METSÄNTUTKIMUSLAITOKSEN TIEDONANTOJA 901, 2003

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WOOD FOR ENERGY

a contribution to the development of sustainable forest management

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JOENSUUN TUTKIMUSKESKUS

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FINNISH FOREST RESEARCH INSTITUTE, RESEARCH PAPERS 901, 2003

Wood Fuel Resources and Bottlenecks of Utilization in Baltic and Nordic Countries

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Abstract

The report is investigating the current state of forestry, forest industries and the bioenergy sector in Denmark, Estonia, Finland, Latvia, Lithuania, Norway and Sweden. The main task of the research is to illustrate the current supply and use of wood based fuels in the Baltic and Nordic countries. Additionally the present use of forest fuels in the different countries in the private and industrial sector is analyzed and bottlenecks in the current supply of forest fuels are identified. The focus on energy policy has been on energy systems with less CO_2 emissions in order to meet requirement of international agreements. Therefore, forest fuels offer great potential as a source of renewable energy.

There has been a steady increase in the growing stock of European forests. Large amounts of residues are left unutilised both in Nordic and Baltic forests, especially in first thinnings and intermediate cuttings. They offer large potential to further increase the share of wood fuels in total energy consumption. Forest industries utilize a great share of wood residues at present but especially in Baltic regions there is potential to intensify the use of wood residues. An additional increase in wood biomass utilization is also dependent on future expansion of the district heating networks in Nordic and Baltic countries. Potential is available especially in the Baltic countries and Norway. The situation in regards to utilization of wood biomass in private dwellings is similar in all seven countries. Large amounts of fuelwood are consumed annually but new furnace and burner technology is necessary to use resources more efficiently. In regards to energy policy a lot has been done to improve the use of biomass utilization, but more has to be done to strengthen the position of forest fuels in the future. The main bottlenecks for the larger use of forest biomass were found to be a lack of utilisation of available technology for harvesting and transport operations and a lack of district heating. An improved use of technology would decrease the price of forest fuels, necessary to compete with fossil fuel prices on international markets.

Keywords: wood energy, bioenergy, industrial residues, forest residues, wood harvesting, district heating, biomass utilization, energy policy

Publisher: The Finnish Forest Research Institute; Project: 832801. Accepted for publication by Professor Jari Hynynen, Research Director, in November, 2003.

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Cover picture: Stefan Hotari

ACKNOWLEDGEMENTS

This study was carried out within the project "Wood for energy – a contribution to the development of sustainable forest management" (WOOD-EN-MAN, QLK5-CT-2001-00527) funded by the European Community under FP5 "Quality of Life and management of living resources"

ISBN 951-40-1893-1
ISSN 0358-4283
Joensuun Yliopistopaino, 2003

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1. INTRODUCTION

1.1 Rationale for the use of biomass for energy

Biomass for energy production has a long tradition globally. The advantages of biomass as a fuel have been recognized particularly in the light of recent international events affecting the energy sector. Bioenergy in general has benefited from recent discussions about global warming since local and global environmental advantages of bioenergy use have been recognized. Today there is an obvious movement towards the production of cleaner, environmental friendly, and more decentralized energy production facilities, also elevating the demand for biomass for energy.

Carbon dioxide, from the combustion of fossil fuels is the major anthropogenic green house gas (GHG) and may cause significant changes to the climate. All information on the possible consequences of climate change provides arguments for using renewable energy resources for energy production. This discussion has given renewable energy supporters strong arguments due to the fact that wood fuels are considered neutral in regards to CO_2 emissions since the CO_2 released from their combustion is considered to bound when new biomass is growing (Ranta 2002). If the sequestration of biomass leads to an increase in the total carbon stock

Bioenergy with its associated activities, production, harvesting, and utilization, is integrated with political, economic and environmental agreements. Recently, many countries have developed an additional range of environmental agreements, conventions and protocols designed to address issues of sustainability of resources and communities. The Framework Convention on Climate Change (FCCC), (United Nations 1992) was signed at the 1992 Earth Summit in Rio de Janeiro by 154 countries. These countries agreed to implement measures relating to the monitoring and reporting of national emissions of GHGs, to undertake actions to reduce these emissions, and to build our global knowledge of climate processes, impacts and responses to change (Richardson et al. 2002). To further the objectives of the FCCC, in 1997 the parties to the Convention adopted the Kyoto Protocol that established emission reduction or limitation targets for 2008-12 in the industrialized countries (United Nations 1997). The European Communities White Paper on Renewable Sources of Energy, encouraged by the 1997 Kyoto Protocol, aims for an ambitious and optimistic target. The paper sets a 12% target of the European Union's gross inland energy consumption by 2010 coming from RES. It is proposed that biomass energy in total in the EU can contribute an additional 3.8 EJ annually by 2010, compared to the current contribution of about 2.2. EJ annually. Today the contribution of Renewable energy sources (RES) represents 10.8% of the total primary energy production in the EU

(European Commission 1999). The more intensive use of energy from biomass resulted from the growth of heat and power (CHP) generation mainly in the northern countries as well as the direct use in the domestic sector.

Woody biomass and forest ecosystems also function as carbon sinks. This role can be maintained and/or enhanced by appropriate forest management practices. The use of forest biomass for energy thus provides an opportunity for sequestering carbon. The dual role of wood as a substitute for fossil fuels and as a carbon storage system, and the net contribution of wood energy to global carbon balances, provides good arguments to promote the use of wood biomass for energy production in the future.

Bioenergy will be the main source of renewable energy for several decades until wind and solar energy play a greater role (Shell 1996). The use of wood energy has been limited especially by weak economic competitiveness. Firewood is the commonly used for domestic cooking and heating purposes. Wood wastes and by-products from primary and secondary forest industries are used for energy production. Other sources for the production of wood energy has only been competitive on a large scale or extensive use if supported by fiscal or legislative actions. The improvement of the competitiveness of wood energy have been the center of attention in research and development efforts, mainly due to the significant environmental advantages of renewable resources compared to fossil fuels (Richardson et al. 2002).

The use of biomass in energy production has also positive socio-economic effects on a regional and national level: On the regional level it can create new markets for foresters and farmers, by contributing to the preservation of rural areas, and improve the local infrastructure (Krotscheck & Obernberger 2000).

It is clear that the development of the past years has contributed to an increased awareness of biomass for energy production in the public, especially to the advantages in regards to global warming. But it is also obvious that there are barriers to an increased use of wood energy in regards to competitiveness compared to fossil fuels. But when social and environmental benefits are taken into consideration, forest biomass for energy production provides multifold opportunities to tackle the challenges ahead.

At present, oil and gas contribute large amounts to the total energy consumption in most countries. Norway in particular stands out as a country with large oil resources whereas other countries largely depend on imports. The current contribution of wood fuels to the total energy production is already relatively high in some northern European countries but there is definitely more potential in the utilization of forest residues and industrial residues. Also, the Baltic countries have abundant resources that are currently only partially utilized. The current state of utilization of wood fuels is a result of political, industrial and social development in the past. Certain bottlenecks have developed in the process and to increase the potential in the future these bottlenecks have to be identified and widened.

1.2 Objectives of the research

This report is examining the current state of forestry, forest industries and the bioenergy sector in Denmark, Estonia, Finland, Latvia, Lithuania, Norway and Sweden. The main objective of the research is to illustrate the current supply and use of wood based fuels in the Baltic and Nordic countries. Additionally, the present utilization of forest fuels in the different countries in the private and industrial sector is analyzed and bottlenecks in the current supply of wood fuels are identified. The situation is different between the Western countries that have been enjoying political stability and prosperity and the Baltic countries economies are in transition and are now in the process to join the EU. These differences are causing different needs for further social, political and technological development. The research is therefore trying to generate solutions and identifying research topics to improve and increase the use of biofuels in Baltic and Nordic countries.

1.3 Research methods

The research methods in this study are a literature review and the analysis of statistical data. Additionally seven country reports were written for this synthesis report and are a core element of the research.

Experts have compiled a synthesis and analysis of the situation regarding the use of wood fuels in each country. The reports were compiled for "Wood for Energy – a contribution to the development of sustainable forest management" project of the EU 5th Framework programme: "Quality of life and Management of Living Resources". The experts were provided with a detailed outline to write the country reports. The quality of the reports varied, which made the analysis a challenging task. Particularly in the Baltic countries reliable data is difficult to find and in some cases non-existent. The provided data, combined with other statistics and information from literature served as a basis to compile this report. Additionally statistical data was analysed to identify current supply characteristics and possible bottlenecks of increased utilization of bioenergy in each country.

1.4 Structure of the report

This report consists of four parts. In the first introductory part, consisting of chapters 1-3 a general background analysis related to the research topic is given. The second part includes chapters 4-5 and regards current and potential wood fuel utilization in forest industries, CHP and private dwellings. In chapters 6-7 national energy systems, energy use and policy are discussed.

Finally chapter 8 presents an analysis of the current bottlenecks of bioenergy utilization, and conclusions are discussed in chapter 9.

Chapter 2 deals with a general background of the seven countries giving an overview of total land area, politics and economy, population and population density and the role of forestry in each country.

In chapter 3 a summary of the forest resources in each country is presented. Topics such as forest ownership, the different forest types, sales, removals and harvesting of wood, and wood harvesting practices and technology are discussed in more detail and relevant issues related to the utilization of wood fuel resources are pointed out.

Chapter 4 starts by giving an overview of the current state of forest industries in each country. The present state is discussed and a closer look is taken at the importance of forest industries in each country and a table with the output of forest industries is presented. The resources available for wood energy are part of the chapter as well and the current output of industrial residues is shown. Origins of forest fuels are presented and the current use and potential utilization is examined. Also production potential on marginal agricultural land and a comparison of guidelines for forest fuel harvesting are part of the chapter.

In chapter 5 the current use of forest biomass for energy is shown. The chapter shows the current level of utilization of wood energy in forest industries, district heating plants and private dwellings. The data indicates where the bottlenecks are and gives an overview of the potential to increase the level of utilization even further.

Chapters 6 and 7 take a closer look at the policy side of the energy use. Chapter 6 presents the national energy systems which points out interesting facts about energy use in each country and the shares of different energy sources of total energy consumption. Energy policy, its focus and means for energy policy are examined in chapter 7.

Chapter 8 analyses the current bottlenecks of bioenergy utilization in each country and examines reasons of development and presence.

Chapter 9 presents conclusions of the research based on the information presented in the previous chapters. The chapter tries to offer some solutions and tools to widen the current bottlenecks from a technological and political point of view. Also, research needs to promote the use of wood fuels are identified in the chapter.

2. GENERAL CONTEXT

2.1 Total Land Area and Forest Area

There are large differences in the land area of the different countries. The largest countries are Sweden, Norway and Finland, all of them being over 30 million ha. Lithuania Latvia, Denmark and Estonia are significantly smaller only ranging from about 4 to 6 million ha. Forest cover is another aspect varying significantly from country to country (Table 1).

Table 1. Total Land Area and Forest Area in 1000 ha (United Nations 2000).

	Total Land Area	Forest Area	Percent of total Land Area
Denmark	4 243	455	10.7
Estonia	4 227	2 060	48.7
Finland	30 459	21 935	72.0
Latvia	6 205	2 923	47.1
Lithuania	6 257	1 994	31.9
Norway	30 683	8 868	28.9
Sweden	41 162	27 134	65.9

2.2 Politics and Economy

Political and economical changes in the Estonia, Latvia and Lithuania are still underway and will be continuing in the future. The proposed membership of the European Union in 2004 will be a considerable improvement for the three Baltic States in regards to economical development and future investments from the west. The recent situation and associated problems that all three countries are facing are very similar. After the disintegration of the former Soviet Union, the countries had to deal with a dramatic economic collapse, and are still trying to recover. All of them are undertaking resolute steps in order to promote the transition to market economy (Jaskelevicius & Kairiukstis 2002). Estonia's economic recovery, for example, started in mid-1993 and gathered momentum in 1994, bolstered by a widespread national desire to integrate into the European Union (International Energy Agency 2002).

The development was similar in Latvia and Lithuania but low GNP, unemployment and low salaries are continuing to be a problem in the Baltic countries. In the year 2001 the average monthly earnings according to the Lithuania country report were equal to €287 and in agriculture and forestry even less with only €216. The situation in the forestry and forestry related fields was a little bit more positive with about €326 monthly. Nevertheless, low salaries can also be a competitive advantage compared to high salaries in the Nordic countries. These reasons together with low capital investment per capita are the main bottlenecks for further economical development in these Baltic States. These problems are also caused partly by the political situation, for example in Lithuania the government has changed twelve times since the restoration of independence on March 11th 1990 (Jaskelevicius & Kairiukstis 2002).

The situation in the western countries is vastly different. The political environment is more transparent and stable, which in return leads to more economic stability. As shown in Table 2 the gross domestic product in the Nordic countries is much higher compared to the Baltic States. Despite economic recessions in the past, and current challenges such as slow economic growth and high unemployment especially in rural areas, the situation remains favorable in the west.

Table 2. GDP in 2001 (Worldbank 2002).

	GDP in US$ billion	GDP per capita in US$
Denmark	162,8	30 602
Estonia	5,5	3 948
Finland	122,0	23 589
Latvia	7,5	3 098
Lithuania	12,0	3 247
Norway	165,5	37 033
Sweden	210,1	23 762

2.3 Role of Forestry

Historically, forests were primarily a source for fuel, construction and shelter. Today, the situation has changed and forests play multiple roles for our welfare. With industrialization forests have become an important source for fuel as well as raw material for forest products.

In recent years forest management has been closely linked to issues such as soil, water and wildlife protection, carbon sinks, biodiversity, recreation and as a renewable resource, by sustainable forest management. Especially in Finland and Sweden where the area of forest per inhabitant is the largest (Figure 1), the role of forestry has been of great importance. Both economies today depend to a large extend on the forestry sector and forest industries. There is common appreciation of forests as a source of income but also as a place for recreation and solitude.

The situation is fairly similar in the eastern countries where the growth of forestry and the forestry sector has been an important factor in the recent development of the countries economies in regards to trade balance and the welfare of the people after the breakdown of the Soviet Union. In the Baltic countries there are large amounts of resources available to supply a growing forest industry, and due to a large demand of timber from Nordic and Central European countries, timber exports have become an interesting investment. Timber exports from the Baltic countries are already common and the share of solid wood products and sawn timber in particular is already very high. There is more potential to increase exports in the future especially since, at present, there is no pulp production in the Baltic States.

