels annually for consumption. This minimum volume increases year-on-year so that in 2008 it will be at least 2% of the total energy content of biofuels, petrol and diesel supplied for consumption by a fuel distributor. In 2009 this share will be at least 4% and in 2010 and subsequent years it will be at least 5.75%. So the obligation satisfies the reference figure for 2010 in Directive 2003/30/EC. [17]

The obligation system is meant to be flexible for distributors, with a view to optimum cost-efficiency. The obligation relates solely to the total quantity of biofuels, so the distributors can themselves meet their obligation by introducing biofuels to replace petrol or diesel at a ratio of their choosing, within the limits of quality standards. The law does not regulate the origin of the biofuels. Distributors may transfer all or part of their obligation to another company on a contractual basis. Irrespective of contracts, all distributors are accountable to the Government for meeting their obligation, either on their own account or through a third party. If a distributor fails to meet his or her obligation, the customs authorities will impose a fine. [17]

4 INDIGENOUS MARKETS OF BIOFUELS

4.1 Wood and peat fuels

Wood and peat covers over 90% of the biofuels use in Finland. The energy use of wood and peat in different sectors in Finland in the year 2006 is summarised in Table 4. The forest industry represents the largest producer of wood fuels, but the industry is also a major user of wood fuels. Almost two thirds of wood fuels use takes place in the forest industry. Wood is the most important fuel at forest industry mills, accounting for about 75% of their fuel consumption [22]. In many cases, paper, paperboard, pulp and saw mills are located on the same site, forming a forest industry integrate which allows efficient utilisation of raw material and energy.

Table 4. End use of wood and peat by end user groups in 2006, PJ.

Fuel / End use sector	Forest industry	District heating	Small-scale use [c]	Other industry & users	Total
Forest fuels [a]	7.8 [23]	9.0 [24]	2.8 [25]	5.0	24.6 [25]
Firewood	0	0	45.3	0	45.3 [e]
Solid wood processing by-products and residues [b]	43.6	17.2	1.0 [d]	21.7	83.5
Black liquor	156.0 [6]	0	0	0	156.0
Total wood	207.4 [22]	26.2 [6]	49.1 [6]	26.7	309.4 [6]
Fuel peat	18.6 [22]	39.4 [6]	1.1 [6]	34.5	93.6[6] [6]

[a] *Excludes firewood.*
[b] *Includes bark, sawdust, industrial chips, pellets, briquettes, recovered wood and all other wood fuels excluded from the other columns. The share of pellets and briquettes was estimated at 1.5 PJ.*
[c] *Includes the use of forest chips by farms and detached house properties.*
[d] *In addition includes wood pellets.*
[e] *Estimated by the author based on Energy Statistics.[6].*

The first district heating networks in Finland were built in the 1950s, and district heating has become the most important heating form in space heating, covering currently half of the net effective heating energy of buildings [6]. District heating networks cover, in practice, all towns and larger densely populated areas, and the potential to construct new networks is limited. As in the forest industry, combined heat and power (CHP) production is widely applied in district heat production. CHP based heat production composed 74% of the total district heat production in 2006 [6]. The imported fossil fuels natural gas (34%) and coal (26%) are the main fuels in the district heating sector [6]. The natural gas grid covers the southern part of the country and gas comes from Russia. In the Helsinki metropolitan area and in the largest cities close to the coast, district heat production has been based on natural gas and coal. Peat and wood fuels are more commonly used inland and they had 19% and 13% shares in 2006, respectively [6].

Firewood has always been an important fuel in the heating of buildings in Finland. The consumption and the importance of firewood as a heating source declined towards the 1970s due to the introduction of modern heating sources such as oil, electricity and district heating. Since the 1980s, the consumption of firewood has been on a moderate increase. At present, wood stoves and fireplaces are commonly used as auxiliary heat sources in detached houses. About 90% of new detached houses are equipped with a fireplace or stove made of heat-retaining

material [11]. The total number of stoves and fireplaces for firewood reaches almost two million [11]. Wood is commonly used as the main fuel in central house heating systems in farms and larger buildings in sparsely populated areas, and almost 200,000 systems of this kind exist in the country [11]. Especially the largest of these systems use chipped wood. In the late 1990s, wood pellets were introduced as fuel, and since then their consumption has been on a moderate increase.

4.2 Biofuels in the road transport sector

The annual total fuel consumption of the road transport sector has increased moderately in past years (Table 5). The consumption of gasoline has remained constant, but instead, the consumption of diesel fuel is moderately on the increase. The consumption of biolfuels has been negligible. In 2002-2004, the consumption of biofuels was based on fixed term pilot projects where bioethanol was used in blends with gasoline. In addition, small-scale trials on the production of biodiesel and biogas for use as a transportation fuel have also been carried out [26]. After these projects, the consumption of biofuels dropped to zero in 2005. In spring 2006, Finland's largest seller of transport fuels, Neste Oil, began selling E98 grade petrol that was blended with 2-5% ethanol in southern and central Finland [17]. Achieving the 5.75% target share set for biofuels in road transport in 2010 will require about a 10 PJ annual use of biofuels.

