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Bioenergy Policy and Market Development in Finland and Sweden

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ABSTRACT

The use of biomass in Finland and Sweden has steadily increased over the past 25 years, up to approximately 20% of the primary energy supply in 2000. In both countries most biomass originates from forests. Forest biomass is now an integral part of modern energy systems, although primarily in industry and in the heating sector. For example, biomass accounts for 7.9% and 53% of the fuel mix in district heating in Finland and Sweden, respectively.

The general energy policy of both countries has supported biomass for energy over the entire period, although specific policies have changed with time. RD&D has been continuously supported, and some subsidy schemes have been applied, in particular for district heating systems and combined heat and power (CHP). Heavy taxation of competing fossil fuels seems to have been the most effective policy instrument, although this has been directed mainly at the heat and transportation fuel markets. Electricity taxes are imposed on consumption (industry is largely exempt), and do not discriminate significantly between the sources of electricity. Starting in 2003, Sweden will have a quota-based system, a renewable portfolio standard, which is expected to increase biomass-based electricity production.

Both countries possess vast and not fully exploited biomass resources in the form of forests, and have a history of rational and large-scale forestry. Strong actors exist both with regard to forest ownership and the industrial processing of forest products. The user side, in particular represented by district heating systems, can also be characterized by strong and professional management. Over time, structures have developed that facilitate an increased use of biomass for energy, e.g., the forest industry infrastructure and extensive district heating. Actors within these structures have had the ability to react to policies, resulting in a stable growth in biomass use.

1. Introduction

Biomass has been an important fuel in the energy systems of Finland and Sweden for centuries. It was not until after World War II that the use of biomass for energy decreased markedly, reaching its lowest level in modern times in the 1970s (Kander, 2002; Statistics Finland, 2001). The demand for more convenient energy carriers and the relative price, as well as other advantages of notably coal and oil, explain much of this decrease. Since then, the use of bioenergy has increased again, in Finland as well as Sweden. This occurred in response to the oil price increases in the 1970s and subsequent government policies aimed at increasing the share of bioenergy in total energy supply. Bioenergy accounted for 20.9% (273 PJ) and 16.1% (340 PJ) of the total primary energy supply in 2000 in Finland and Sweden, respectively, making them two of the leading bioenergy-using countries in the world. Figure 1 and Figure 2 present the total energy supply in Finland and Sweden since 1970.

Finland and Sweden have many geographical, climatic, and industrial features in common. Both countries have considerable forest resources, and consequently the forest industry plays an important role in their economies. Both countries have nuclear power and per capita electricity consumption is high, 15,076 kWh in Finland (5.17 million people) and 15,450 kWh in Sweden (8.86 million people) in 1999 (IEA, 2001). They also share the same three general energy policy goals of secure energy supplies, low health/environmental impacts, and economic competitiveness through efficient use and cost-effective supply (Swedish Government Bill 2001/02:143, 2001; Finnish Ministry of Trade and Industry, 1997). Biomass can play an important role in meeting these partly conflicting goals but the prospects for doing so depend partly on energy and biomass policy.

The primary objective of this study was to identify and discuss the key factors that have influenced the relatively rapid expansion of bioenergy in Finland and Sweden in recent decades. For this purpose, we have performed a comparative analysis of bioenergy policy and development in the two countries. To some extent, we used the analytical framework for identifying critical factors for bioenergy implementation presented by Roos et al. (1999). A recent account of Swedish biomass policies and lessons learned has highlighted the importance of: (i) the establishment and maintenance of a sustainable biomass resource base, (ii) the demonstration of systems and technologies, and (iii) the formation of markets, as having a decisive impact on the development in Sweden (Hillring et al., 2001).

In this paper we extend and complement earlier analyses by focusing on policy and the interplay between policy measures, structures and actors in Finland and Sweden. Many countries, in addition to Finland and Sweden, have the ambition to increase the use of bioenergy in order to meet the commitments set out in the Kyoto protocol and various other policy goals. The aim here is to make observations that are relevant for future policy development in Finland and Sweden, as well as for other countries. The main focus is on forest fuels and their use in industry, district heating and small-scale heating applications, although other aspects of supply and demand are considered when relevant.