Forests have also gained in importance in the ongoing discussion about CO_2 emissions. Forest play an important role in those discussions as an alternative energy source, but providing residues for energy use is not the only advantage of forest products, wood is also widely used for long-lived products, with a CO_2 mitigation benefit. First, it can be used as a substitute for more energy-intensive products (e.g. concrete, steel), which leads to an indirect replacement of fossil fuels. Furthermore the stock of carbon in wood products can be increased and finally wood products can be used as energy source at the end of their life cycle contributing to the displacement of fossil fuel (International Energy Agency 1998). Through this development the importance and role of forestry has considerably changed in recent years, and called for new improved management practices combining maximum production with environmental protection and management for maximum CO_2 sequestration in forests.

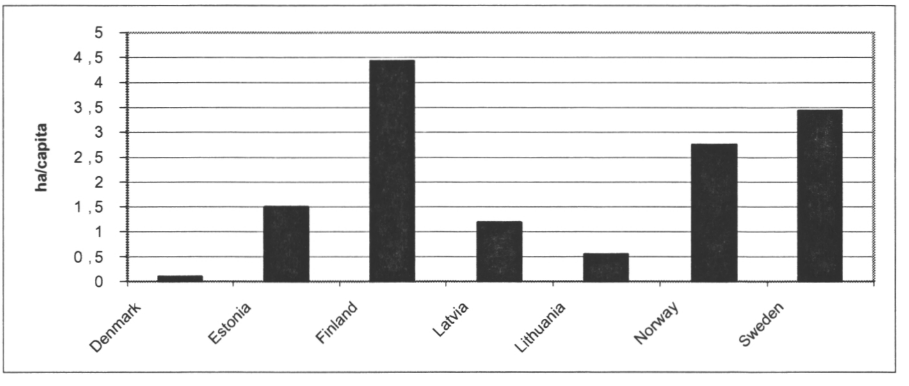

Fig 1. Area of forest and other wooded land per capita (United Nations 2000)

3. FOREST RESOURCES

3.1 Forest Ownership

The forest ownership structure varies significantly between the Nordic and the Baltic states, but within the Nordic countries they are very similar, where private forest owners and companies own the larger share of the forests. In Finland for example one in five families owns forestland with the average size of the forest holding being about 33 ha. The respective figure in Sweden is even higher, with the average forest area in family forests amounting to 42 ha. The largest share, however of all seven countries, is found in Norway where the average size of forest properties is 57 ha, whereas 72% of Danish forest properties are smaller than 5 ha. Figure 2 shows that the share of privately owned forest is much larger than state owned forests in all Nordic countries.

Conditions in the Baltic countries are considerably different due to the political history of the countries. Before the breakdown of the Soviet Union most of the forestland was owned by the state, and after the countries gained independence many efforts have been made to privatize forestland. The average size of private forest holdings, in the Baltic countries, ranges from 3.2 ha in Lithuania to 8.2 ha in Latvia. As shown in Figure 2 the percentage of private forestland in Latvia has reached almost 50%.

In Lithuania the share of private forest owners is relatively small despite an increase in the area in private ownership since the early 1990's. Projections estimate that this will reach 33-36% of the whole forest area in the near future (Jaskelevicius & Kairiukstis 2002).

In 1991, a property and land reform was started in Estonia, and it is estimated that as a result of the land reform 40 -50 % of the land will go from to public to private ownership. By July 1st 1996, approximately 150,000 ha of the forestland had been registered as private property. The average size of forest plots, held by private owners, is approximately 14.3 ha (RMK 2002). The process of privatization is continuing in Estonia.

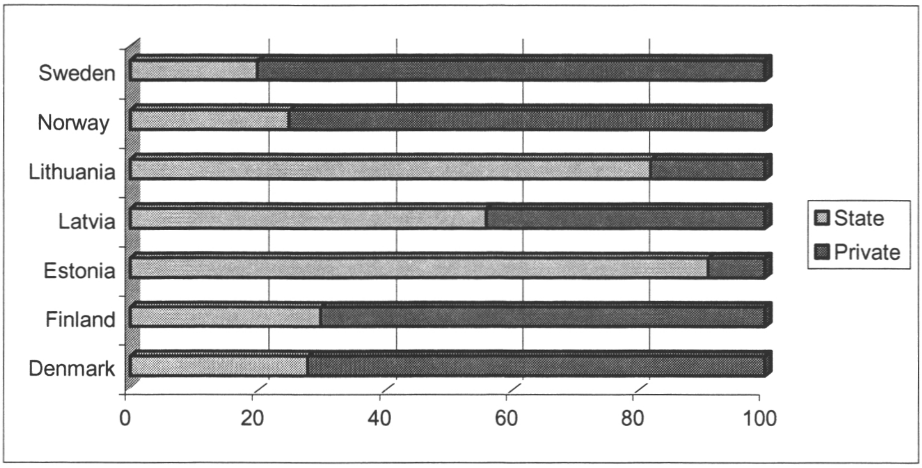

Figure 2. Ownership Structure (United Nations 2000).

3.2 Forest Types

Forests of the Nordic Regions are dominated by coniferous tree species (Figure 3). Denmark, due to its geographical location, has a larger share of broad-leaved species compared to the other countries, with Quercus spp. and Fagus spp. being more common. Sweden has also some Fagus spp. in the southern parts of the country but in the other countries the most common tree species are Pinus sylvestris, Picea Abies and Betula spp. as the most common broad-leaved species mixed with Alnus spp., Populus spp., Quercus spp. and Fraxinus spp (Baltic 21 2000).

The tree species is important in regards to profitability of the operation since the amount of biomass residues after harvesting of conventional timber varies between light-demanding Pinus sylvestris and shade tolerant Picea abies. The amounts of residues are higher in Picea abies stands due to greater foliage and crown mass whereas in Pinus sylvestris and Betula spp. stands the mass foliage is substantially smaller (Hakkila & Parikka 2002).

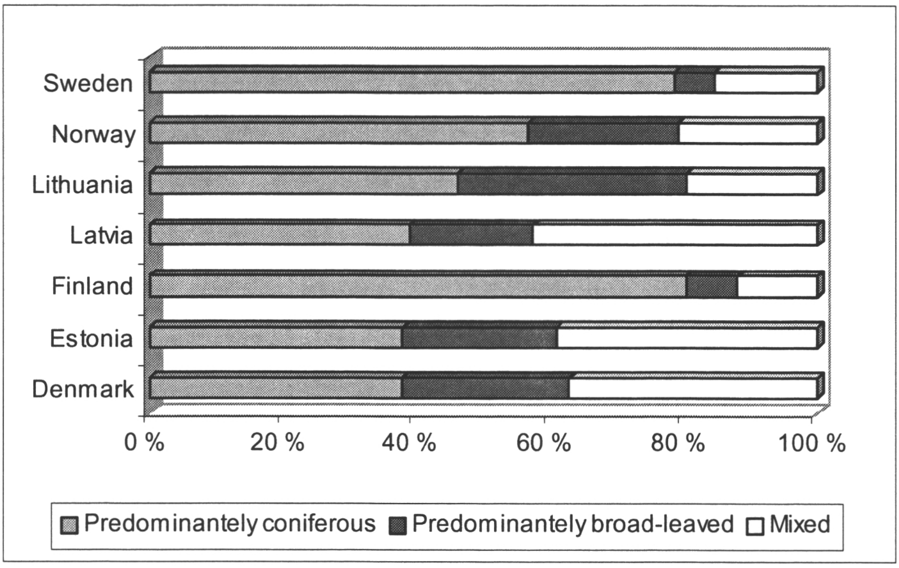

Figure 3. Proportions of different forest types (United Nations 2000) Definition:(By predominantly is meant that the species group covers 75% or more of the area).

3.3 Growing Stock, Annual Increment and Annual Fellings

Table 3 gives an overview of growing stock, annual increment and annual fellings in all seven countries. Figure 4 illustrates that the fellings in all seven countries are below the annual increment, which indicates that there is a permanent increase in the countries growing stock. In 1996 a research report by the European Forest Institute was published which presented the results of growth studies in 12 different countries. Most studies showed that site productivity has increased on numerous sites, in particular in many Central European countries (Karjalainen et al. 1999). The reasons for the increase are multifold. Kuusela (1994) concluded that recorded growing stock in Europe has increased by 43% during the period 1950-1990. Net annual increment has exceeded annual fellings and the difference has been increasing. If that trend is going to continue, stand density, age and growing stock volume per hectare will increase and pose a risk for larger damages by insects, fungis, wind, and other natural losses. The development also shows the vast amounts of resources available for forest energy. Intensified utilization of forest biomass for energy can be a partial solution to the problem. The benefits of a more intensive use of forest fuels for the forest owner are twofold. Particularly first or intermediate thinnings could be increased in the future and provide a source of income and furthermore the overall health and stability of forest and stands would be improved.

Table 3. Growing stock, annual increment, annual fellings in 1000 m^3 overbark (United Nations 2000).

	Growing Stock	Gross Annual Increment	Annual Fellings
Denmark	61500	3 770	2 444
Finland	2 002 000	75 974	54 300
Estonia	326 812	10 110	
Latvia	546 000	17 800	8 150
Lithuania	371 700	12 844	5 750
Norway	859 433	27 370	11 632
Sweden	3 071 172	103 415	67 766

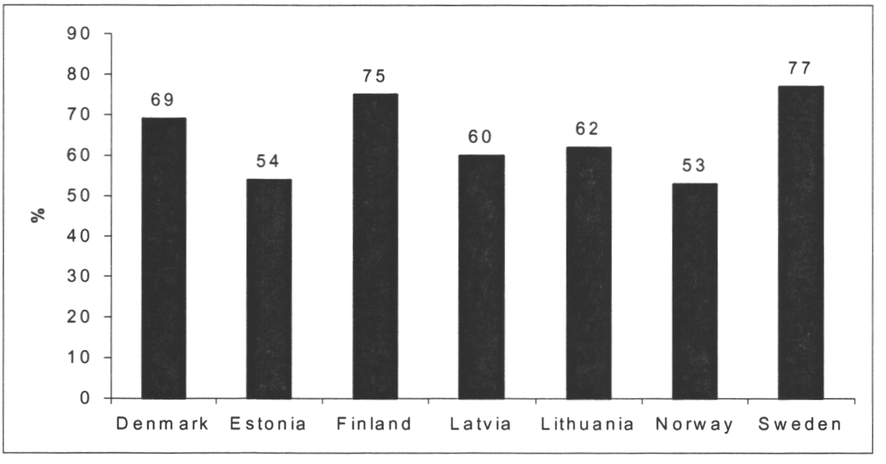

Figure 4. Balance between fellings and net annual increment (United Nations 2000).

3.4 Sales, Removals and Harvesting of Wood

In the Nordic and Baltic countries, at present, two methods regarding timber sales are dominating. They are stumpage sales and delivery sales. When using stumpage sales, the purchaser pays a net price to the forest owner and has to cover the logging costs. In delivery sales, the seller does the harvesting and then he receives a (roadside) gross roundwood price that covers both the felling cost and the timber.

- In Denmark the sale of wood is done on the basis of delivery sales. Most roundwood is delivered to the forest road, where ownership passes over (Suadicani 2002).

- In the year 2000 RMK (Estonian state forest management organization) organized 30 bidding sessions for selling the cutting rights for standing forest in Estonia. The annual sales of standing forest have been decreasing steadily. Compared to 1999, the sale by bidding dropped by 15%. The main reason behind that development is the change of orientation from selling roundwood instead of standing forest (RMK 2002).

- In Finland timber sales transactions are predominantly stumpage sales. 69% of all commercial harvesting is covered by stumpage sales. In the private forests even 73% of the timber harvested has been sold by stumpage sales. The situation is different on state owned land where sales are based on long-term contracts and can be comprehended as deliveries by the forest owner to the industry. It is also important to note that forests owned by private individuals are the main source of round wood for Finnish forest industries. The forest owner associations are an important mediator in the forestry sector since about 35% of sales from privately owned forests are made with forest owners' association as a mediator (Sikanen 1999).

- In the year 1999, timber in Latvian state forests was mainly sold on the basis of long-term contracts and in auctions. The situation is similar to the Finnish market situation with the share of stumpage sales in private forests being considerably larger. Private forest owners accounted for 62% of the stumpage sales whereas the remaining 38% where done by the state joint stock company "Latvian State Forests" as well as other state forests (Vilkriste & Konstantinova 2002).

- The Lithuanian forest sector experienced an increase in stumpage sales by 5% amounting to a total of 600 000 m^3 in 2000. Nevertheless roundwood delivery sales from state forest enterprises dominated the market with 3.3 mill.m^3. The largest share of round wood came from state forests representing 73% and the remaining part was from private forest owners (Jaskelevicius & Kairiukstis 2002).

- The dominating form of timber sale in Sweden is cutting assignments. The forest owner contacts a forest company, which carries out the harvesting with different contractors. The volume is measured at the mill and paid depending on quality and quantity. Another option is a settlement either according to a pricelist, a fixed cost or net agreement. These types of timber sale are widespread representing about 60-80 % of total sales. Delivery sales amount to about 20-40%. Timber sales according to stumpage sales are not common in Sweden and represent only a small percentage (Johansson 2002).

Table 4. Removals by forest owner group in 1000 m^3

	Denmark	Estonia	Finland	Latvia	Lithuania	Norway	Sweden
Total commercial Removals	2 100	6 439	55 613	10 512	5 346	7 478	70 800
Private	1 400	3 667,2	51 314	6 510	1 414	6 920	65,3
State/Public	700	2 609,5	4 589	3 840	3 932	259	5,2
Others	-	161,9	-	-	-	-	-
Percent of State Removals	33	41	8	37	73	4	7

Table 5. Removals by species in 1000 m^3

	Denmark	Estonia	Finland	Latvia	Lithuania	Norway	Sweden
Total commercial Removals	2 100	6 439.2	56 613	10 512	5 346	7 478	70 800
Scots Pine	0	1 977.1		3 170			
Sawlogs		1 186.2	10 930			987	34 300 coniferous sawlogs
Pulpwood		790.9	12 408			598	
Norway spruce	1 400	2 195.9		2 737			
Sawlogs	800 Norway and Sitka	1 209.9	15 991			3 015	
Pulpwood	300	986	9 872			2 792	
Hardwood (mainly birch)	700 beech	2 137.5		4 125			
Sawlogs	450	151.6	1 331			9	600 non-coniferous
Pulpwood	0	1 985.9	5 331			52	28 600 total pulp
Commercial fuelwood	250	128.7	750			3 000	6 700
Other roundwood							600

3.5 Wood harvesting practices and technology

3.5.1 Degree of mechanization and technology

Generally, in Nordic countries a high degree of mechanization is characteristic. The seven countries can be divided in three groups according to their current degree of mechanization.

In the first group, including Finland and Sweden, a high degree of mechanization is characteristic. Single grip harvesters, contracted by forest industries, do 90% of the fellings in Finland (Asikainen 2002). The situation is similar in Sweden where fellings are highly mechanized in thinnings and final fellings. Felling operations in valuable broad-leaved forests are commonly carried out manually due to quality requirements.