Table 5. Fuels consumption in road transport in 2000–2004 and the proportion of liquid biofuels.[6]

	Fuels in road transportation, total	Gasoline	Diesel fuel	Liquid biofuels	
[Year]	[PJ]	[PJ]	[PJ]	[PJ]	[%]
2000	153	76	77	0	0
2001	156	77	78	0	0
2002	159	79	80	0.033	0.02
2003	161	79	82	0.176	0.1
2004	166	80	86	0.186	0.1
2005	167	80	86	0	0
2006	169	80	89	0.034	0.02

Despite the insignificant domestic consumption of biofuels in road transportation, the production of transport biofuels has been on the increase over the past years. In 2004, Neste Oil started the production of ETBE at its Porvoo refinery. The ETBE plant's production capacity is 100,000 tons per year. The ethanol contained in ETBE is imported from Brazil and the end-product is mixed with petrol for export. Furthermore, Neste Oil has developed a technology to produce high quality biodiesel, equivalent to good-quality fossil diesel from tri-glycerides (vegetable oils and animal fats). The first large-scale, 170,000 ton (~7 PJ) per year biodiesel plant based on above mentioned technology entered into production in Porvoo in 2007. The second similar plant will be ready at the end of 2009. During 2008-2011, Neste Oil will be constructing two large biodiesel plants abroad: a 500,000 ton per year plant in Singapore and a 800,000 ton per year plant in Rotterdam. [17, 27]

In 2007, the St1 oil company started the production of fuel-ethanol based on a production technology developed by the Technical Research Centre of Finland (VTT) where ethanol is produced from waste generated by the food processing industry in a number of small-scale plants (capacity of several thousand tonnes). The ethanol plants of St1 use food industry waste as a raw

material and are located alongside of raw material sources and produce 85% ethanol that is transported to a centralised dehydration plant that produces 99.8% ethanol. [28]

Ongoing intensive development work aims to commercialise second generation transport biofuel production technology. Neste Oil and the forest industry company Stora Enso have established a join venture NSE Biofuels with the purpose of building a industrial pilot plant in 2008 at Stora Enso's Varkaus mills. The idea is to produce raw biodiesel from woody biomass at the trial plant, and then process it into commercial fuel at Neste Oil's Porvoo refinery. Another forest industry company, UPM-Kymmene, has announced that it will focus strongly on second generation biodiesels and that it intends to become a remarkable second-generation biofuel producer. [17]

4.3 Potential to produce biomass for energy

The total volume of forestry industry by-products depends directly on the production rate of forest products. Energy production from black liquor is a solid part of the chemical pulping process, and black liquor has no alternative use. Solid by-products consist of pulp chips, bark, sawdust and industrial chips and they are utilised both as raw material and in energy production. Pulp chips as a whole and a part of sawdust are utilised as raw material in pulp mills. Sawdust is also the primary raw material for particleboard and fibreboard mills. The rest of the solid by-products are used in energy production. It was estimated that the total volume of the forest industry by-products available for energy purposes would not change substantially from the current level by the year 2010 [29]. The estimated increase in pellet production will redirect a part of the sawdust stream from power and heating plants to pellet factories [30].

Forest chips from logging residues, stump and root wood and small-diameter energy wood constitute a large and underutilised biofuel potential, and the largest share of the future growth of biofuels production will consists of forest chips.

Agrobiomass and biogas have had minor importance as biofuels and there is some potential to increase their use, but not on the same scale as forest chips. The outlook of agrobiomass utilisation for energy purposes depends largely on the agricultural policy and the future use of agricultural land. The productivity of agricultural land is weak due the cold climate.

Peat is internationally a poorly known fuel, but is has a significant role in the Finnish energy system. The climate and natural geography create favourable conditions for peat growing in Finland. The Geological Survey of Finland has estimated the employable energy reserve of peat at 48 EJ and the area suitable for peat production purposes about 1.2 Mha [31]. Approximately 60,000 ha are utilised annually for fuel peat production [30]. The upcoming consumption of energy peat depends on the development of the prices of emission trade, and policy measures will be needed to maintain the use of peat at its current level.

Table 6 compares the current use, production potentials and estimated use of major biofuels. The production potentials indicated in the table are based on various studies and they indicate technical, and in some cases techno-economical, production potentials where several factors that constrain the production possibilities were taken into account. The lowest limit of the range presents the anticipated use of biofuels in the year 2010 if energy subsidies and taxation remain equal to those in 2005. The upper limit represents a realistic consumption of biofuels in 2015, which could be achieved by more intensive application of energy policy measures.

Table 6. The current use, production potential and prospective use of the most important biofuels in Finland.

Fuel	Use in 2006 [6] [PJ]	Production potential [PJ/y]	Estimated use in 2010-2015, [PJ/y]
Black liquor	156.0	-	154-166 [32]
Solid processing industry by-products and residues	81.5	-	65-85[a]
Forest fuels (forest chips)	24.6	80-140[b]	40-73 [32, 33]
Firewood	45.3	-	55-63 [32]
Wood pellets	1.5	9-25 [c]	1-25[d]
Biogas	1.7	8-64 [32]	2-8 [32]
Agricultural biomass	0.9[e]	54[f]	3-28 [32, 33]
Biofuels in road transport sector	0.0	-	0-10[g]
Peat	93.6	-	61-97 [18]
In total	405.1	-	381-524

[a] The lower value results from the increased use of sawdust in pellet production [30] . The upper value is an estimate by the author.
[b] The theoretical maximum production potential was evaluated at 45 million solid-m^3 (324 PJ) [34]. The range is based on studies by Hakkila, 2004, Karjalainen et. al., 2004, and Ranta et. al., 2005 [29, 34, 35].
[c] This equals 0.55-1.5 Mt/yr pellet production. The lower limit is a production target of the Finnish pellet energy association for the year 2010 [36]. The upper limit was taken from [32]
[c] The lower value is based on [18] and the upper limit was taken from [32].
[e] Includes also animal derived biomass.
[f] The figure is from [32] and is 50% of the theoretical maximum potential.
[g] The EU biofuel directive (2003/30/EY) set the indicative target 5.75% for the proportion of biofuels used in road transportation, which would mean 9-10 PJ consumption of biofuels in road transportation. The satisfaction of the goal will need policy measures such as tax relief for biofuels and the obligation to use biofuels.

4.4 Prices of biomass fuels

Fuels used in the production of electricity are exempt from energy taxes, whereas in heat production taxes are levied on some fuels. In heat production, fossil fuels and tall oil are taxed and the total prices of the fuels consist of market prices and taxes. The energy taxation of fossil fuels changes the mutual competitiveness of the fuels based on market prices. The energy taxation has rendered the consumer prices of heating oils and coal more expensive compared to wood fuels. Wood pellets are less expensive than fuel oils, but are not competitive against coal in heat production (Figure 6). In a longer 15-year period, the price development of indigenous fuels (wood and peat) has been moderate and stable compared to prices of fossil fuels, which have fluctuated remarkably mainly due to world market prices.