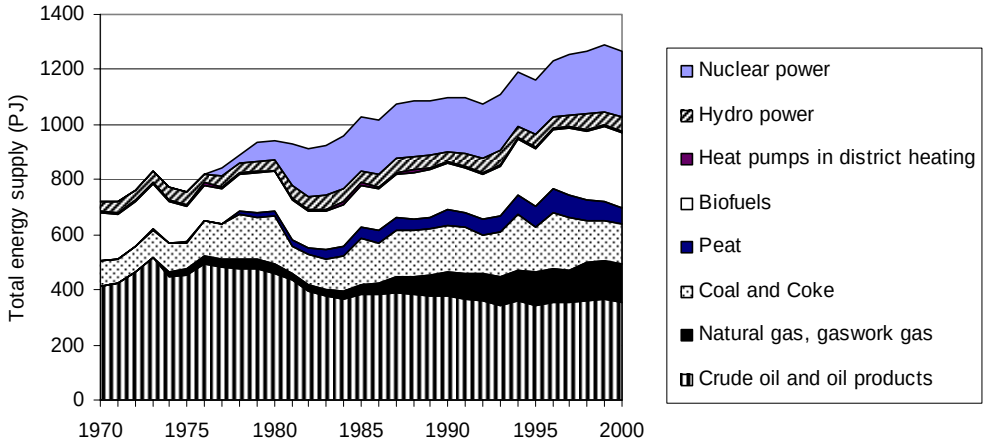

Figure 1. Total energy supply in Finland over the past thirty years (Statistics Finland, 2001). Nuclear power is presented as its thermal equivalent (electricity production multiplied by 3). Electricity imports and exports have not been taken into account.

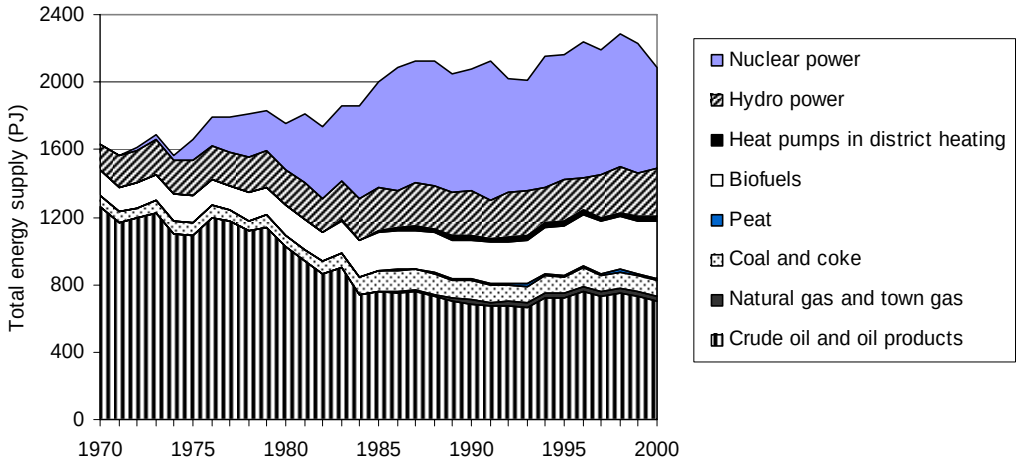

Figure 2. Total energy supply in Sweden over the past thirty years (Swedish Energy Agency, 2001). Nuclear power is presented as its thermal equivalent (electricity production multiplied by 3). Electricity imports and exports have not been taken into account.

2. The setting: general energy policy

Bioenergy policy is developed and implemented in a broad energy and environmental policy setting, and a broad political context. A specific policy can be the result of political bargaining, for example in the budgetary processes or other situations (Nilsson, 2002). One example is the recent parliamentary decision in Finland to grant permission for the construction of a new nuclear power plant, which was complemented with a decision to improve conditions for renewable energy (Finnish Parliament, 2002).

Energy policy in Finland and Sweden has been controversial and hotly debated at times, but the overall energy-policy-making process is relatively open and consensus-seeking in both countries, at least attempting to create stable energy market conditions although governments may change. Also, with a high level of public ownership in

energy companies through local authorities and the state, energy sector regulation in both countries has a tradition of being light-handed.