The second group consists of Denmark and Norway, where mechanization is on a higher level compared to group 3 but hasn't reached the level of group 1. This group is characterized by a continuous increase of mechanization in forest operations, over the past years. In 1997 64% of the removals were transported with forwarders and 56% was harvested using harvesters in Norwegian forests. Today, the share has increased to 75-80% for both transport and harvesting. However, 24 percent of forest owners are still working in their own forests (Lunnan et al 2002). An increase in mechanization particularly in younger stands has been noticed in Danish forests. The degree of mechanization in spruce stands is more than 90%, whereas mechanization is not developed for hardwood species (Suadicani 2002).

Group three consists of the three Baltic countries where the situation is opposite to group 1. In this group most of the felling operations are done manually. In Latvia, for example, the harvesting operations are primarily carried out manually using chainsaws. Forwarders are used for timber transport in industrial logging operations whereas adapted agricultural tractors are generally used in private small scale logging operations. Harvesters are not very common and their utilization is only about 7-9% (Vilkriste & Konstantinova 2002). In the past, the Baltic countries have experienced an increase in mechanization. In Lithuania, for example, the percentage of wood hauled by forwarders has increased from 2% in 1991 to 62% in 2000, but one of the foremost obstacles is that credible information is scarce (Jaskelevicius & Kairiukstis 2002). The problem is similar in Estonia where an exact statistical analysis has not been carried out and thus it is difficult to acquire accurate data. According to estimations, about 60% of the timber in state forests is harvested using harvesters whereas in private forests the respective figure is only 10–15%. Baltic countries face major difficulties, particularly in the private sector as well as middle and average size harvesting companies where due to low salaries inexpensive manpower is usually employed.

In regards to the logging system the situation is similar in all seven countries with cut-to-length method being dominant. According to Johansson (2002) in Sweden the cut-to-length method is used in 99% of the logging operations, and in Finland only small proportions are logged as whole stems. In Denmark, only timber from clearcuts is produced in full length, otherwise the cut-to-length system is dominating. The whole stem technology prevailed in Lithuania until 1992 but since then the situation has changed considerably resulting in a rapid decrease of the whole stem technology. In 2001 timber logged in whole stems only amounted to 4% of the total (Jaskelevicius & Kairiukstis 2002). In Latvia the cut-to-length method is dominant in final fellings and in thinnings.

3.5.2 Organization of Harvesting and Transport

In Denmark, state forests generally have their own machines, but contractors are employed by the state if required. One large contractor dominates the market, and additionally there are many small contractors operating with about 1-3 machines (Suadicani 2002).

90% of Finland's fellings are contracted by the forest industries. Large forest companies manage the wood harvesting but private forest machine entrepreneurs carry out the operational work (Asikainen 2002).

Sweden's forestry sector is organized in a similar way since small-scale forestry companies perform most of the operational work. In Norway the trend is different and removals of roundwood, performed with the owners own equipment and implements have decreased in the past years (Lunnan et al 2002).

In Latvia, all state owned harvesting companies were privatized by 1996. Simultaneously many private companies were established. Today, all major harvesting operations are performed by small to medium seized companies and private farmers. The long term contracted volume of the 10 largest companies amounts to about 1 million m^3 annually. The Latvian Union of Timber Harvesting Companies (LUTHC) consisting of 35 enterprises related to timber harvesting acts as an important institution on the Latvia forestry sector representing member's interests and seeking international cooperation (Vilkriste & Konstantinova 2002).

In Lithuania, according to Jaskelevicius & Kairiukstis (2002) approximately 1 175 private forest enterprises operate in logging, silviculture and other related fields both in state and private forests. Only about 50% specialized in logging operations. 65.7% are enterprises with only 1 worker, 29% have 2-10 workers and 5.2% employ more than 10 workers.

One of the main goals of Estonia's RMK is to increase the share of contractors. There are agreements that the amount of timber cut by the forest districts, should not surpass 20% of the total prescribed cut. In accordance with the RMK Development Plan for 2001, the forest districts are expected to carry out about 12% of the cuttings and 19% of the transport (RMK 2002).

Transportation:

- Timber in Denmark is in general transported by truck. Some imports of beech originating from Germany and Sweden are transported by rail.

- In Latvia, long distance transportation via rail is decreasing. Transportation with trucks is the dominant means for timber transport on a local level. The increase of timber exports has supported a rapid development and improvement of harbors (Vilkriste & Konstantinova 2002).

- Transport of forest products in Sweden represents about 25% of total terrestrial transportation. During 2000, timber trucks transported 47.8 million tons of roundwood compared to 4.8 million tons transported via rail (Johansson 2002).

- Long distance transport in Finland is dominated by truck transportation directly to the mills. Trucks transport about 80% of wood, railway transport represents 14% and waterway (floating and barge transport) about 6% of all wood transports.

- The forest industry in Norway is similar to Sweden and Finland a major consumer of transport services. The transport of wood and forest products stands for 15 percent of the entire road and 35 percent of the railroad transport of goods in Norway. Annually, in total about 17 million tons of forest products are transported by sea, road and rail. The average transport distance of each ton of finished forest product is 4,300 km (Lunnan et al. 2002).

- In Estonia, according to Pärn & Mandre (2002) 90% of the long distance transports are performed by timber-trucks and 10% by rail.

In general conditions in Nordic and Baltic countries are favorable for the recovery of forest residues. The efficient production of chips originating from logging residues is nevertheless dependent on the degree of mechanization. The research has shown that mechanization is at a high level in the Nordic countries. But mechanization is much lower in the Baltic countries and efficiency could be improved if more modern technology would be utilized in harvesting operations in future. In the Nordic countries, mechanization of forest work has stimulated the development of cost-effective harvesting machinery and methods for bioenergy production (Asikainen et al. 2002). This encouraging development in the Nordic countries should stimulate similar actions in the Baltic countries. The challenge now is to export the expertise to the Baltic countries to make forest fuel procurement more efficient and thus profitable.

4. WOOD ENERGY RESOURCES

4.1 Definition of wood fuels

Wood fuels can be grouped according to their source of origin. Ranta (2002) classified wood fuels as follows: The first group is industrial wood waste and by-products including black liquor, bark, sawdust, cutter shavings and endings and cross-cut ends. The second group consists of forest fuels, which consists of logging residues, thinning residues and stumps. The third category is energy forest based on short rotation trees. Recycled wood is the last group made up of used wood such as recovered construction and demolition wood.

4.2 Forest industries

4.2.1 Overview

Forest industries play an important role in the different countries' economies. In addition, forest industries are usually the largest users of woody biomass in energy production and their role in the development of wood fuel utilization is very important (Richardson et al. 2002). In Sweden and Finland forest industries traditionally contribute essentially to the countries economies. The Swedish Forest Industries Federation (2001) states that the Swedish forest industry plays an relatively more important part in the Swedish economy than its counterparts in other EU countries, apart from for Finland. The forest industry and forestry sector account for more than 4% of Sweden's GDP, 12% of total value added in industry, 12% of industrial employment, and for almost 15% of Sweden's exports. The paper industry is the major individual sector, accounting for more than half of the added value and of exports by value of the Swedish forest industry.

Finland's production of sawn timber has experienced a gradual increase during the 1990's. This increase was supported by a high demand of sawn products particularly on European markets. The production in other sectors has also been increasing and at present there are; 239 sawmills, 16 plywood mills, 3 particle board mills, 2 hardboard mills, 32 paper mills and 14 paper board mills employing 96 000 people highlighting the important role of forest industries in the Finnish economy.

Norway has about 200 sawmills and 25 pulp mills. The sawmills are located mostly in rural areas, where they support local economies and the employment situation.

Denmark's forest industries are comparatively small and most of the sawn timber and particleboard is produced for the domestic markets. 75% of the total consumption of sawn timber is imported, whilst most of the wood-floor production is exported. Denmark's pellet production is growing rapidly and has reached 200 000 tones annually and is expected to grow further in the future. Today, Denmark has a wide pellet distribution network, which has grown after several large oil companies have entered the market. The price of pellets has increased over the last years due to a beginning shortage of wood wastes for the pellet production (Suadicani 2002).

The wood-processing sector in the three Baltic States experienced a downturn along with the national economy caused by the separation from the Soviet economy. Despite the transition to market economy, most of the Lithuanian forest industrial sectors managed to survive (Jaskelevicius & Kairiukstis 2002). From then the situation has been improving constantly and in recent years the forest sector in Lithuania has been contributing about 3.4 % to the GNP. The increase in sales of wood processing and furniture sub-sectors reached 24%, whilst in the paper sub-sectors it grew by 20%. The woodworking industry accounted for 7.4% of the total manufacturing output and the export of timber is becoming more and more important, accounting for 5.9% of total exports in 2000.

According to the Estonian Investment Agency (2002) the Estonian forest and wood working industries including primary wood processing, furniture manufacturing and pulp and paper production are the third largest industrial sector, with almost 15 % of total industrial output, at present. In 1998, total production increased by 20% compared to the previous year, maintaining the highest growth rate in the manufacturing sector in Estonia.

During Soviet times, wood processing had a strong impact on the Latvian economy. The recent recovery has generated the fastest growth rates in the Latvian manufacturing sector. The wood processing industry today contributes 1.5% to the GDP accounting for almost 20% of total manufacturing output, being the second largest industrial sector in Latvia after food processing (Lill 2002).

In general forest industries in all seven countries are contributing extensively to rural development, being close to the raw material sources and with an important role in local economy and employment as seen in tables 6,7 & 8.

Table 6. Number of sawmill, papermills, pulpmills and boardmills.

	DK	EST	FIN	LAT	LIT	NOR	SWE
Sawmills	200	150-170	2 239[1]	1 400[2]	-	200	1 875
Paper&Pulp mills	0	2	46	1 (Paper)	-	25	93
Board mills	1	3	5	7	-	-	12

[1] 128 mills produce over 10 000 m^3 sawn timber annually
[2]3 large sawmills with capacity of 50 000 m^3 and 20 medium seized sawmills with a capacity ranging from 10 000 to 30 000 m^3

Table 7. Output of the forest industries in m^3 (FAOSTAT 2003).

Products	DK	EST	FIN	LAT	LIT	NOR	SWE
Roundwood	2 370 273	12000 000	52 210 000	14 037 000	5 700 000	8 379 301	64 920 000
Sawn wood	81 000	1 436 300	12 770 000	3 840 000	1 250 000	2 253 000	15 810 000
Plywood	108 000	29 000	1 066 000	175 000	50 000	28 000	106 000
Particleboard	360 000	189 800	430 000	109 300	195 200	428 000	584 000
Hardboard	-	180 000	99 000	-	42 200	35 000	95 500
Fibreboard	-	180 000	152 000	-	60 400	72 000	240 000
Paper and paperboard Production (Mt)	253 000	54 000	12 503 000	24 300	68 170	2 220 000	10 535 000

Table 8. Number of people employed in different forestry sectors.

	DK	EST	FIN	LAT	LIT	NOR	SWE
						Hundreds of employees	
Forestry	25	14.4	240	160	-	-	173
Wood processing industry	-	209	340	340	-	50	399
Pulp and Paper industry	-	69	380	10	-	74	404
Forest industries total	50	278	-	510	-	124	803

4.2.2 Industrial Residues

Industrial residues are an important factor on the market for wood energy (Table 9). Residues from industrial processes are a waste product and costs are lower compared to forest residues. This results in the dilemma that as long as there is sufficient supply of industrial residues, on the market for wood energy, the price for forest residues is not competitive. The utilization of industrial residues in the forest industries is further discussed in chapter 5.1.

In Baltic countries industrial residues are not utilized to their full potential and the remainder is either dumped or burned. A study conducted by Asikainen et al. (2001) estimated that about 440 000 m^3/a of sawdust, 315 000 m^3/a of bark and 465 000 m^3/a of solid residues has no current use in Latvia. These large amounts of unused raw material show the large potential if industrial residues were utilized more intensive. If 1 million m^3 of sawmill residues were used annually as energy, it would replace 170 000 tons of heavy fuel oil equaling 1.9 TWh and reducing greenhouse gas emissions by about 0.54 $MtCO_2$.

It is a great challenge to obtain accurate data in Lithuania. Reliable data is only available from large enterprises. But there is a trend that the production and utilization of industrial residues is continuously increasing. Jaskelevicius & Kairiukstis (2002) estimated that the production of industrial residues from the industry was approximately 1.2 million m^3 in the year 2000. Approximately 100 000 m^3 are still taken to dumps which could be utilized for energy.

In the Nordic countries the situation is different with a high utilization of the industrial residues. Particularly in Finland forest industries utilized close to 100% of the industrial residues, and in Denmark, pellet production is facing resource shortages in the future.

Pellets as a fuel have also gained in importance over the last decade. They are a fuel product compressed from milled wood. The use of wood pellets has increased significantly since the 1990 particularly in Sweden, Denmark and Austria and even earlier in North America (Alakangas & Paju 2002). Today pellet systems offer a convenient and efficient form of heating competing primarily with oil and electric heating systems. Additionally pellets offer competitive alternatives in district heating and power plants. But the availability of pellets has been a problem particularly in Finland but several plants have been established and the availability of utilization equipment has also improved. In the end of 2001 pellet production capacity has reached 200 000 t annually and the rapid development on the pellet market has been supported by a high oil price, convenience of the system and environmental friendliness. Alakangas & Paju (2002) expect that pellets consolidate their market share in Finland.

The introduction of a new tax on $C0_2$ In Sweden was significant step towards the expansion of pellets. During the 1990's the pellet production capacity expanded to around 1 million tons per year. The market for pellets reached 800 000 tons in 2001 and the fuel is mainly delivered to large boilers converted from coal to pellets. This fast expansion also stimulated development on the midsize and private home market, which expanded by about 100% in 2001 and is expected to continue for the next years (Dahlström 2002)

According to Bjerg (2002) the wood pellet market in Denmark increased by 53% in the 1993-1998 period. The consumption of pellets was 198 000 tons in 2000 and market actors assessed the market to be growing to at least 250 000 tons in the future. In 2000 more than half of the Danish pellets were used in district heating plants and the rest was mainly utilized in private homes and public buildings.

Table 9. Production of Industrial Residues in million m^3

	DK	EST	FIN	LAT	LIT	NOR	SWE
Bark+chips	0.8	-	7.2	2.4	-	1.05	4.5 fuel chips
Sawdust	0.3	-	2.4	1 495	-	0.5	4.3 sawdust and bark
Total Wood Waste	1.1	1.46	9.6	-	-	1.55	8.8
Black Liquor	0	-	19.0	-	-	1.75	34.53 TWh
Non classified	0	-	1.7	-	1.2	-	2 Processed wood fuel

4.3 Forest fuels and their potential

Besides industrial residues, forests are another valuable source of woody biomass for energy. Currently, there is significant potential in Finland to further exploit these resources in the future. Today there are vast amounts of logging residues left untouched after final fellings. Also, at present the forest owner's interest in first thinnings is not very high due to the fact that they are not very profitable. With an increase in the utilization of residues that trend could possibly change since the forest owner would receive some income if he sold the biomass for energy production, additionally if first thinnings are carried out properly a silvicultural benefit is achieved. However, the utilization of biomass has to face concerns dealing with nutrient outtake and loss of biodiversity (Richardson et al. 2002).