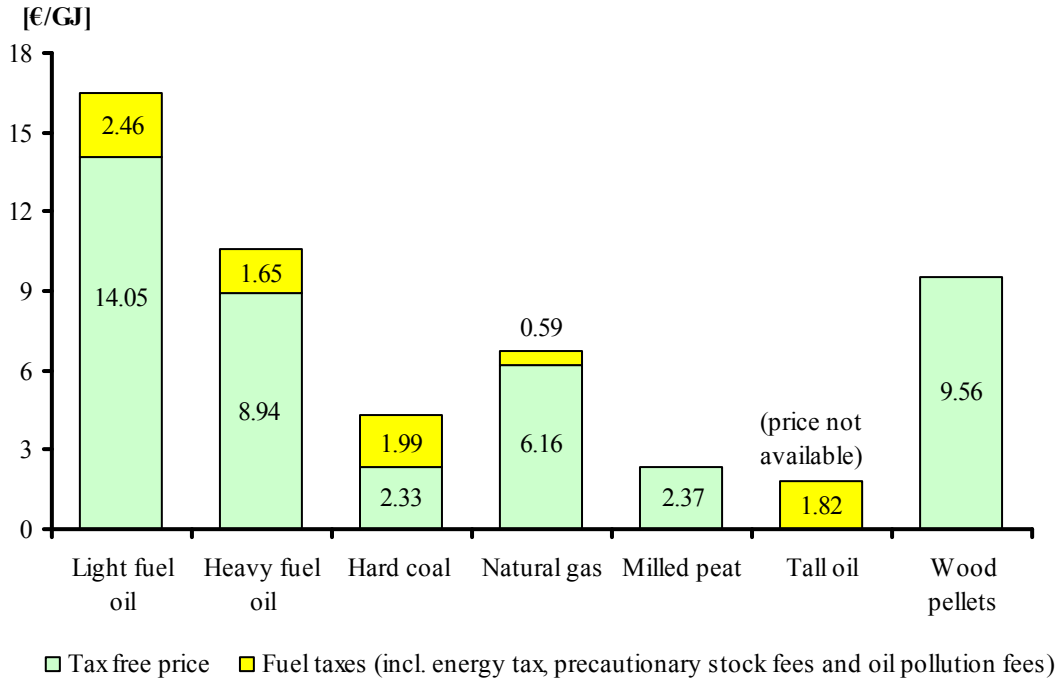

Figure 6. Fuel prices in heat production in January 2008 [37, 38] . The price of tall oil was not available.

In Finland, wooden by-products from the forest industry are fully utilised as raw material or in energy production, and their use cannot be increased unless the production volumes of the forest industry increase. Forest fuels from logging residues, stumps and small-diameter energy wood constitute a large underutilised biofuel potential. Increasing the use of forest fuels in heating and power plants has an important role in the Finnish energy policy in decreasing CO_2 emissions from energy production. In Finland, the use of forest fuels in heat and power plants has been increasing moderately since the 1980s. The increased consumption of forest fuels and strong development of technologies for forest fuel production within national technology programmes have lowered the prices of forest fuels during the 1990s. Since the turn of the millennium, the prices of forest fuels have been on the increase (Figure 7). The measures of the domestic energy policy have boosted the demand for biofuels, which has caused an upward trend in prices of wood fuels in recent years. Since the beginning of 2005, the start of the trading of CO_2 emission allowances within the EU emission trading scheme has enhanced the paying capacity of power plants for biofuels, and forest fuels have been to a greater extent produced at sites where the production costs are higher and the production has previously been uneconomical. Also the utilisation of costlier raw materials, small-diameter wood and stumps in addition to logging residues has been on the increase in the production of forest fuels. A collapse in the prices of emission allowances in 2007 broke the long-lasting growth in the use of forests chips in energy production. In 2007, the use of forest chips was 17% lower compared to the volumes in 2006. Zero price emission allowances decreased the competitiveness of wood fuels when power plants increased the use of peat and fossil fuels [39].