Energy wood in Finland is produced in intermediate thinnings and final fellings. Despite the current utilization of 1.3 million m^3 forest residues there is large potential to further increase the production of forest fuels in Finland. There are numerous silvicultural operations that produce woody biomass useable for energy production. Due to the unprofitability of the harvesting they are currently left at the site but pose a significant potential. For example, from plantation cleanings 1.2 million m^3 of energy wood could be harvested annually if the recovered volume of wood was 24 m^3/ha, and from intermediate cuttings 3.1 million m^3 could be added annually (average roundwood yield of 45 m^3/ha, 8 cm top diameter, and utilization of all stems fewer than 8 cm at dbh) (Hakkila & Fredriksson 1996). Another source is logging residues from regeneration cuttings, including branches and tops but excluding stumps and roots of felled trees. The large volumes available from each unit-area and the fact that procurement is fully mechanized have made it an attractive biomass resource. On average, per harvested ha of spruce round wood, 167 m^3 of logging residues are produced. For pine and birch the production is lower with 79 m^3 and 70 m^3 respectively (Hakkila 1991). Annually, approximately 47 million m^3 of roundwood are produced. When the procurement losses are subtracted and ecological aspects are taken into consideration about 9 million m^3 of residue material would be available.

The largest share of Danish harvesting of wood chips is produced in thinnings of immature stands. The annual removals from Danish forests in the 1990-1999 period amounted to 175 000 m^3 wood chips and 421 000 m^3 firewood. The future potential to increase the production of wood chips is estimated to be between 50-100% (Suadicani 2002).

Up to 100 years ago, wood was the dominating energy resource in Norway but today oil and electricity are the major energy sources. Nevertheless firewood in Norway is one of the most important energy sources originating from Norwegian forest. A shortage of electricity during the first part of 2003 has led to a large increase in bioenergy in Norway. The big question is if the electricity prices will stay at a relatively high level or decrease in the coming years. Private homes and other small scale heating systems use about 7TWh firewood annually. Wood chips are mainly produced in conifer thinnings and to a lesser degree from clearcuts. With low prices on pine pulpwood, pine pulpwood is to some degree used as fuel chips and this might increase in the future. The importance of chips as a fuel has continued to increase over the past 20 years, and today approximately 300 000 m^3 solid fuel wood are produced each year. The future potential in Norway is estimated to be around 14.4 TWh annually (Lunnan et al. 2002); nevertheless there is considerable uncertainty in the estimation of this figure.

At present residues from originating from logging or thinning operation are not utilized in Latvia. Industrial residues and firewood are the dominating forest fuels. Calculation carried out by the Latvian Department of Forest Resources and other researchers have shown that approximately 15 % of the harvesting amount is firewood and amounted to 1.65 mill m^3 in the year 2000, not including tops, branches and small dimension trees etc. These sources are additionally available for the production of forest energy. The potential amount of fuelwood from forestry is estimated to be around 1.5 million m^3 firewood, 0.8 million m^3 tops and branches, 0,7 million m^3 from non-commercial thinning and 0.5 million m^3 from brushwood. At present there is also further potential to increase the use of firewood (Vilkriste & Konstantinova 2002).

Currently, the situation in Lithuania is not very transparent making it very difficult to provide exact data. Problems have to be solved regarding lack of cooperation, organization and large differences depending on regional development. In Lithuania the sources for forest fuels are diverse. The utilization of salvage cuttings has traditionally been a key source for the production of fuel wood. Thinnings and intermediate cuttings provide an additional source. The species composition is contributing to the production of wood fuels. During logging operations in mostly mixed soft-deciduous stands firewood production is generally high. Smaller amounts of firewood are produced in Alnus incana short rotation forests in central and northern regions of Lithuania. Jaskelevicius & Kairiukstis (2002) estimates that in 2000 removal of firewood in state and private forests amounted to 2.4 –2.6 million

m^3. At present logging residues are not used to their full potential due to economic and technical difficulties. The potential to increase the use of wood fuels is significant. The total amount of available forest biomass for energy in the next decade can possible reach 3.3 – 3.5 million m^3 if cuttings are carried out according to current policies and estimations. If logging residues would be harvested intensively another 0.8 million m^3 could be added. Combined with industrial residues the total amount of available wood fuels can reach 5 million m^3 in the next decade (Jaskelevicius & Kairiukstis 2002). According to Jarmokas (1999) the real maximum potential of using wood fuels may contribute more than 7-9% of all primary energy sources used in the country.

The main sources of forest fuels in Sweden, as in Finland, are final cuttings and the resulting logging residues. At present fuel originating from first thinnings is not utilized very often but constitutes a large potential to increase utilization in the future. Today forest fuels are mainly utilized for the production of thermal energy producing approximately 43 TWh annually. There is a large potential to increase the use of forest fuels in the future, particularly in first thinnings. Estimations vary largely depending on the organization that carries them out and on ecological factors taken into consideration.

Pärn & Mandre (2002) state that, the total felling volume in Estonian forests reached 6.7 million m^3 in 2000. The production of residues was 1 206 000m^3 of which 603 000m^3 could be used for energy purposes. Additional sources include roundwood of low quality or originating from species with insignificant industrial value and wood from forest cleanings available for energy production. The actual amounts largely depend on forest management, wood-harvesting systems, consumption of the forest industry and exports just to mention a few. In 2000 the amount of fuelwood harvested was 1.34 million m^3.

Overall the situation is different between the Baltic and Nordic countries since there is no tradition to harvest logging residues, on a large scale, in the Baltics. Therefore the potential in the Baltic countries is great if the necessary actions are undertaken and infrastructure for a supply chain is developed. Resources are largely available and especially if the expertise from the Nordic countries would be applied, growth in the sector is significant. The use of forest resources for firewood, on the other hand, is very common both in Baltic and Nordic countries.

Finland and Sweden are the countries in which logging residues are utilized most intensively. In Denmark and Norway forest residues are used and the utilization is expected to increase further in the future. The research has shown that 1st and intermediate thinnings provide a very large potential to increase the share of forest fuels in all of the countries. Finland and Sweden stand out as the countries with the largest potential. Abundant resources are available but the challenge is to make operations profitable.

4.4 Production potential on marginal agricultural land

Most countries of the European union are facing problems with the overproduction of agricultural crops. The EU's agriculture policies suggest lowering the amount of arable land in the future. Rather than discontinuing, the land could be used for sustainable energy production. In all of the seven countries there is large potential to increase the amount of forestland that was previously in agricultural use.

In Latvia abandoned farmland is increasing annually and has reached about 433 000 ha in 1999. Despite these vast amounts of available land it is expected that only about 10 000 ha of farmland will be afforested in the 2001-2006 period due to a lack of financial resources (Vilkriste & Konstantinova 2002). To promote the afforestation process in Latvia the EU SAPARD program has made financial support available starting from 2001. Additionally the non-existence of a unified state land-use policy makes it very difficult to make a precise prognosis of farmland-use.

The situation is very similar in Lithuania were forecasts are a very difficult task to make. Forestland has been increasing by about 13 000 ha annually giving an additional possibility to increase fuelwood production by at least 1 % annually.

Estonia reported 300 000 ha as agricultural or grazing land, but currently future plans for afforestation are not mentioned. Fuelwood resources available in overgrown non-managed areas consisting of mainly gray alder, aspen and birch that are mainly used for fuelwood by local residents. The total biomass available from non-forest land is estimated to be about 1.06 million m^3 annually.

The potential in Denmark, in contrast to the other countries, is rather marginal due to a decrease in the percentage of marginal agricultural land.

The situation is different in Sweden and Finland where research into Short Rotation Forestry (SRF) on former agricultural has been done. Particularly in Sweden, a significant effort has been put into optimizing SRF systems, but price competition with other wood fuels has proven to be a major obstacle regarding SRF. Also, the development is still in an experimental stage and the future of SRF in Sweden largely depends on future EU and Swedish energy policy as well as on the Swedish markets itself (Johansson 2002). At present in Sweden, energy crops grow on 25 000 ha. According to Svebio (Swedish Bioenergy Association) 20 TWh could be produced with biofuels from agricultural land by the year 2020.

335 000 ha were considered as abandoned non-forested fields in Finland. The area is expected to increase even further due to an ongoing process of restructuring in the agricultural sector and the resulting a reduction of traditional agricultural production. The problem could be tackled through an increase in energy production on abandoned and set-aside arable lands (Toivonen et al. 1994). Nevertheless, at present there are no large-scale commercial plantations, due to high costs associated with the production. At present, the economic competitiveness of energy originating from SRF plantations is unsatisfactory, when compared to fuel wood from conventional forestry operations (Jyhlä 2002).

In Norway there is production potential on marginal agricultural land, but subsidies are not available. No information is available regarding the total area of available land. However, considerable quantities of broadleaved trees, mainly birch, are growing on large areas of previous grazing lands.

Denmark stands out as a country where the agricultural land taken out of production is decreasing. Therefore the potential to produce additional woody biomass is marginal. The trend in Baltic countries is that more former agricultural land is available and overgrowing with forests. There are insufficient funds to establish stands and to manage the process of afforestation. Nevertheless the potential to produce additional sources of woody biomass is significant. Finland also faces problems with an increasing area of former farmland and the production potential is growing. Sweden is trying to tackle the problem with increasing use of SRF of agricultural land hoping to produce 20 TWh by SRF in the year 2020. Overall the potential to increase woody production on marginal or abandoned agricultural land is quite significant and woody biomass production is a good solution to the problem but systems need to be optimized, funding made available and governmental and institutional actions to support the development taken.

4.5 Comparison of guidelines for forest fuel harvesting

In Estonia, at present, there are no official national level specific guidelines for fuel wood harvesting and fuel wood and wood residue utilization for energy production. The situation is similar in Latvia, which has no official national guidelines regarding the harvesting of forest fuels. In the coming National Forestry Program or Forest Cluster guidelines might be included. At present there are also no guidelines regarding the harvesting of forest fuel utilization in Norway.

In Finland, an up-to-date synthesis of the knowledge and research findings concerning the environmental effects of forest fuel harvesting has been released which included environmental impacts such as greenhouse gases, nutrient balance in the soil, forest regeneration, forest pests, biodiversity and landscape and recreation (Nurmi & Kokko eds. 2001). The synthesis also includes some general restrictions and recommendations regarding the harvesting of forest fuel. At the national level, The Forestry Development Centre Tapio (Polttohakkeen tuotanto metsänuudistamisaloilta 2000) has published a booklet called "General guidelines and procedures for forest fuel harvesting from regeneration cutting areas". Recommendations concerning environmental aspects of forest fuel harvesting are included, and it is, for instance, recommended that not more than 2/3 of residues should be harvested and that all stands with specific ecological value should be excluded. All forest companies involved in larger scale harvesting of forest fuels have guidelines for stand selection and the harvesting operation (Saksa 2002).

Guidelines in Denmark make it obligatory to dry residues for one summer before they can be removed in order to minimize nutrient outtake of the forest.

The Swedish Forestry Board has written recommendation for forest fuel harvesting and compensation fertilization and in the Swedish Forest Act are regulations concerning forest fuel harvesting and compensation fertilization can be found in 30 § (environment consideration), 14 § (report of forest fuel harvesting) and 29 § (forest protection). In addition, many forest companies in Sweden have their own guidelines. Sydved, for example, has guidelines including the whole chain from felling, transport to terminal. The guidelines are updated regular as new information becomes available (Johansson 2002).

The general situation is that there are no specific guidelines regarding the harvesting of forest fuels in most countries of this research. The only countries that have specific guidelines are Finland, Sweden and Denmark. However, in Denmark the extent of the guidelines is very limited only requiring drying the residues for one summer before harvesting. In Finland and Sweden, where the largest part of forest residues are harvested, the guidelines are more comprehensive and detailed. One of the main concerns are the environmental and ecological consequences of forest fuels harvesting, such as nutrient outtake or loss of biodiversity. The research has shown that there is a clear lack of guidelines regarding forest fuel harvesting, and if forest residues are harvested more extensively in the future, guidelines are needed to ensure sustainability and well being of the forest ecosystem and to avoid the exploitation of the forest resource particularly in Baltic countries.

5. CURRENT USE OF FOREST BIOMASS FOR ENERGY

5.1 Forest Industries

The forest industries in Norway are a significant user of bioenergy in Norway with the pulp and paper industry being the largest producer of bio-energy. According to Lunnan et al. (2002) the Norwegian pulp and paper industries, sawmills and furniture industries utilize the byproducts of the production processes to generate thermal energy. In total, the industry consumed 6.7 TWh in 2000 of byproducts, representing about 45% of the total bioenergy consumption in Norway.

The Swedish forest industries generated about 59.3 TWh in 2000, which originated from byproducts of industrial processes. The largest share, 39 TWh, is produced of the pulp industries' black liquor. Some surplus quantities of fuel are sold to district heating plants and there is potential to increase the use of industrial residues even further, through the replacement of oil in the pulp and paper industry and a more efficient internal use of wood fuels (Johansson 2002).

In Finland 55.7 TWh of residues were burned in 2001 (Statistics Finland 2002) to provide heat and electricity for industrial processes, making the forest industries the largest user of bioenergy. This volume represents 72% of the forest industry's combustible fuels and provided 33% of the electricity used by the forest industry. About 19 million m^3 came from black liquor and bark and sawdust are additional residues with significant contribution.

The situation is different in the Baltic countries. In Estonia, for example, there is no tradition of utilizing the wood fuels in forest industries and therefore the present use is marginal. The consumption of fuel wood and wood waste for energy production in the industry sector was 36 000m^3 and 452 000m^3 respectively (0.04 TWh). However, a successive conversion to wood fuels can be expected as the industry develops further in the future (Pärn & Mandre 2002).

According to the Central Statistical Bureau of Latvia (2001) the industry sector accounted for 20% of the total fuelwood consumption in 2000, which equals approximately 1.8 TWh.

The main wood residues in Lithuania are residues originating from the wood processing industry. Unfortunately, not all of the residues are utilized at present and a significant amount is dumped. In sawmills of forest enterprises, wood waste and sawdust amount to 130–140 thousand m^3 per year. During the last ten years the development was positive with fuelwood consumption on the rise in total energy consumption. With this increase in fuelwood, containing industrial and logging residues, also comes a more intensified use of industrial residues. But despite these positive developments the fuelwood consumption in the Lithuanian industrial, agricultural and construction sector remains comparatively insignificant and changes unevenly. Nevertheless the fuelwood consumption in the above sectors has increased one and a half times between 1997 and 2000 (Jaskelevicius & Kairiukstis 2002). In 2000 the industrial sector as a whole consumed approximately 0.5 TWh of fuelwood

The use of wood energy in Danish forest industries accounted for about 1.2 TWh (Danish Energy Authority 2002).

5.2 District heating plants

In Sweden, there are about 200 companies that produce and distribute heat in district heating networks representing a total share of 42% of the market for space heating. Wood biofuels, the prevalent single fuel category, contributed about 17.5 TWh of energy in district heating in 2000 (Swedish Energy Agency 2001). Over the last few years the use of wood fuel has increased rapidly, in the district-heating sector, and there is potential for further expansion by either building out existing district heating networks or replacing mainly coal and oil by wood fuels. Common wood fuels include sawdust and bark from sawmills and other wood processing industries, chips from logging operations, crushed recycled wood, and in larger amounts refined wood fuels such as pellets, briquettes or wood powder. Due to the electric market situation Sweden stands out as a country where the amount of CHP generated electricity and contribution to DH is generally quite low. The abundant hydro and nuclear power resources in the region remains a barrier to expansion of CHP generated electricity. There is potential for growth in DH by about 36 PJ during the next ten years. Despite the above-mentioned problems the share of CHP is expected to increase considerably based on exploiting DH networks without CHP production. The potential for CHP electricity production, based on DH, is about 20 TWh annually by 2010 (Larsson 2001 & Johansson 2002)

District heating has a strong position on the Finnish energy market with a total share of 48% of total space heating. Finland is the world's leading country in the combined production of heat and power. In 2001, power and heating plants consumed approximately 23 TWh of solid wood fuels (Finnish Forest Research Institute 2002). District Heat in Finland will not increase in any considerable degree in Finland since it has been delivered in all parts of the country where it is economically feasible. Growth is expected in the range of 1-2% annually. The share of wood as a fuel can be increased in the forest industries as well as in district heating plants and CHP-plants accepting wood based fuels either as such or together with peat (Kostama 2001)

The development in Lithuania is also interesting. Most industrial enterprises and the communal and public sector are supplied with electric and thermal power by power and heat plants of local energy providers. The market share of DH is 68% with 57.8% of households connected to the heating grid. However, many boiler plants had to stop generating heat due to a rise in fuel, electricity, and heat prices, a decline in industries, reorganization of the public sector and more effective power consumption. Currently, 258 power plants and boiler plants are in use with Mazut as the most important source of fuel. In 2001 over 60 new and modernized boiler plants used wood waste, sawdust and chips with a total capacity of 150 MW. The quantity of heat generated and supplied to the district heating net constantly diminishes both in heat and boiler plants since heat has been utilized much more efficient through modern utilization equipment. Fuelwood consumption in power and boiler plants has been fluctuation over the last ten years. During the 1994-1998 period fuelwood consumption increased 3.5 times reaching the peak in 1997 with just below 400 TJ. Nonetheless, in 1999-2000 with a consumption of just above 100 TJ its consumption fell to the level of 1990-1993 period. In 2001, 0.67 TWh of forest energy were utilized in district heating plants. Besides fuelwood, other primary solid fuels used for heat generation consist of logging, wood processing, and agricultural residues such as straw and boon. These sorts of fuel represent about 1% of total fuel consumption (Jaskelevicius & Kairiukstis 2002 & Euroheat 2001).

DH in Latvia has a very important role. 70% of all households are connected to DH networks accounting for 39% of total energy consumption. Latvia has good potential for CHP since it has to import most of its electricity and lacks indigenous resources. Also the potential for wood fuels is steadily increasing. Industrial residues are increasingly utilized in local district heating systems. In 1998 the wood fuel consumption had doubled compared to 1996 covering about 26% of total primary energy consumption. The larger share of the utilization is from consumption of wood logs used in DH networks smaller than 3 MW and local boiler plants. Most of the recent rehabilitation projects anticipate conversion of log boiler plants to combined wood chip-sawdust installations. The total sum of fuelwood consumption in district heating amounted to 1.5 TWh in the year 2000.

DH heat in Estonia has a market share of 52% but in large towns the share is close to 90%. There are plans to improve combustion technology, since present technology is outdated. The share of oil shale in the primary energy demand is expected to decrease by 47-50% by 2010 with wood and peat increasing their share to 13% and natural gas to 22% (Euroheat 2001). Authorities also favor district heating and co-generation, because it is a powerful tool for the reduction of CO_2 emissions. However, competition on the heating market is intense. District heating will continue to be market leader in existing building stock, but in new buildings local natural gas boilers or electric heating are increasingly used and the structural changes in the building stock will provide a big challenge for district heating in the future. Only 10 district heating plants use wood, mainly wood chips as fuel for energy production at present in Estonia. Among them, only one utilizes wood 12 month a year. In 2000 the energy sector in total consumed 36 000 m^3 of fuel wood and 443 000m^3 of wood waste corresponding to approximately 1.8 TWh (Energy Balance 2000).

In Norway it is not common to utilize the heat surplus from the industry in the district heating plants. In addition there is no history of larger district heating plants and due to low electricity prices in the past, district heating based on fossil fuels has not been competitive. The situation is also represented in the following figures. DH today has a market share of only 4%. Of the total, biomass is currently contributing 1.5 TWh to the district heat supply. The share of DH in Norway is expected to increase, but it will mainly be small plants with just a few buildings connected. Biomass and heat pumps seem to be the most competitive renewable alternatives (Juhler 2001).

There are about 400 district heating companies supplying about 50% of the space heating in Denmark. This share is expected to increase to about 65% in the next years, mainly from growth in the existing supply network. There is no potential to increase DH in a larger geographical area. About 7% of the total sources for DH are originating from biofuels. (Jensen 2001) accounting for roughly 2.2 TWh (Danish Energy Authority 2002).

In all countries, except Norway, the DH generation is centralized, which means that the infrastructure for increased use of forest fuels and CHP is good and growth is expected in the future. In Finland, growth in the DH sector is limited since an expansion of the network is not economically feasible. Sweden is facing competition from abundant hydro and nuclear power generation but nevertheless growth is expected. The share of DH in Norway is also expected to increase but mainly for small-scale DH networks mostly due to low prices of electricity. The DH sector faces difficulties in the Baltic countries. A lot of the equipment used is outdated and major investments are needed to update production facilities and convert boilers to wood chips if economically feasible. This will offer large potential for the increased use of forest fuels in the future, and there is a clear need for transfer of expertise from Nordic to Baltic countries. Estonia, at present, largely depends on oil shale as an energy source. DH based on wood fuels offers the potential to decrease the dependency on oil shale. Latvia is in the same situation having close to no indigenous resources and the utilization of forest fuels would provide a resource largely available in the country. The literature review has also revealed that especially Combined Heat and Power (CHP) offers a lot of potential to increase the share of forest fuels in the future. The price for heat originating from district heating has also proven to be competitive compared to electric and natural gas.

5.3 Technology in district heating plants

The large-scale conversion of forest biomass to heat or electrical energy is commonly based on grate combustion or fluidized-bed combustion (Asikainen et al. 2002). Grate combustion is the traditional technology used for solid fuels but due to high investment costs, greater emission levels and limited applicability to multifuel use, not often used in modern high capacity boilers. If the boiler is less than 5-10 MW_{th} grate combustion is still competitive. In order to combust wet materials such as sawmill residues, a new type of rotating grate boiler has been developed. New high capacity boilers are based on the fluidized bed combustion technology, which allows a wider range of fuel types, variability in particle size and moisture content. A more developed type of fluidized-bed combustor is the circulating fluidized-bed. The advantage of circulating fluidized bed is that it enables to burn a mixture of fuels at a higher efficiency and that plant sizes range up to 600 MW.

There is a need to modernize DH facilities in the three Baltic States. Most of the current equipment is outdated “Soviet Style”. A survey of pilot district heating plants by Sawdust and Wood Waste…(1999) showed that many boilers operating on wood fuels are converted from e.g. coal or steam, and based on grate combustion. The size of the boiler capacity was also rather small compared to Nordic countries ranging between 0.3 and 11.4 MW. The automation level of the boilers is low and there is no flue gas cleaning. In many cases the fuel, mainly firewood, slabs, chips and sawdust, has to be fed either manually or by tractor.

There are plans to improve combustion technology in the future. Special focus is put on CHP development. This development also gives the opportunity to promote technology combusting wood fuels, particularly considering the abundant resources in the Baltic States.

In Sweden the prevailing technologies to combust biofuels on a larger scale are the grate boiler, fluidized bed boiler and powder-fired boiler (Johansson 2002).

In Finland the most common combustion system is the fluidized-bed for both large and medium scale municipal plants (Nurmi 2002).

Currently, in Lithuania, all industrial boilers using solid fuel and in regional boiler (heating) plants, in which wood fuel is widely used, smoke vapor condensers are usually installed. In addition it aims to utilize the thermal heat in the form of water vapor. In order to increase the consumption of wood as a fuel for boiler plants that supply thermal power in a district heating net it is important that new boilers based on woodfuel are installed or older ones, using imported fuel, are modernized. Currently there are many local firms in Lithuania promoting, producing and installing equipment to burn wood fuels.

The main technologies used in Danish district heating plants are solid fuel boilers with step grate or traveling grate (Suadicani 2002).

Estonia combustion technology used in district heating plants depends on the fuel type. In 2000, 16% of thermal energy was produced utilizing solid fuels such as coal and wood, whereas 38 % used liquid fuels like light and heavy fuel oil, and 46% worked with gaseous fuels.

The general trend is that in the Nordic countries grate combustion and fluidized bed technologies are dominating whereas the Baltic countries mostly rely on outdated technology.

5.4 Forest biomass utilization in private dwellings

5.4.1 Volume of utilization

Vast amounts of available resource are probably a good explanation for the intensive use of forest biomass by private individuals. Approximatel 950 000 fireplaces are in use in Finland (Nevalainen 2001) and firewood is also commonly used in adjacent buildings and in over 2 million saunas (Tilastokeskus 2001, Salakari & Peltola 1995). Estimation suggests that 5.6 million m^3 of firewood are consumed each year and the small-scale combustion of wood amounted to 13 TWh in 2001 (Statistics Finland 2002). There is potential to increase the share of firewood consumption by 1 million m^3 in the future. Despite this positive development there are also obstacles that have to be overcome for a further increase and especially the movement from rural areas to urban areas could hamper the development (Jylhä 2002)

Sweden has about 1.7 million detached houses and for heating and hot water purposes about 12 TWh are produced from wood fuels, compared to 50 TWh produced by nuclear and hydropower. The main sources of wood fuel are traditional firewood, smaller chips and pellets. The annual use of woodfuels, in this sector, has not changed significantly in the last ten years, despite the construction of new buildings based on wood fuel heating, and state subsidies for switching from electricity heating to wood or pellets heating (Johansson 2002).

About 25% of the households in Norway use firewood as the main energy source which translates into approximately 800 000 firewood stoves. About 80% of Norwegian households have the option to heat with firewood or firewood in combination with oil or electricity. The consumption of firewood has a total heating value of approximately 7 TWh and represents about 50% of the total bioenergy consumption, in Norway. There is potential to further expand the firewood production, due to a decrease in the price of pine pulpwood, there are also large quantities of broadleaved species, which are not fully utilized (Lunnan et al. 2002).

Estonians utilize the largest share of fuel wood and wood waste in households. Fuel wood consumption was 1.43 Mm^3 and wood waste consumption 502 000 m^3 in 2000 amounting to 3.9 TWh (Pärn & Mandre 2002).

In Lithuania, the use of firewood in households has a long tradition. The main sources of fuel are chopped firewood, strips and sawdust. Chips and pellets are not used commonly due to the higher price compared to traditional firewood. Fuelwood consumption increased 5 times in the last eight years and exceeded 5.7 TWh in the year 2000. 90% of fuelwood was consumed in private households in 2000, compared to 64% in 1990. Today fuelwood is the main fuel consumed by the population living in the suburbs, small towns and villages. Due to high costs and transportation expenses coal and peat are only of minor importance (Jaskelevicius & Kairiukstis 2002).

The use of forest energy in private dwelling in Latvia and Denmark was 3.7 and 4.1 TWh respectively (Table 10).

5.4.2 Heating systems

Burner technology is generally poor in Lithuania. The efficiency of stoves burning fuelwood is only about 50% and more has to be done to increase the share of newer technologies.

Jylhä (2002) stated that in Finland only about 8 % of private dwellings have a central heating system based on wood as an energy source. Fireplaces are commonly used as a backup heating system (Salakari & Peltola 1995). Recently, heat-retaining fireplaces made of soapstone have become a very popular backup system and are also utilized as decorative interior elements (Sivonen 2001). Split firewood and billets remain the dominant sources of fuel. Pellets and briquettes, can be utilized in boilers and special fireplaces constructed for pellets. Billets and split fuelwood are suitable for accumulating and direct central heating, wood chips and pellets preferably for direct central heating. At present emission levels of fireplaces used in Finland is acceptable but doesn't compare to furnaces available in Central Europe. Tightening the discharge regulations would cause major changes in fireplace technology, and the automatic feeding of combustion air, exhaust fans, control systems and catalytic cleaning of flue gas would be required in the future (Oravainen 2001).

In Norway it is most common to use firewood in traditional heating stoves. Some households do have central heating systems for firewood but in general it is more common on farms. There are about 800-900 chip heating plants in Norway and most of them are located on farms or as central heating system for apartment blocks. Sizes range from 20kw to 150kw. Estimations also suggest that there are about 7-district heating systems based on bioenergy with efficiencies ranging from 2-15 MW (Lunnan et al. 2002).

The utilization of firewood in private dwellings has a very long tradition, which also shows in the energy balances of the countries. Table 10 gives an overview of the use of forest energy in individual houses in each of the countries and it shows that Finland utilizes the most firewood followed by Sweden and Norway. It is very characteristic that in Nordic countries firewood is mainly used as a supplement to gas, oil or electric heating. In Lithuania the use of wood fuels in highest in the Baltic countries and in Latvia the least amount of forest energy is utilized in private dwellings. Lithuania has experienced an increase of the share of forest energy in private home over recent years, whereas the same level was maintained in Sweden over the last decade. Furthermore potential for growth was mentioned in Finland and Norway. As in DH technology Nordic countries utilize more modern equipment than Baltic countries where efficiency is generally poor. Technology transfer from Nordic to Baltic countries again comes into play. Major challenges to further increase the share of forest energy in private dwellings in the future is the movement of people from rural areas to the cities. However this movement also has a positive development since many people living in the cities like having a fireplace or stove in their homes. If supply chains are optimized and the price for delivered forest energy becomes more profitable the development would further promote the use of forest energy.