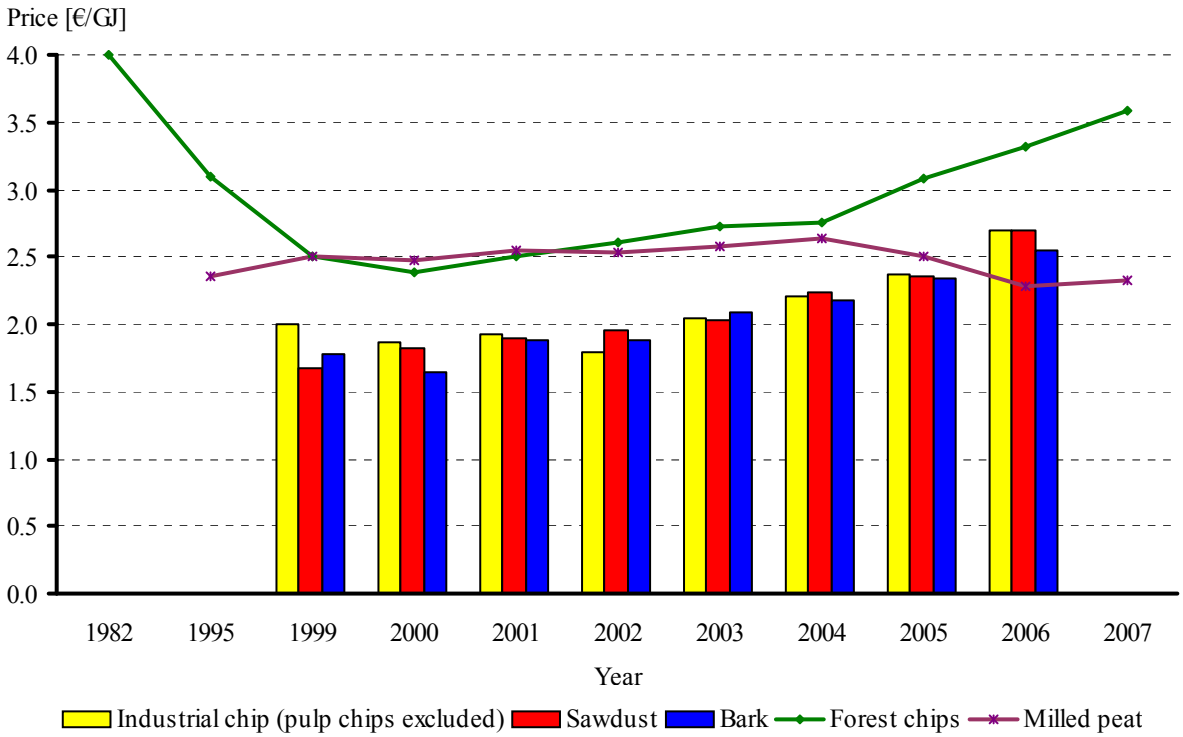

Figure 7. Wood fuels and milled peat prices delivered to plants in 1982-2004. VAT excluded. Sources: Wood fuels, (years up to 1999 [40], years 2000-2006 [23, 41-46], year 2007 [47]; Peat [6, 47]. Prices of sawdust and bark in 2007 were not available because the Finnish Forest Research Institute no longer compiles statistics on wood fuel prices.

The growing demand for wood in energy production and the increasing paying capacity of energy production for wood have affected the other users of wood in various ways. A direct consequence has been the growing competition for wood between energy and raw material uses. In Finland, the competition for wood between raw material and energy purposes mainly involves sawdust, which is used as raw material in particleboard and fibreboard mills, and several pulp mills. Sawdust is also a good fuel for heating and power plants and can be used as raw material in the production of wood pellets. For particleboard and fibreboard mills, sawdust is the major raw material representing about 95% of the total raw material volume, and for pulp mills it supplements pulpwood and pulp chips as raw material. The increased demand for sawdust in energy production has raised its price. According to statistics, the price of sawdust has risen almost 50% between the years 1999 and 2006; see Figure 7. The increased price of raw material has weakened the competitiveness of particleboard and fibreboard manufacturers against manufactures operating in countries not participating in the emission trading.

5 INTERNATIONAL BIOFUELS TRADE IN FINLAND

5.1 Indirect trade of biofuels

The forest industry procures wood primarily for use as raw material. In many cases, the wood is imported from other countries. In the manufacturing of primary products, a significant amount of the raw wood ends up in energy production or is converted into by-products that are utilised in energy production. In this paper, biofuel purchase and use of this kind is defined as indirect import of biofuels, and corresponding export is referred to as indirect export of biofuels. The above-mentioned wood streams jointly constitute the indirect trade of biofuels.

Investigation of wood streams in the forest industry is needed for determining the status of the indirect import of wood fuels. For that purpose, wood streams in energy production, raw material use and final products were calculated for the branches of the Finnish forest industry by means of an Excel-based spreadsheet model. The principle of the model is described in detail in source [48]. The model takes into account the differences between the various branches in the efficiency of conversion of wood into products and uses branch-specific consumption volumes of round wood, imported pulp chips, and indigenous wood by-products in the forest industry and the production volumes of sawn timber and plywood as initial data. The above mentioned data came from Finnish forestry statistics. Wood stream calculations were performed separately for the years 2004, 2005, and 2006.

The calculations for the major wood streams in the Finnish forest industry in 2006 are presented in Figure 8. By-products from the upgrading industry, which uses sawn timber as raw material, are the main raw material for the wood pellet industry, and on this account the wood pellet industry was excluded from the figure. In 2006, 25% of raw wood used in the forest industry was imported, and in total, 40% of the raw wood volume was converted into black liquor and solid biofuels.