Table 10. Usage of forest energy in TWh.

	Industry	District Heat	Private Dwellings
Denmark	1.2	2.2	4.1
Estonia	0.04	1.8	3.9
Finland	55.7	23.0	13.0
Latvia	1.8	1.5	3.7
Lithuania	0.5	0.67	5.7
Norway	6.7	1.5	7.0
Sweden	59.3	17.5	10.5

6. NATIONAL ENERGY SYSTEMS

The energy supply in Sweden has increased by 28% from 457 TWh in 1970 to 585 TWh in 2000. Since the 1970 a major change in the composition of energy supply has taken place. In 1970 draft oil and oil products dominated the energy supply with 77% whereas in 2000 draft oil and oil products provided only 33%. Furthermore, in 1970 the biggest share of energy went to households and the service sector while today the largest amount of energy is consumed by the transport sector. The movement away from oil supply was achieved through an increase in nuclear power, biofuels and hydropower. In 2000 nuclear and hydropower represented 42% of the total energy supply. The supply of coal has remained stable at 4% in the 1999-2000 period. Additionally the share of biofuels has increased from 9% in 1970 to 16% in 2000. The energy produced from biofuels is primarily used in the industry sector and district heating plants. Sweden has a leading role in Europe regarding the utilization of renewable energy sources including hydro, biofuels and wind power, in 2000 these sources contributed for 30% of the total energy supply (Johansson 2002).

The development on the energy market has been similar in Finland. According to Jylhä (2002) the gross inland consumption of energy has grown 1.7 fold since the energy crisis in the mid and late 1970's and since then two additional energy sources have been utilized; 1) nuclear energy and 2) peat (Ministry of Trade and Industry 2000). The most significant decrease, on the other hand, has taken place in oil consumption, amounting to 27% of the total primary energy supply in the year 2000. Among energy sources whose use has recently been increased are wood-based fuels and natural gas. Renewable energy and slowly renewable biomass peat covered 29% of the total primary energy supply in 2000. The upward trend has several reasons. Black liquor and industrial wood waste utilization has increased in the pulp and paper industries supported by the higher energy wood consumption and an increased utilization of wind power. The industry in Finland accounted for 52% of the final energy consumption in 2000 making Finland's energy consumption per capita one of the highest in Europe.

Norway's domestic energy consumption has increased more than 30% between 1976 and 2000. About 50% of Norway's energy consumption is electricity originating from hydropower. The annual production fluctuates depending on precipitation. In 2000, a wet year, 143 TWh were produced compared to only 105 TWh in 1996, which was a dry year. In an average year electricity production is approximately 118 TWh. A considerable part of the energy is consumed in the energy-intensive industries (aluminum, metallurgic industry, newsprint). According to the Norwegian Energy Agency approximately 4.5% of Norway's total primary energy supply comes from renewable fuels, a figure substantially smaller than that of other Nordic countries. Other important energy sources are oil and gas having great importance on the export markets. In 1999 the production of primary energy carriers was 11 times the domestic energy consumption (Lunnan et al. 2002).

A major challenge Latvia is facing is, that it is heavily dependent on fuel imports. Russia is supplying 100 % of the gas and most of the oil and oil products. In 2000 the total consumption of energy has fallen from 378.6 PJ in 1996 to 154,1 PJ. A large share of total energy consumption comes from biofuels including fuelwood, wood residuals, chips, sawdust, peat, hydro, and wind energy. These energy sources have accounted for 30.4 % of the total energy consumption. Other important energy sources in Latvia are oil products with residual fuel oil representing 6.8 and other oil products 26% of the total. Natural gas accounts for 29.7 % and the imports of electricity 4.2%. 100% of the gas, oil and oil products are imported, while electricity imports fluctuate depending on precipitation levels feeding the hydropower stations. The Energy Sector is not only one of the most important sectors; it has also become a politically sensitive issue.

In Lithuania the structure of primary energy sources has changed considerably since 1990 along with the economy and industry. The share of organic fuels steadily decreased, and in 1996 only amounted to 62%. At the same time the share of nuclear energy increased due to the Ignalina nuclear power plant which is of great importance in supplying electricity to the national economy, producing 80% of total electricity consumption and nuclear fuel constitutes to 38% of the primary energy sources. Over the same period the share of so called "local fuels" such as fuelwood, logging residues, industrial residues, straw, waste, biogas and hydro energy has also been increasing annually in the total fuel balance. It increased from 3% in 1990 to 8% in 2000. However, the contribution of local fuels is changing continuously. For instance, recently the consumption of peat and blocks decreased whereas the share of wood fuels increased to 85%. This increase also means growth in the use of forest and industrial residues. The total amount of imported energy amounted to 90.8% in 2000 consisting of the following sources: oil 30.5%, natural gas 28.7%, nuclear power 30.5% coal 1.1% and net imports of electricity 0.2%. The remaining 9.2 came mainly from wood-based fuels (7.5%), hydropower (0.4%), peat (0.2%) and other sources (1.1%) (Jaskelevicius & Kairiukstis 2002).

Suadicani (2002) pointed out that Denmark's gross energy consumption fell by 0.7% despite a 3.2% increase in GDP. Energy consumption dropped in road transport, households, agriculture and industry while it remained unchanged in the trade and service sector. There is an ongoing process of change in the composition of fuelwood. While oil and coal consumption fell by 2.5% in 2000, consumption of renewable energy rose by 9%, now comprising 11% of total Danish energy consumption. In 2000 energy production was 39% higher than energy consumption, rising the degree of self-sufficiency to 139%. Of the total production, crude oil represented 764 526 TJ, natural gas 310 295 TJ and Renewable Energy Sources 89 060 TJ. The total share of wood fuels amounted to 22 558 TJ in the year 2000.

Domestic oil shale and some peat and wood satisfy about 50% of the Estonia's primary energy demand with oil shale representing about 99% of total electricity generation. For the other half, Estonia is totally dependent on imported motor fuels, natural gas, coal and fuel. Estonia is almost energy independent in terms of its electricity needs mainly because of: 1) abundant domestic fuel resources such as oil shale 2) a competent infrastructure for natural gas and liquid fuel imports; and 3) a well-developed national power system consisting of power plants, transmission networks (the national grid), and distribution networks. But, the dependency on oil shale (70% of world's oil shale production) has also caused environment-related problems due to high emissions and the EU has been pressuring Estonia to reduce the share of oil shale use

Table 11. Total Wood Fuel Consumption in PJ (FAO 2001).

	Fuelwood Consumption	Charcoal	Black Liquor	Wood Fuel Total
Denmark	5.4	0.43	1.61	7.44
Estonia	12.45	0.00	0.82	13.27
Finland	40.8	0.12	162.36	203.28
Latvia	18.5	0.15	-	18.65
Lithuania	11.47	-	-	11.47
Norway	3.14	1.96	18.8	23.9
Sweden	38.81	0.49	171.2	210.5

The study has shown that wood energy is part of all of the countries energy systems (Table 11). With international agreements, demanding the reduction green house gases, renewable energy sources, including wood fuels, are expected become even more important in national energy systems. The White Paper on Renewable Energy Resources, for example, set an ambitious target to triple the share of the current level of biomass contribution by 2010. This target can only be achieved, if the standing of wood energy sources is strengthened in all National Energy systems. However each country is facing individual challenges to increase the share of renewable energy sources in the total energy consumption. At present Finland and Sweden have a leading role in Europe with renewable energy sources contributing about 30% of total energy supply whereas Denmark and Norway are considerably lower. The present situation in the Baltic countries favors a stronger role of renewable energy sources in their national energy systems. In Latvia, which is very much dependent on energy imports, wood energy resources offer significant potential to decrease dependency of imports in the future and the Estonian government is facing pressure from the EU to lower the share of oil shale in energy production

Table 12. Shares of total primary energy consumption in ktoe.

	DK	EST	FIN	LAT	LIT	NOR	SWE
Oil	12 590		8 400	1 189	2 194	6 639	16810 petro-leum
Coal	5 903		3 520	66	79	1 218	2 241
Natural Gas	6 585		3 375	1 140	2 065		690
Nuclear	0		5 622		2 194		4 914
Imports	68	1 270	21 938	396	6 544		
Hydro and Wind	512	0.5	1 249		29 hydro	9 697	6 810+ 38
Wood based Fuels	204	169	6 472	910	542	24	8 362
Black and other Liqours	0		3 428			24	
Industria lWood Residues and by-products	238		1 962			573	
Small scale combustion of wood	444		1 082			597	
Peat	0	17	1 384		11		
Others	1 808 Waste& Straw	2 670 (oil shale)	191		77	119 DH	603 waste
Total	28 354	4 127	58 623	3 702	7 203	19 370	40 468

The reliance on energy sources such as oil, coal or natural gas also comes with a dependency on the energy prices on the world market. Local fuels such as wood energy on the other hand offer energy systems independent from prices of fossil fuels. The prices of oil products rose in the 1990's and since 1999, in particular, there has been a sharp rise in the prices of all products resulting in higher expenses in the industry and private households. Prices for peat and fuel chips on the other hand have remained quite stable over the same period of time.

Table 13. Estimated cost of Forest Chips €/MWh.

DK	EST	FIN	LAT	LIT	NOR	SWE
14.28	6-7	9	3.4-4.5	7.2	13	11.6

Table 13 shows that there are great fluctuations regarding the cost for forest chip in the different countries, which can be explained by the different energy taxation and subsidies in each country. Especially in Denmark and Norway the price of forest chips is very high whereas the lowest price level is found in Latvia. Finland is the Nordic country with the lowest price of forest chips.

7. ENERGY POLICY

7.1 Focus of energy policy

The latest Danish energy plan, Energy 21, was introduced in 1996 with the long-term objective to half the CO_2 emission by the year 2030 compared to 1998. This objective is supposed to be achieved through energy savings, better exploitation of the energy resources and contributions from renewable energy sources amounting to 35% of the gross energy consumption in 2030. Energy 21 also aims to cover 12-14% of the country's total energy consumption with renewable energy sources in 2005. The main share of this contribution is to originate from wind and biomass (Suadicani 2002).

The focus of energy policy in Sweden has changed considerably during the last decade and emphasis has been put on supporting the utilization of renewable resources. The current policy was established in 1997 by a parliamentary decision to secure the short- and long-term electricity supply. The supply of energy from other sources was also supported as long as they are competitive in relation to the rest of the world. Among other objectives it should also contribute to a broadening of co-operation within the Baltic region regarding energy, the environment and climate. The national electricity supply should be secured with an energy system based on lasting, preferably domestic and renewable energy sources as well as cost-efficient use of energy. Nuclear power should be replaced by converting to renewable energy sources and environmentally acceptable electricity generating technology. Fossil fuel utilization should be minimized. Of the fossil fuels, natural gas is the most advantageous and the existing natural gas network should be utilised. According to energy policy established in 1997 regarding electricity production, the share of renewable energy sources should increase by 1,5 TWh during a five year period, which corresponds to a yearly increase by 0,3 TWh. The Government even raised these ambitions and proposed a new target in which the renewable electricity production is supposed to increase by 10 TWh by the year 2010. In case the development is positive the government will raise levels even further. A reasonable goal is to increase the production by at least 15 TWh by the year 2012 (Johansson 2002).

Norway's energy policy is greatly influenced by oil policy, which is of great national interest. Oil resources should be managed to give Norwegian people maximum welfare. Currently, Norway is in the process of freeing up the marketing of gas and companies are now able to sell their own gas, which was previously done by the Gas Negotiations Committee. Energy policy is supporting an ambitions environmental policy. The focus is on securing electricity systems as the utilization of exciting systems will be intensified. There are plans to build new hydropower plants but environmental considerations have made new projects controversial. In the future electricity supply will be limited and a new balance between energy production and consumption has to be found. This transition has to implemented in such a way that the welfare of the people is not affected, meaning that the price of electricity has to increase gradually over the years. This ambitions target should be met with the following actions: 1) to limit energy consumption more than a free market situation would do, meaning that the growth in energy consumption should be reduced. 2) To increase district heating by 4 TWh, based on renewable energy (mainly biomass and heat pumps) within 2010. 3) To build wind energy producing 3 TWh annually within 2010 (Lunnan et al. 2002).

Finland's objectives of the national energy policy are multifold and cover a wide range of topics. They can be summarized as follows:

- To support economic and labor policy
- To guarantee availability and a competitive price of energy
- To ensure that emissions are within the limits set by international agreements
- To accelerate the use of energy savings
- To promote the use of renewable energy technology, development and commercialization.

The council of states focuses its activities especially on the following actions:

- Promotion of a less carbon intensive energy production structure
- Promotion of energy markets
- Effective and sparing use of energy
- Promotion of the use of biofuels and other domestic energy sources
- Maintaining a high level of energy technology
- Ensuring of versatile and competitive purchase capacity of energy
- Guarantee energy supply security

Objectives associated with bioenergy utilization are found in the National Forest Program (NFP) as well as the National Wood Energy Technology Program (NWETP). The NFP is aiming to use 5 million m^3 of forest chips by the year 2008 and the NWETP aims at the level of 2.4 million m^3 of forest chips by the year 2003.

The Latvian Energetic Program is anticipating to support the use of local energy sources planning up to the year 2020. In order to accomplish the goals it is necessary to increase the share of local energy sources to 20% of the total energy balance. In return, the dependence of imported fuels would be decreased. The Latvian government has also accepted the Kyoto protocol and governmental institutions have started projects to meet its goals (Vilkriste & Konstantinova 2002).

According to Jaskelevicius & Kairiukstis (2002) Lithuania's major objectives of energy policy are formulated in the "National Strategy of energetics". Future perspective policy is based on the following points:

- The strategy and its support for local energy sources of national energetics will aim at economic, legal and organizational measures promoting the use of wood, municipal and agriculture waste as well as other kinds of indigenous fuels.
- The national program of enhancing the effectiveness of energy consumption, seeks that a total of 15% of the imported energy resources currently used will be changed to local renewable energy sources improving the ecological state considerably. From 2001 it was possible to substitute about 0.3% of the above-mentioned resources.
- A special program implementing actions to save energy, also anticipates supporting measures of effective energy consumption as well as projects dealing with the utilization of local and renewable energy sources. Practical implementation will be that methodical support and financing of the above-mentioned program and project will be provided. Also, a total of 1–3 projects will be chosen and implemented. It is foreseen to utilize only local fuels and to increase the coefficient of utilization of energy from 3 to 7%.
- In the Act of Energetics the importance of using local fuel and renewable energy sources is indicated.
- The Act of Biofuel (No. VIII–1875, adopted on July 18, 2000) indicates that biofuel has been given priority.
- The Ministry of the Environment has prepared a revision of the Act of Environmental Pollution. It involves the mechanism of privileges concerning taxes for the branches of industry using biofuel.
    - The program of creation and development of the biofuel industry. It was calculated that potential total quantity of round wood for heat production makes up 2700 thousand m^3 (800 thous. m^3 of wood chips, 800 thous. m^3 of sawdust, fuelwood makes up the remaining part). Also, it is indicated that in 2001–2003, 700 units of boiler plant equipment will be produced in the country.

The energy sector in Estonia has been given priority in the ongoing economic reform. The goal is to bring its energy policy in line with that of the EU providing a reliable source of energy for the country at the lowest possible cost. The promotion of bioenergy and reaching a competitive price level independently of political development are both seen as major targets of Estonian energy policy today. A strategy to promote the use of Estonian biomass resources such as wood and peat, especially in CHP generation is needed.

In 1998 The Estonian Parliament accepted the "Long-term National Development Plan for the Fuel and Energy Sector" forecasting development of the fuel and energy sector to the year 2005. Among the strategic goals taken into consideration in developing the energy policy were according to Polito (2000):

- To provide a stable and independent fuel and energy supply
- To promote a wider use of renewable energy by applying tax allowances both on the investments and energy production based on those investments
- To provide integration of the Estonian energy sector to the European energy systems in conformity with EU directives and trends

In Estonia, at present, there are no official national level specific guidelines for fuel wood harvesting or fuel wood and wood residue utilization for energy production. But, there are general suggestions and plans to increase the use of forest energy. In the Forestry Development Program 2001-2010 it is mentioned that the fuel wood production could reach 2.46 million m^3 and residues 2.27 million m^3. In the "Development Program of the State Forest Management Center" it is planned to participate in projects dealing with the possibilities to use low quality timber for energy production and to support the possible high refining of the pulp and paper wood. Finally, the Ministry of Economy, in the Fuel and Energy Management Long-Term Development Plan, aims for a 1,65-fold increase of consumption of the renewable energy sources (wood and peat) by 2010 from 1996. Therefore investments into the development of peat and wood fuel production will be favored due to relatively large peat and forest resources, low environmental risks and positive impact to the regional development and employment (Pärn & Mandre 2002).

In all countries the promotion of renewable energy sources, particularly biofuels, has high priority in energy policy. In all the countries energy policies it is planned to increase the share of renewable energy sources in energy production. In order to meet targets of international agreements especially Nordic countries put their focus on developing energy from biomass and wind. Norway, for example, despite having abundant oil resources is also trying to support an ambitious environmental policy with an increase in district heating based on biomass and wind. Energy savings are also an important goal of energy policies and are mentioned in Energy strategies of Denmark, Norway and Finland. Challenges ahead are the implementation of policies to meet these ambitious goals. However, the research has revealed that energy policy favors the use of woodfuels for energy production immensely. There have also been positive changes over the last years in the Baltic countries. At present, the common focus of energy policy is the promotion and use of local energy sources to lower the share of imports and in the case of Estonia oil shale. The strategies are very clear however it is not always clear how these targets will be implemented. In Lithuanian, for example, the general problem is that there are plenty of ideas in state documents but concrete action plans and mechanisms to implement them are missing. In Estonia, a distinct strategy to promote the use of Estonian biomass resources such as wood and peat, especially in CHP generation is needed.

7.2 Means for energy policy

The Danish parliament passed the Heat Supply Act in 1990, which gave the Ministry of Energy wide powers to control the choice of fuel at district heating plants, and decentralized combined heat and power (CHP) plants. Following this act a number of coal fired district-heating plants have been converted to natural gas-fired, decentralized CHP generation and some smaller district heating plants, not connected to the large district heating networks, have been converted to use biofuels. Additionally, two acts with the prospective of subsidizing the process of conversion to environmentally more desirable fuels followed the Heat Supply Act. The use of biomass was further supported by an agreement of the Danish parliament concerning the increased use in the energy supply sector. A core element of the agreement requires, that the centralized electrical power utilities have to buy 1.4 millions tones of biomass annually. The objectives of the agreements were supposed to be met in 2000, but under a new complementary agreement in the year 2000 the time limit was extended to the year 2005. The electrical power reform was supposed to ensure that markets for electrical power would be opened entirely by the end of 2002. To ensure the competitiveness of renewable energy sources a special market for "Eco-friendly" electrical power was opened at the same time promoting the generation of electricity in e.g. biogas plants. Denmark has a CO_2 tax, equivalent to 13,28 € per ton of CO_2 emitted, whereas energy used for electricity production is not taxed (Suadicani 2002).

Sweden has a tradition of energy taxes since the 1950's and today the energy tax system is very complex with different taxes levied on electricity, energy, carbon dioxide, sulphur and nitrogen oxide. The budget proposal for 2002 suggested an increase of the carbon dioxide tax on fuel by 15% from January 1st 2002. Energy tax, independent of the energy content, is paid for most fuels. In 1991 a tax was levied on carbon dioxide and is paid for most fuels. Exceptions are biofuels and peat. At present the carbon dioxide tax amounts to 5.83 €/kg. Also in 1991 a sulphur tax was introduced, and 3.19 €/kg sulphur emission on coal and peat and 2.88 €/m^3 for 1/10 weight % sulphur content in oil have to be paid. These two taxes were followed by an environment tax for nitrogen oxide emission, which was introduced in 1992. The tax amounts to 4.26 €/kg emitted nitrogen oxide for furnace, gas turbines and stationary combustion buildings of at least 25GWh. In general, fuel sources for the generation of electricity are free from energy and carbon dioxide taxes. In certain cases nitrogen oxide and sulphur taxes are levied on the fuel. Biofuels and peat are tax-exempt for all users. An exemption is a sulphur tax on peat. Special rules apply to the production of heat and electricity in combined heat and power generation. Special rules apply to the manufacturing industry, greenhouse services, agriculture and forestry and water purification plants. No taxes are levied on energy and the carbon dioxide tax is reduced to 35%. The situation in household greatly varies on the geographical area someone lives in.

As mentioned in 7.1 Sweden is aiming to increase the share of renewables in electricity production to 15 TWh by 2012. In order to achieve that goal new tools and ideas are required. Trade with electricity certificates to support electricity from renewable resources is one of the tools proposed by the government. The system is market-based meaning that the state sets an objective for how much electricity originating of renewable energy sources should increase, while the market itself takes care of the expansion. The system is based on competition between the different renewable energy sources and will start working January 1st 2003.

The Swedish Energy Agency, (STEM) finances and supports research linked to supply, conversion, distribution and use of energy. The agency works on local, national and international level carrying out numerous programs on national and European level and also providing practical assistance. At the local level, the Agency supports installations of biofuel-fired combined heat and power production, wind power plants and small-scale hydro power plants. There are a large number of grants available to property owners. Actions supported by the agency are for example the conversion of heating systems from electric heating to district heating, or some other form of heating or the installation of equipment intended to reduce power demand. Elforsk, owned by Svenskt Kraftnät and Svensk Energi, carries out research and development that the Swedish electricity supply companies consider suited for joint R&D-work in co-operation with other interested parties. Elforsk`s activities are divided into five programme areas Hydro Power, Electricity and Heat Production, Transmission and Distribution, Utilization, and Strategies and Systems (Johansson 2002).

Taxes levied on CO_2 are also an important tool in Norway's climate policy and effect energy prices considerably. In the future, the taxes are expected to remain rather stable with only slight increases. Currently, there are also energy taxes on electricity, oil and gas. Oil has been competitive with bioenergy despite the taxes, but recent developments on the oil markets and resulting rise in oil price might change the situation. Also due to higher oil prices there has been an increasing interest to invest into bioenergy systems. At present, there are no direct subsidies or tax exemptions for bioenergy but some investment credits and subsidized loans for investment in alternative energy systems are available through the ENOVA cost share program. Green certificates as an instrument to boost green technologies in the production are under consideration, which would result in a competitive advantage for bioenergy systems (Lunnan et al. 2002).

Investments into bioenergy research have been rather insignificant in Norway. The situation is similar regarding industry involvement in development of bioenergy technology. But positive changes have taken place during the last years. The government and energy utilities both have programs to limit and promote efficient energy use, which in return will benefit bioenergy systems. In March 2002, the government prepared a report for the Parliament concerning climate policy in Norway. In this report it was proposed, to reduce fuel oil consumption by 25% during the 2008-2012 period compared to the 1996-2000 period. And additionally, a strategy for conversion from fuel oil to renewable energy sources (mainly bioenergy) was outlined. It was also announced that a national plan for district heating would be presented in 2002. Other measures included are, increased utilisation of the energy resources in forestry and agriculture and higher priority of research and development of new technologies for renewable energy.

All in all these proposals have raised optimism in the bioenergy sector in Norway, but the future will show how the proposals will be implemented in practical policy (Lunnan et al. 2002).

Finland had to modify its energy taxation at the beginning of 1997 because domestically produced electricity was not able to compete with imports and complicated electricity trade with other Nordic countries. Today electricity is taxed as an end product, whereas in heat generation it is dependent on the carbon content of the fuel. For the industry and professional greenhouse owners electricity taxes are lower, whereas taxes are equal for all consumers in heat generation. Energy investments are supported by state subsidies and are granted within the frame of EU legislation. There are fluctuations regarding investments in wood fuelled DH plants they are largely dependent on size of investment, regional policy and the level of technology applied. Energy taxes are a strong means to support the use of wood fuels since no taxes are levied on heat production, whereas fossil fuels are taxed heavily. Norm steering and competition supervision are additional tools of energy policy in Finland.

The government underlines the importance of energy technology development in the National Climate Strategy. The focus is on the introduction of new combustion technologies and the utilization of bioenergy and other renewable energy sources. The National Wood Energy Technology Programme's (1999-2003) focus is on further developing the production technology and on improving the quality of forest chips from logging residues and small-sized trees. Research, development and demonstration projects are the main parts of the program. Also involved in the program with a share of 50% is the industry. Additionally large-scale forest industries are investing large sums in solid fuel combustion plants based on wood chips and peat as main fuels.

Finland is putting a lot of effort to promote bioenergy sources by investing large amounts to promote bioenergy technology and in addition energy taxation is used as a tool to support biofuels. Nevertheless, final success will to a large extent depend on the development of the international energy market and particularly on prices of imported fuels (Jylhä 2002).

In Latvia, an excise tax on fuel is levied on: 1) heavy fuel oils 2) diesel oil, 3) liquefied char and 4) petrol. A natural resource tax has to be paid for light fuel oil and kerosene. There are no taxes on natural gas and coal. The aim of this taxation system is to promote cleaner fuel use and to protect the environment. There are also plans to introduce a tax on CO_2 emissions (Vilkriste & Konstantinova 2002).

Energy originating from renewable energy sources is not able to compete with energy from conventional energy sources in many cases in Lithuania, therefore Lithuania is relying on the green certificate system of the EU, which will create more favourable conditions for competition in the liberalized energy market. The Lithuanian Institute of Energetics participates in preparing the proposal for the REGOSUN project (Renewable Energy Guarantee of Origin Synergy). It is one of the main objectives of the project to establish a system of origin guarantee for energy generated from renewable energy sources. In return this system would provide the foundation to implement the green certificate system and would enable Lithuania to join the international trade within the EU (Jaskelevicius & Kairiukstis 2002).

In Estonia, there are no direct subsidies for fuel, electricity or heat. The concrete mechanism of price formation depends on each specific field. There are also no special energy taxes in Estonia. An additional fiscal tax is applied to liquid fuels. District heat for the residential sector, hydroelectric and wind energy are still exempt from VAT.

The research has shown that the main means for energy policy are taxes. Except for Estonia and Lithuania taxes are levied on fossil fuels in order to promote the use of more environmental friendly resources. CO_2 taxes on emissions are a very important measure in the Nordic countries. Latvia is also planning to introduce a tax on CO_2 emissions. Nevertheless each country has developed individual means to promote the use of renewable energy sources. Lithuania is relying on the green certificate system of the EU and Norway is also considering green certificates as an option. Sweden has also established a system for trade with electricity certificates trying to increase the share of electricity produced from renewable energy sources. Additionally grants are available for converting from electricity to district heating. Denmark has been active to stimulate the use of environmental friendly energy sources and the special market for "Eco-friendly" electrical power is just one example. Funding for Research and Development has been high in Finland and Sweden compared to the other countries. Particularly in Norway research in bioenergy and involvement of the industry in development of bioenergy technology has been low but due to higher oil prices it has been increasing in recent years.

8. BOTTLENECKS OF BIOENERGY UTILISATION

Although there is a strong political will to increase the use of wood fuels in all countries the progress has been slower than anticipated. In Sweden, for example, the demand for bio-fuel is increasing very rapidly and supply has managed to keep up. During the last ten years the price of wood fuel has halved and the volumes have doubled (Johansson 2002). This growth, however, has partly resulted from the increased imports of recycled wood and wood wastes from European countries. In Finland, the use of wood fuels in general has also been increasing, but the growth of forest fuel utilization has been much slower than the targets. The reasons are multifold but obviously there are some bottlenecks in bioenergy utilization. To identify these bottlenecks is a challenge since many factors are linked with each other. To improve the situation, it is essential that these bottlenecks are identified and necessary actions are taken to overcome them. In this study bottlenecks were divided into 6 categories according to their origin. In each category examples of country specific challenges and difficulties are highlighted. It should be noted that these groups provide an overview of the challenges that countries have to overcome, and they act as a guide as to where problems and challenges should be tackled as a whole.

Bottlenecks related to mechanization and technology

In Sweden bottlenecks are associated with the transport of forest fuel and its limitations to a radius of about 80-100 km surrounding the power plant, which is caused by low net loads. Solutions for these this bottlenecks are being developed. Compacted slash residue rolls could be one of them and have already been tested. In addition, refined wood fuels such as pellets or briquettes also have great potential, since energy density is higher and transport efficiency is improved. However, at present only industrial residues and briquettes are compressed into pellets whereas forest residues are considered to be a raw material source too expensive to be refined.

In Finland, problems from a technological point of view are also considered an important bottleneck. Today the supply of forest fuels is associated with high harvesting and transportation costs. Furthermore, skilled entrepreneurs to undertake the harvesting are a limiting factor also caused by to low profit margins in the operations. At present, there is insufficient manpower to carry out first thinning operations and there are not enough harvesters suitable for harvesting of small sized trees and thinning operations. These shortages create bottlenecks particularly since abundant resources are available. The situation could be improved with an increase in the use of available modern technology making harvesting processes more profitable.

From a practical point of view, there are two significant bottlenecks in Lithuania that make it unprofitable to harvest forest residues. First there is an obvious lack of infrastructure on large forest territories and the lack of modern harvesting equipment makes it an unprofitable and technological challenge to gather forest residues (Jaskelevicius & Kairiukstis 2002). In Euroheat (2001) it was also noted that the limiting factor for deploying larger wood chip installations is the fuel supply infrastructure, which takes time to develop. However, the process has started and further development is expected in the future.