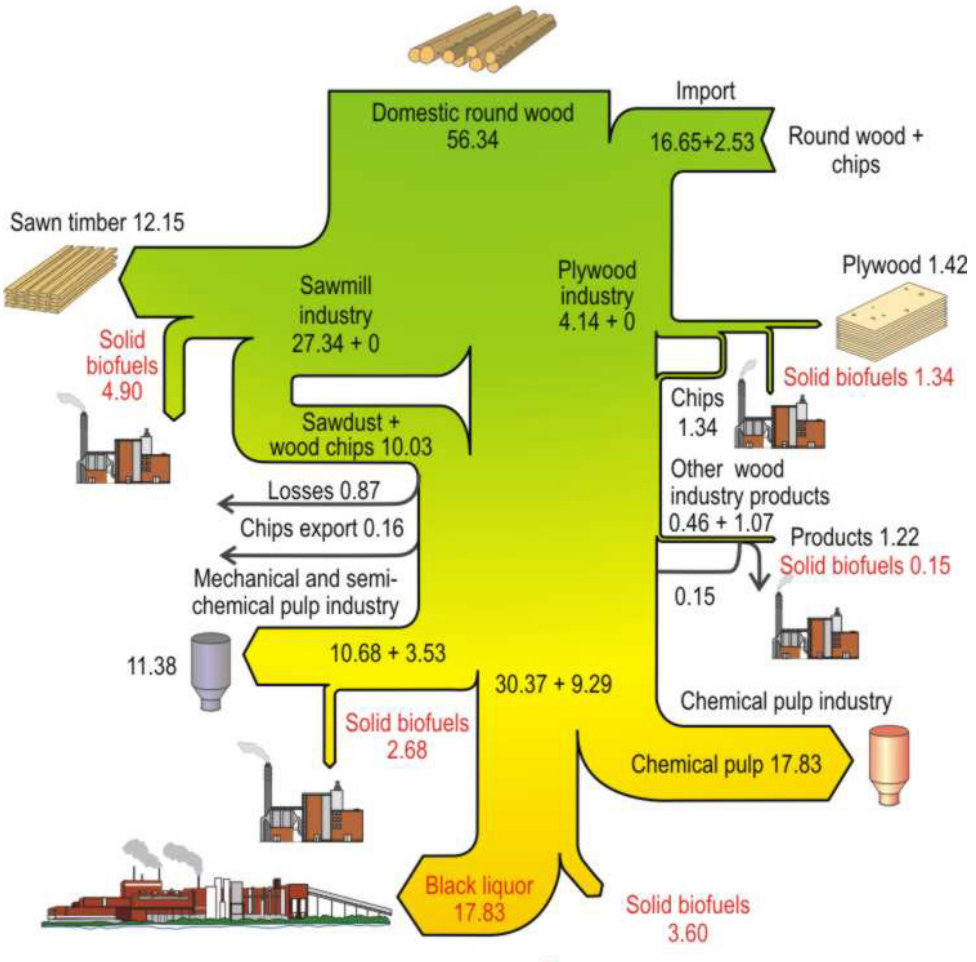

Figure 8. Wood streams in the Finnish forest industry in 2006, in million m^3, round wood includes bark. Figure: J. Heinimö (Lappeenranta University of Technology) & E. Alakangas (VTT)

5.2 Biofuels import and export in Finland in 2004-2006

Similarly to raw wood, a part of imported and exported forest products, food, and fodder streams end up as energy. Determining to what extent a country's bioenergy production is based on these mentioned products is troublesome, and these products were thus excluded from the study. The study covers all remaining biomass streams, which can be scategorized as follows:

- Biofuels (products traded for energy production, such as fuel ethanol, wood pellets, and firewood)
- Raw materials that are traded for the manufacturing of biofuels (e.g. sawdust and pulpwood used in pellet production or pre-processed biomass that is used in the production of liquid biofuels)
- Raw wood (wood matter used in the manufacturing of forest products)

First, cross-border biomass streams were considered in view of foreign-trade statistics. The information was obtained from the EUROSTAT database, which can be accessed freely over the Internet. The product groups selected in the investigation and their Combined Nomenclature (CN) codes are presented in Table 7.

Table 7. The CN codes of the products included in the investigation.

Product	CN code(s)
Round wood	44032031, 44032039,44032011, 44032019, 44032091, 44032099, 44039951, 44039959, 44034100 …44039910 and 44039995
Chips	44012100, 44012200
Sawdust from wood	44013010
Wood waste and scrap	44013090
Fuel wood	44011000
Tall oil	38030010, 38030090, 38070090
Peat	27030000
Ethanol	22070000
MTBE, ETBE	29091900

The information on the volumes of import and export streams from the Foreign Trade Statistics and the wood streams determined for the forest industry provided a starting point for evaluating the energy balance of international biofuels trade. The product-specific data used and the assumptions made in the calculations of import and export balances of biofuels are presented as a summary in Appendix I. The export and import balances of biofuels determined for 2004–2006 are presented in Table 8. In Finland, the direct import and export of biofuels, being mainly composed of wood pellets and tall oil, have minor importance compared to the total consumption of biofuels. The largest biofuels streams are composed of raw wood. The indirect import of wood fuels was on the increase during the period under investigation.

Table 8. Import and export balance of biofuels in Finland in 2004-2006, in PJ. The total calorific values were calculated based on the state the streams across the border.

Stream/year	2004			2005			2006		
[PJ]	Import	Export	Net flow	Import	Export	Net flow	Import	Export	Net flow
Direct trade	**5.38**	**8.15**	**-2.77**	**5.48**	**8.38**	**-2.91**	**5.31**	**8.40**	**-3.09**
- Wood pellets	0.00	2.65	-2.65	0.00	3.27	-3.27	0.00	3.26	-3.26
- Energy peat	0.47	0.29	0.17	0.26	0.60	-0.34	0.11	0.26	-0.15
- Fuel wood	0.92	0.06	0.86	0.94	0.04	0.90	0.90	0.08	0.82
- Wood residues	1.21	0.06	1.15	1.26	0.21	1.05	0.02	0.02	0.00
- Tall oil	2.14	4.45	-2.31	2.03	3.87	-1.85	3.21	4.46	-1.25
-Ethanol	0.64	0.00	0.64	0.99	0.00	0.99	1.06	0.00	1.06
-ETBE [a]	0.00	0.64	-0.64	0.00	0.39	-0.39	0.00	0.31	-0.31
Indirect trade	**56.01**	**2.40**	**53.61**	**57.58**	**3.02**	**54.57**	**61.16**	**3.08**	**58.08**
- Round wood	50.71	2.00	48.71	52.08	2.56	49.52	55.52	2.61	52.91
- Chips	5.16	0.39	4.76	5.25	0.45	4.80	5.26	0.35	4.91
- Sawdust	0.14	0.00	0.14	0.25	0.00	0.25	0.37	0.12	0.25
Total	**61.39**	**10.55**	**50.84**	**63.06**	**11.40**	**51.66**	**66.46**	**11.48**	**54.99**

[a] Includes only the bio-based proportion, which is evaluated the same as ethanol used as raw material.

Foreign-origin wood energy as a proportion of Finnish primary energy consumption in 2004–2006 was calculated by means of the methodology described in [48], and the results are depicted in Table 9. The results differ from the figures presented in Table 8. One explanation for the difference is the fact that the actual calorific values of imported wood in energy production differ from their values across the border.

Table 9. Foreign-origin wood energy in primary energy consumption in Finland in 2004–2006 [6]

Year	Foreign-origin wood energy in primary energy consumption	Percentage from total wood fuel consumption
2004	64 PJ	22%
2005	66 PJ	24%
2006	73 PJ	24%

6 OVERVIEW OF THE MAJOR IMPORT AND EXPORT STREAMS OF BIOFUELS

In Finland, wood pellet export is the largest export stream of biofuels. Accordingly, raw wood import represents the largest import streams related to biofuels. These streams are outlined in the following.