Estonian bottlenecks are also largely caused by technological inefficiency. Many forest and industrial residues are left unutilized due to a lack of mechanization and inadequate technology to carry out the collection and transport. The production of chips is also irregular resulting in an insufficient supply of wood fuels.

In all Baltic countries the share of mechanization in fellings is comparatively low and carried out manually. Prerequisite for more profitable harvesting of logging residues is the mechanization of fellings using modern harvesting and transport equipment. This would allow the piling of residues and forwarding would be more effective with improved quality.

Bottlenecks related to economics

At present low profits of the wood fuel sector are a key bottleneck in Sweden. The business has not yet succeeded to find its right form, which means that there are plenty of development opportunities in the future. It is of great interest to improve production and marketing to make it more effective and rational. A solution to the problem could be increased use of modern technology to improve efficiency of the operations. Also, a more intense integration of the forest industry and energy companies could in return decrease production costs and increase profits. At present imports of cheap, recycled wood fuels mainly in southern Sweden put pressure on the overall prices of solid fuels, which is crucial for the use of forest fuels in particular, since production costs are higher. However, the availability of imported fuels is expected to decrease due to investments in solid fuel plants in Germany and BENELUX countries and by expected changes in legislation regarding the incineration of recycled wood (Johansson 2002).

In Finland the price of forest fuels, especially from early thinnings, creates problems as well, since they are not competitive without subsidies. The situation is much better regarding forest residues of final fellings but only if no excess amounts of industrial residues are available on the fuel market. Some negative attitudes of district heating entrepreneurs towards forest fuels are still hampering increased utilization. Prices of forest fuels are considered high in comparison to peat and industrial wood residues (Asikainen 2002).

Bottlenecks in Norway are similar to the Swedish situation. Currently forest fuels are more expensive compared to other biofuels. Nevertheless the outlook is relatively positive, due to expected growth on the bioenergy market in the coming years and only limited supply of cheap biofuels such as industrial residues (Lunnan et al. 2002). There is potential to increase the share of forest fuels but there is insufficient demand at the current prices.

According to Suadicani (2002) in Denmark the current situation is also characterized by a forest fuel price that is too high. Although the bioenergy sector is being subsidizes by high taxes on fossil fuels, lower prices of fossil fuels on the international markets have reversed the situation.

The price of wood fuel in Lithuania is too high due to high harvesting and transportation costs. The combustion technology for wood fuels is more complicated and expensive compared to traditional fossil fuel combustion. Additionally there is a widespread lack of technology and to update current technology about 2.3 million Euros would be needed annually. (Jaskelevicius & Kairiukstis 2002). As a result of the current situation, wood fuels are not competitive with fossil fuels. Investments to further develop the utilization of these resources investments are essential to improve the situation.

In Estonia the problems are caused by the same problems, and particularly high prices of timber and even firewood on international (Nordic) markets cause problems in Estonia.

A partial solution to the above mentioned problems could be green certificates as an instrument to boost green technologies in the production resulting in a competitive advantage for bioenergy systems.

Bottlenecks related to social barriers

Even Sweden, known for its leading role in the field of bioenergy, considers itself at the start of the development. New unconventional business ideas related to energy support are a key element to develop new markets for biofuels in the future. In the Sala-Helby municipality for example a new innovation is taking place. The municipality sells finished biofuels to homeowners that are not connected to district heating. The homeowner only has to do order his pellets. Under the terms "farmer energy", farmers run collective heating enterprises based on self produced agricultural biofuels. About 20 different companies work successful on the basis of this model (Johansson 2002).

In Finland, forest fuels face a major obstacle of being a secondary forest product and, at present, many forest owners don't see forest fuels as a source of income. Forest Owners Associations play a key role in the marketing and promoting of forest fuels, and if the association's perception towards forest fuels is pessimistic it has a negative impact on fuel markets. Currently the situation is that Forest Owners Associations are not very active with forest fuel trade, but there are some promising examples involving associations that have been successfully promoting the use of forest fuels in their districts.

The large-scale utilization of woody biomass, especially from forest residues, is still in its infancy and a lot has to be done in the future to tackle this problem. Development is not only needed from a technological point of view but also the awareness of people has to be increased and misconceptions overcome.

Bottlenecks related to resources and supply

The already high degree of utilization of industrial process residues results in limited opportunities to increase energy production. In Nordic countries, larger sawmills consume their residues very effectively and even in smaller sawmills less than 5% of the residues are not utilized; therefore the primary focus must be on forest residues from conventional forestry and energy crops from plantations.

The quality of logging residue chips is causing some bottlenecks at smaller CHP plants (< 10 MW) due to large quality variations such as high proportions of needles, high moisture content and bigger particles in the material.

The Danish wood fuel production also has to deal with a lack of sufficient resources to meet future demands particularly in regards to industrial residues. The price of pellets has been increasing due to a lack of sawdust. Additionally, the production of wood chips faces competition from imported woodchips and imported round wood chipped at the harbor (Suadicani 2002).

The main source of wood fuels for boiler plants in Lithuania comes from industrial residues. More wood fuels will have to be produced from the forest in the future, due to a reconstruction process of sawmills, which increases the share of drying capacity for timber and causes a lack of industrial residues. An additional problem is a decreasing demand for chopped wood. During the process of privatization two rather large enterprises that utilized wood waste were liquidated. The surplus of industrial residues also hampers development on the domestic market. The demand for forest fuel is reduced by a large supply of industrial residues.

In Finland, major bottlenecks can be found in the distribution of chopped firewood to private users. More and more people are moving from rural to urban areas and need firewood for their personal use. The supply of affordable finished products to the consumer is currently insufficient. Sizes of deliveries are small and due to long transportation distances the cost of fuel becomes too high

Bottlenecks related to district heating

A significant bottleneck in Norway is the lack of district heating networks. Norway's heating systems are largely based on electricity and wood, as a fuel source in district heating is limited to small installations.

In Denmark a significant hurdle to overcome is the fact that the natural gas net is widely spread and that the government does not allow the use of biofuels in district heating plants that are in the natural gas net

In Baltic countries almost all equipment in district heating plants has been supplied from factories in the former Soviet Union, designed to operate on heavy oil and natural gas, which results in a lack of sufficient plants to utilize wood fuels.

Institutional bottlenecks

In Norway, there are a number of institutional bottlenecks that are discussed in parliament in the near future. Financial gaps in all public institutions make it difficult to find money for new investments. It is has proven to be much easier to find money for the ongoing operations and maintenance. This leads to sub-optimal solutions and capital-intensive bioenergy systems end up loosing. A needs analysis concluded that a research program on bioenergy is needed and that report is now under consideration in the research council (Lunnan et al. 2002). In general, the knowledge about bioenergy of the decision makers in the energy and public sector in Norway is limited. This is considered to be a serious bottleneck for the growth of bioenergy. Up till now there has also been little public awareness about bioenergy. Public authorities undertake most of the larger bioenergy investments and competing energy solutions seem to have better lobbying institutions. Another institutional barrier is the lack of standardization of the fuels.

In Lithuania, there is a need to introduce taxes on boiler plants using fossil fuels, since they are polluting the environment. Through these taxes an increase in the share of forest fuels would be promoted. Jarmokas (1999) stated that without the regulation of prices, the programs to utilize forest residues will not be vital. The lack of specific policies supporting the use of natural resources is causing a lack of stimulation to increase the use of local fuels.

Summary

Some of the bottlenecks are very characteristic for all of the countries. One of the most important issues is the lack of investments into harvesting, transport, and combustion technology. Research has been carried out, particularly in Finland, to develop more enhanced and efficient systems. Now it is up to the industry to implement them into the operations and to the political level to implement necessary reforms to support the use of renewable energy sources. One of the biggest challenges is to get forest residues to the end user more efficiently, whether they are DH plants or private customers. If harvesting and transport efficiency can be improved one of the main bottlenecks would be widened.

Some measures to improve the situation have already been undertaken in Estonia and the basic tendencies in energy industry foresee an increasing role of the wood and peat in energy balance (Fuel and Energy Management Long-Term Development Plan). The aim is a 1,65-fold increase in consumption of renewable energy sources wood and peat by 2010 compared to 1996. Additionally nowadays some district heating plants are converting or replacing boilers to mainly wood based indigenous fuels (Pärn & Mandre 2002).

Finland, in particular, has invested large sums into large technology programs, where machine technology, logistics and organizational aspects of forest fuel supply have been developed. These programs have been an important tools to widen existing bottlenecks. Today there is a clear need for the delivery and extension of research results into the operational level and all parties dealing with forest fuel supply (Asikainen 2002).

Chapter 4.3 has shown that the overall potential to increase woody production on marginal or abandoned agricultural land is quite significant due to abundant available land resources and woody biomass production is a good solution to the problem but systems need to be optimized, funding made available and governmental and institutional actions to support the development have to be taken.

9. CONCLUSIONS AND DISCUSSION

Woody biomass has always played an important role in the production of heat. In the past it was the only source of thermal energy but has lost its importance with the exploitation of fossil fuels. In recent decades the development has been positive towards wood fuels, due to heightened environmental awareness, the realization that fossil fuels are not only finite but also pollutant, and increased hostility towards nuclear energy. The large-scale utilization of wood fuel offers new, environmental friendly energy systems coming from abundant resources. Much has been done to improve harvesting, transport and combustion systems, resulting in rapid technology development. The study has shown that the focus on development in the Baltic countries should be on reaching a degree of mechanization similar to that of the Nordic neighbours. The Baltic States should take advantage of knowledge and experience gained by the Nordic countries and information exchange ought to be intensified.

As economies in the Baltic States will expand, forest industries will also gain in importance. With this growth in forest industries there will be more demand for industrial industrial residues that can be utilized for energy production. Asikainen et al. (2001) conclude in their study of the situation in Latvia that the most important constraint limiting the growth of sawmill residue is the lack of funding for boiler plant investments.

With an increase in mechanization forest residues will become more readily available in the future and wood fuel prices will fall, making them more competitive on the energy market. The urgent need to lower the costs of wood fuels was also mentioned in the report of Baltic 21 – Energy sector (2001) which states that in order to increase the share of renewable energy sources on the energy market significantly on a long view, the relative costs of renewable energy sources must be reduced so that they may become competitive with other energy sources. The focus of energy policy and research and development in all seven countries should be to achieve this goal. Borsboom et al. (2002) conclude that it is likely that the energy markets of tomorrow will be less regulated than today and that the forest bioenergy industry will depend more on market forces. This development underlines how important it is to develop efficient bioenergy systems in the future

To increase the level of mechanization particularly in first and intermediate thinnings is also urgent in the Nordic countries since more residues would be available at a better price. Andersson et al. (2002) mention that a number of fuelwood harvesting systems based on the recovery of thinnings exist, but they are not widely used because of economic considerations.

In order to further develop forest fuel utilization in the Baltic countries help from the Nordic neighbors is needed to develop and optimize infrastructure and forest operations. This will not only contribute to the Baltic States economies but also provide employment and export and import opportunities for the Nordic countries.

There is an ongoing process in which the district-heating (DH) sector is switching fuels, mainly away from coal and oil and towards natural gas and renewables (Euroheat 2001). The large potential in CHP in all seven countries, favors wood fuels as an energy source. This development is positive in regards to the expansion of wood and more resources at a competitive price have to be made available to meet the increasing demand. Modern combustion technology is essential in the Baltic countries in order to promote the use of wood fuels and to increase efficiency. In Latvia the average size of sawmills is expected to increase and their ability for boiler investments will also improve (Asikainen et al. 2001).

The price of and the lack of investments into new technology has proven to be a key bottleneck to further expand the use of wood fuels, therefore the focus should be on trying to lower the price. In Baltic 21 – Energy sector (2001) it is mentioned that investments required in the energy sector and especially for renewable energy sources are in general very high with long payback periods, which put strain on the economies complicating the access to finance on economic acceptable terms. To improve the current situation energy policy has to work together with the energy sector to create and promote better conditions for renewable energy systems.

At present guidelines for harvesting of forest fuels are not common, but in order to increase the share of forest fuels they are essential to ensure proper organization of harvesting and transport and to avoid excessive nutrient outtake in harvested stands. Sustainable management is an essential part of the increased utilization of forest fuels. Raison (2002) states that the sustainability of forests that provide fuel is a critical element of the overall sustainability. To ensure sustainability, guidelines are needed to identify stands suitable for harvesting, to estimate how many residues can be taken out, and whether it is necessary to fertilize stands with, e.g. ash following harvesting.

In Nordic and Baltic countries wood fuels have played an important role in heating private homes, summer cottages and saunas. Also, the number of fireplaces is expected to increase even further in the future (Sikanen & Tahvanainen pers.comm.). At the same time people are moving away from rural areas to cities and to make firewood becomes a nuisance for many individuals. Currently, the supply chains are far from perfect and research is done, for example in Finland, on how to decrease the current high prices for split firewood. These markets for split firewood do have a lot of potential to increase the share wood fuels as well.

There is a general lack of experience in renewables and biomass – both within the public sector, the industry and among private users (Baltic 21 – Energy sector 2001). The analysis in this report has also revealed the same tendency and it is important to keep in mind that development of renewable energy systems doesn't have a long history. In Austria and Germany in particular the development has been rapid over the last 10 years, and at present efficient and user-friendly systems based on wood-chips, pellets or briquettes are available. Emissions are kept to a minimum, fuel prices are competitive and subsidies are available. Potential in the Nordic and especially Baltic countries is apparent, especially due to abundant resources, but larger investment costs and lack of awareness of available systems has proven to be a bottleneck for development in Nordic countries.

Other factors favoring further development of utilizing wood fuels are of social importance. Due to the location of the resource in rural areas, an increase in the utilization, of especially forest fuels, will also support rural development creating employment opportunities and improve local economies. Recent global events affecting the energy sector are raising public awareness of biomass for energy production, particularly the environmental benefits of bioenergy in regards to global warming (Eriksson et al. 2002). Wood fuels will also help to meet the target levels for CO_2 emissions of the Kyoto protocol. Our society today has the responsibility to reduce the human impact on the environment in order to preserve the planet for future generation. Wood as an energy source from sustainable forest management is one step towards meeting that goal.

A number of research programs were carried out and are in progress. Important topics cover harvesting technologies, logistics, combustion and gasification processes, and efficiency of boilers and emissions. Several programmes are currently on going in Finland. New research programmes for utilization of recycled fuels and wood fuels especially logging residues have been launched currently (Renewable Energy in Finland 2000). Additionally, further research how to export current "Nordic" expertise to Baltic countries and ways to implement new measures is needed. Research is also essential in regards to first and intermediate thinnings since they were found to be a major bottleneck.

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ISBN 951-40-1893-1
ISSN 0358-4283