6.1 Export of wood pellets

Wood pellet production in Finland started in 1998. The Finnish pellet industry was founded on export supplying pellets to Sweden, where pellet markets were developing rapidly at the time. Since then, pellet production has increased steadily, climbing to 326,000 tons (5.4 PJ) in 2007 (Figure 9). The majority of Finnish pellet production has been consumed abroad. The peak in pellet export was in 2005. In 2006 and 2007, pellet export slightly declined compared to the level in 2005. The number of export countries of pellets has increased resulting from booming pellet markets in Europe. In addition to Sweden, Finnish pellets have been exported to Denmark, the Netherlands, the UK and Belgium. At the beginning of 2006, there were 17 wood pellet factories in operation [5]. In the same year, the export of wood pellets was 193,000 tons. Denmark (34%), Sweden (30%), and the Netherlands (24%) were the main countries of export for wood pellets [6, 49]. In 2007, the export of wood pellets was 186,000 t, Sweden (42%), Belgium (21%), Denmark (16%) and the Netherlands (16%) being the major export countries [49].

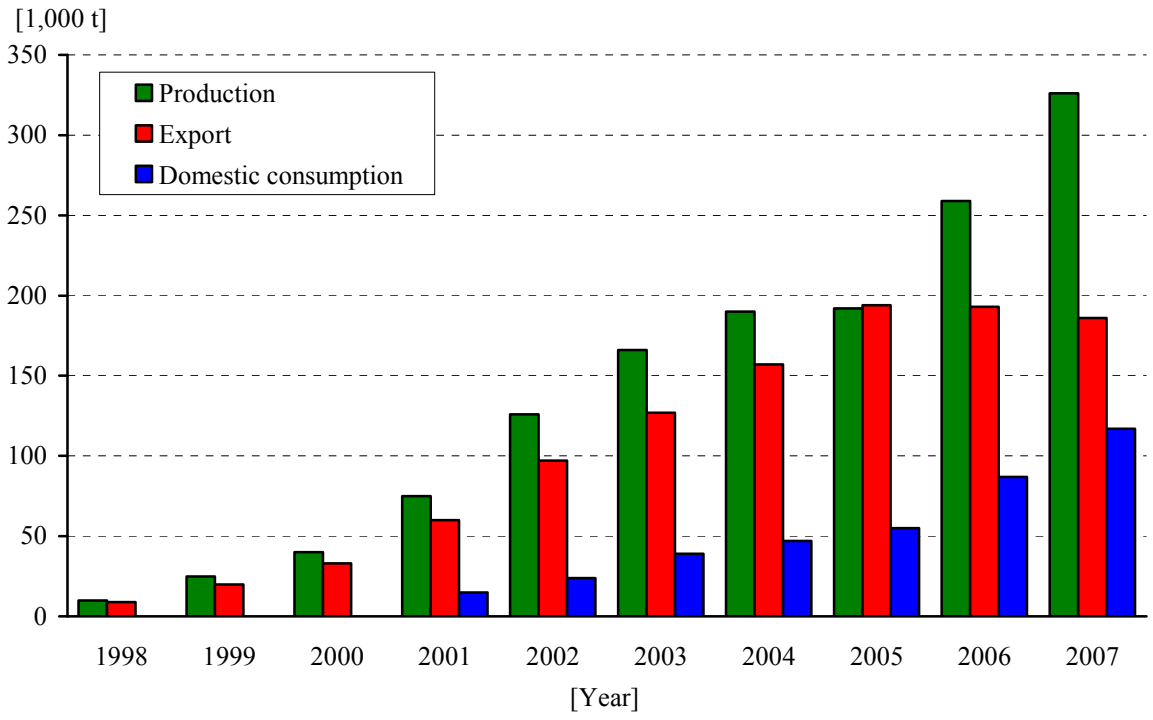

Figure 9. Wood pellet production, domestic consumption, and export in Finland in 1998–2007. In 2005, the export surpassed production resulting from a change in stocks. The figures of the yeas up to 2006 are from references [6, 50, 51] and figures from the year 2007 are from the Metinfo database of the Finnish Forest Research Institute.

In 2004–2007, the domestic consumption of wood pellets more than doubled but was in 2007 still only about one third of the production. The number of private small-scale pellet users in 2008 was estimated at 13,000 [37]. In 2007, about half of the domestic consumption of pellets in Finland took place in small boilers, the thermal output of which was less than 25 kW. Pellets have not been competitive with heavy fuel oil or coal as fuel in heating and power plants, and they are mainly used in applications where light fuel oil is an alternative fuel, typically in the heating of dwellings. Previously, pellets were mainly manufactured from dry by-products from the sawn timber refining industry. This has allowed simpler processes for manufacturing pellets without drying the raw material. Recently established new pellet mills are equipped with drying process and they utilise moist raw materials.

The main destination countries' considerably higher taxation of fossil fuels in energy production and the subsidies for electricity from biomass have made the exportation of pellets economical. In Sweden and Denmark, the taxation of fossil fuels in heat production is remarkably higher than it is in Finland, and there wood pellets are mainly used for substituting coal in district heating and oil in space heating. The Netherlands have heavily subsidised renewable energy sources in electricity production, and wood pellets are primarily co-fired there with coal in large power plants.

The consumption of wood pellets is still at a modest level in Finland compared to the usage potential. About 50 PJ of light fuel oil is consumed for the direct heating of Finnish dwellings each year[6]. Estimations showed that the annual domestic consumption of wood pellets could be raised to 1–1.5 Mt (17.5–26 PJ) by replacing a part of the consumption of light fuel oil with the use of pellets [32]. In addition, a remarkable though less economically feasible potential use for pellets lies in substituting coal in power plants. In recent years, the average consumption of coal in energy production in Finland has been approximately 200 PJ [6]. Coal-fired power plants using pulverised combustion, e.g. in the Helsinki metropolitan area, could increase their use of pellets to even 2–3% of their fuel use without great technical changes in the burning systems if pellet use becomes economically competitive with coal. The largest Finnish coal-fired power plants are found in coastal areas with their own coal ports, which could be used for shipping of pellets if needed.

6.2 Import of raw wood

The Finnish forest industry has long traditions in the import of raw wood. Over the past forty years, the annual raw wood consumption of the forest industry has almost doubled, from 40 million m^3 to 75 million. In the same forty years, the volume of imported raw wood has multiplied, climbing from 8% to 25% of the total wood consumption of the forest industry (Figure 10). The strongest growth in total wood use and raw wood import has taken place since the mid-1990s.

Currently, Finland holds the third position, after China and Japan, among the largest round wood importers in the world [52]. The imported raw wood has originated almost totally from the area of the former Soviet Union (Russia and the Baltic states). In 2006, Russia provided 78% of the total raw wood import, and the share of the Baltic countries was 15% [53].

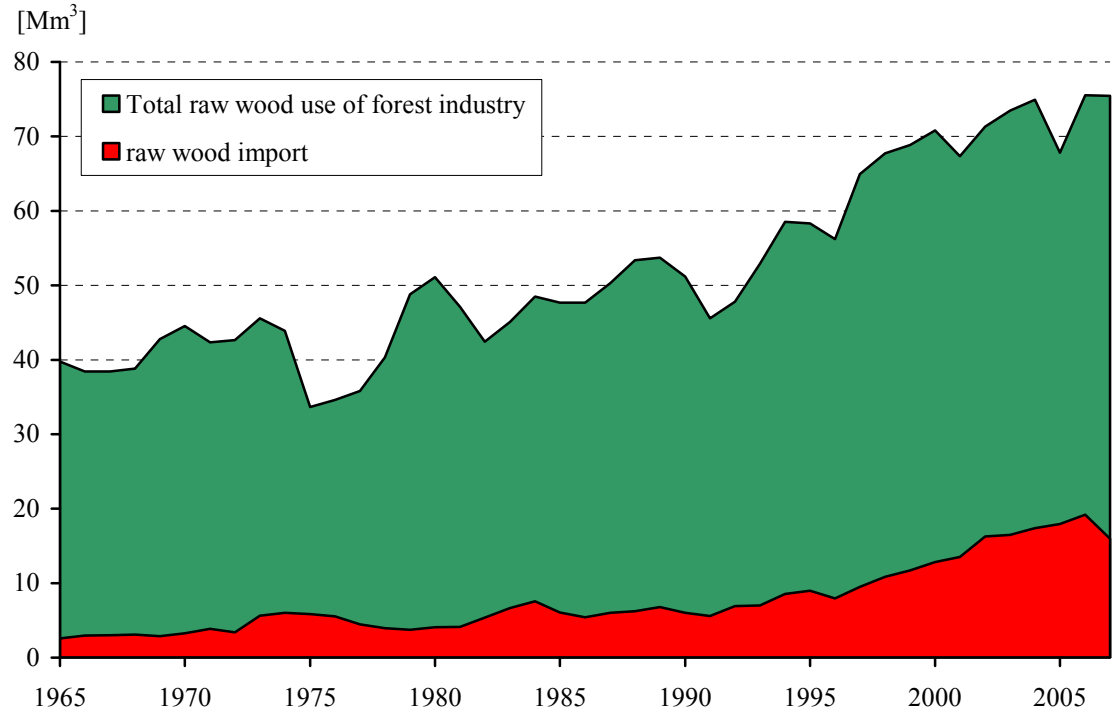

Figure 10. Raw wood use of the forest industry and raw wood import in Finland, 1965–2007 [22, 53]

In Finland, birch pulpwood has been the most important timber assortment in raw wood imports. The boom of Russian raw wood import to Finland started in the early of 1990s, when the transition to a market economy had harmed the Russian forest industry greatly, resulting in the collapse of round wood demand in Russia. Despite the positive development of Russia's forest industry during the past years, the commercial utilisation of forest resources in Russia is still modest.

Various factors, among them the development of round wood use in the forest industry in the Baltic Sea region, the structure of wood consumption in terms of pulpwood and logs, and the development of raw wood prices, affect future volumes of Russian raw wood import to Finland. In particular, development in the Russian forest industry is crucial because it affects all of these factors. Russian ambitions for developing the domestic forest industry will have a large impact in Finland's forestry sector. Russia has launched a programme to raise export duties of round wood in 2007–2011. By 2009, the duties will have been raised gradually by 80% compared to the prevailing level at the beginning of 2007, increasing approximately € 50 / solid m^3 in the price of exported round wood, which will cause a collapse in Russian raw wood import to Finland. [54]

7 SUMMARY AND CONCLUSIONS

This study considered the current situation of biofuels markets in Finland. The cold climate, low population density, energy-intensive structure of the industry and natural resources of the country have affected the development of the Finnish energy system. The only notable indigenous energy resources are hydropower, wood, peat and wind energy. The fact that industry consumes more than half of the total primary energy, widely applied combined heat and power production and a high share of biofuels in the total energy consumption are specific to the Finnish energy system.

Wood is the most important source of bioenergy in Finland, representing 21% of the total energy consumption in 2006. Forestland covers almost 90% of the country's land area, and the national forest industry sector is extensive. Almost 80% of the wood-based energy is recovered from industrial by-products and residues. Due to the forest industry, black liquor represents the largest source of wood energy. The forest industry is also the most important user of wood fuels: almost 70% of wood fuel consumption takes place in the forest industry.

Finland has commitment itself to maintaining its greenhouse gas emissions at the 1990 level, at the highest, during the period 2008–2012. The present National Climate and Energy Strategy was finished at the end of 2005. According to a trend outlined in the strategy, the diversity of the Finnish energy system and the security of the energy supply will be preserved, or even improved. The volume of indigenous energy sources and their share of the total energy consumption will be increased during the period 2005–2025. The implementation of the energy and climate strategy calls for financial support measures. Technology R&D and the implementation of new technologies are the main measures in aiming for economically competitive solutions for the open energy market. Also, taxation, investment aids, regulations and norms support the accomplishment of the target.

The indigenous production potential of bioenergy is not utilised in its entirety. Forest chips from logging residues, stump and root wood and small-diameter energy wood constitutes the largest underutilised biomass potential. There is also potential to increase the use of agrobiomass and biogas, but not on the same scale as forest chips. The growing demand for wood in energy production has increased the competition for wood between energy producers and the forest industry. The current competition in Finland mainly involves sawdust, which is used as raw material for particle board, fibreboard and pulp.

The study showed that Finland is a large net importer of biofuels. Most of the import is indirect and takes place within the forest industry’s raw wood imports. Wood pellets and tall oil form the majority of export streams of biofuels. The indirect import of wood fuels increased almost 10% in 2004–2006, while the direct trade of solid and liquid biofuels has been almost constant.

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A SUMMARY OF THE DATA USED AND THE ASSUMPTIONS MADE IN THE CALCULATIONS OF THE MASS AND ENERGY BALANCES OF INTERNATIONAL BIOFUELS TRADE

Direct trade:	
Wood pellets	• The import of wood pellets was evaluated at zero. • The export volume came from Energy Statistics data(157,00 t /2.65 PJ in 2004, 194,000 t /3.27 PJ in 2005, and 193,000 t / 3.26 PJ in 2006) [6]. • The average moisture content of pellets was evaluated at 10%. • Wood pellets were assumed to be manufactured from indigenous wood.
Fuel peat, including peat pellets	• Horticultural peat accounts for a remarkable proportion of peat exports. • The Energy Statistics information includes the export of fuel peat but does not offer data for fuel peat import. • Foreign Trade Statistics information includes peat import and export but does not distinguish between energy and horticultural peat. • The export volumes and the total calorific values of fuel peat were from Energy Statistics [6]. • The peat import reported in Foreign Trade Statistics information was assumed to be composed entirely of fuel peat. • The net calorific value of imported fuel peat was evaluated at 10 MJ/kg. • The average moisture content of fuel peat was assumed to be 50%.
Fuel wood	• Import and export volumes were obtained from Foreign Trade Statistics information. • The calorific values applied were 8.3 MJ/kg in import and 13.7 MJ/kg in export. • The moisture content applied was 50% in import and 25% in export.
Wood residues	• The import volume was from Foreign Trade Statistics [49, 55]. • Foreign Trade Statistics records wood pellets under the CN code 44013090, which also includes waste wood. The export volume of wood residues was evaluated at 4,000 t in 2004, 25,000 t in 2005, and 3,000 t in 2006, which was the total export under CN code 44013090, with the export of wood pellets subtracted. • The moisture content and calorific value of wood residues were evaluated at 50% and 8.3 MJ/kg, respectively.
Tall oil	• Import and export volumes were taken from Foreign Trade Statistics values. • The calorific value applied for tall oil was 36.9 MJ/kg, which is 90% of the calorific value of heavy fuel oil. The traded tall oil volume was calculated in the overall balance.
Ethanol	• The import volume for energy purposes was evaluated at 23,800 t in 2004, 36,600 t in 2005, and 39,200 t in 2006, which equals the volume of ethanol consumed in the production of ETBE as announced by the manufacturer [56, 57]. • The export volume of ethanol was taken from Foreign Trade Statistics information. • The calorific value used for ethanol was 27 MJ/kg.
ETBE [a]	• According to the manufacturer, the production of ETBE in Finland totalled 48,000 t in 2004 and the production was predominantly exported [56]. • According to the manufacturer, exports of ETBE were 29,100 t in 2005 and 23,100 t in 2006 [57]. • In the calculations, the indigenous consumption of ETBE in 2004 was estimated at zero and the entire production volume of ETBE was calculated to have been exported. • The bio-component percentage of exported ETBE was assumed to be 50% (concerning years 2005 and 2006). • The calorific value of the bio-based component of ETBE was assumed to be similar to that of ethanol used as raw material.
Indirect trade:	• The total calorific value of the indirectly imported and exported biofuels was determined based on the state of the streams when they cross the border.
Round wood	• The actual average density of imported round wood was defined according to the recorded mass and volume as 790 kg/m^3 [55, 58]. On this basis, the average moisture content was assumed to be 45% when the net calorific value is 9.4 MJ/kg.
Chips and sawdust	• The net calorific value and moisture content of wood chips and sawdust were assessed as 8.3 MJ/kg and 50%, respectively.
Export of raw wood	• The proportion of round wood, wood chips, and sawdust exported that ended up in energy production was presumed equal to that imported.

[a] Bio-ETBE (ethyl-tertio-butyl-ether) is an additive that enhances the octane rating of petrol (replacing lead and benzene in unleaded petrol) and reduces emissions. ETBE is produced by combining bio-ethanol and fossil isobutylene.

This study considered the current situation of solid and lquid biofuels markets in Finland. The fact that industry consumes more than half of the total primary energy, widely applied combined heat and power production and a high share of solid biofuels in the total energy consumption are specifi c to the Finnish energy system. Wood is the most important source of bioenergy in Finland, representing 21% of the total energy consumption in 2006. Almost 80% of the wood-based energy is recovered from industrial byproducts and residues. Finland has commitment itself to maintaining its greenhouse gas emissions at the 1990 level, at the highest, during the period 2008–2012. The Finnish energy policy aims to achieve the target, and a variety of measures are taken to promote the use of renewable energy sources and especially wood fuels.

The international biofuels trade has a substantial importance for the utilisation of bioenergy in Finland. In 2006, the total international trading of solid and liquid biofuels was approximately 64 PJ of which import was 61 PJ. Most of the import is indirect and takes place within the forest industry's raw wood imports. In 2006, as much as 24% of wood energy produced in Finland was based on foreign-origin wood. Wood pellets and tall oil form the majority of export streams of biofuels. In 2004-2006, the indirect import of wood fuels increased almost 10%, while the direct trade of solid and liquid biofuels has been almost constant.

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