It has been argued that Swedish energy politics and policies cannot be understood without reference to the role played by nuclear power and the conflicts surrounding it, starting in 1973 (Vedung, 2001). Before then, nuclear power had been embraced also by environmentalists, and seen as a power source that could help to avoid exploitation of the remaining rivers in northern Sweden. Nuclear power later became an obvious alternative to oil, leading to a rapid increase in electric heating during the late 1970s and 1980s. The expansion of nuclear power in Finland was smaller and led to less controversy.

Oil accounted for 57 and 77% of the primary energy supply in 1970 in Finland and Sweden, respectively. Thus, reducing oil dependence has been high on the energy policy agenda since the first oil crisis in 1973. The use of electricity, coal, peat and biomass increased in response to higher oil prices and various support schemes. The use of natural gas, which was introduced in 1974 in Finland and in 1985 in Sweden, has also increased, but is still small in Sweden (see Figure 2). In response to environmental concerns, including climate change, political support for coal and peat has diminished since the late 1980s. Increased use of natural gas is still considered a viable alternative by many actors.

Renewable energy sources, notably wind and biomass, have received various types of support since the inception of the first Energy Programme in Sweden in 1975 and in Finland in 1979. Following a phase of support for research, development and demonstrations (RD&D), wind power expansion has been supported through investment grants and production subsidies in Finland since 1993 and Sweden since 1991. Energy efficiency RD&D programmes have also been an important part of energy policy in Finland and Sweden since the 1970s, relative to other countries (Blok et al., 1996).

Electricity market reforms have important implications for renewable energy and bioenergy policy. Finland and Sweden reached full market deregulation during 1995-1997 and 1996-1998, respectively (CEC, 2001). The removal of electric monopolies has fundamentally changed the prospects for electric utility involvement in "public benefit" activities such as non-profitable bioenergy development. Furthermore, policies aimed at promoting bioenergy must be adapted to the new market situation and not distort competition. Sweden will introduce a quota-based system with certificate trading in 2003 to promote renewable electricity production, whereas Finland will rely on traditional subsidy schemes, see below.

3. Bioenergy markets

3.1. Supply of biofuels

Essentially all biomass used in Finland and Sweden originates from forests, which makes forest owners and the forest industry key actors on the biofuel[1] market. Figure 3 illustrates that a range of different wood fuels originate from the forest, some of

[1] This article only deals with wood-derived fuels, such as wood chips, black liquor (i.e., spent pulping liquor), firewood, used wood and pellets.

which are removed from the forest as fuel and others that become fuel after passing through the forest industry.

Sweden and Finland are countries rich in forest resources where productive forest land makes up 52 and 66%[2] respectively of the total land area. Coniferous species, with Scots pine and Norway spruce, account for most of the growing stock. Birch is the most common broadleaved species. The annual growth in Sweden was 101.3 Mm^3 standing volume, i.e. stem volume including bark (an average for the period 1995-1999) and in Finland 79.4 Mm^3 (an average for 1992-2000), while felling was 74.1 and 61.5 Mm^3 standing volume, respectively, in 2000 (Swedish National Board of Forestry, 2001; Finnish Forest Research Institute, 2001). Roughly 90% of the felled stem wood is used as roundwood in the forest industry. The remaining 10% is fuel wood. About half of the industrial round wood is made up of timber and the other half of pulpwood. Approximately 40% of the timber and pulpwood eventually become residues and are used for energy purposes. At the sawmills half of the input volume ends up as by-products: wood chips, bark and sawdust. Nearly all these wood chips are sold as pulpwood. Sawdust is used in the wood fibre industry and as fuel. In Sweden, most of the sawdust that reaches the commercial biofuel market has been upgraded to pellets or briquettes. A number of pellet factories have been established in recent years, especially in Sweden, where the capacity of pellet production is about 1,000,000 tonnes/year. In Finland the production capacity is about 200,000 tonnes/year. The actual production amounted to 570,000 and 90,000 tonnes in Sweden (2000) and Finland (2001), respectively. Moreover, 190,000 tonnes of briquettes and 130,000 tonnes of powder were produced in Sweden in the same year (Alakangas and Paju, 2002; Swedish Wood Fuel Association, 2001).

Logging residues, mainly tops and branches, and undergrowth trees, represent the largest potential source of forest biomass that can be used for wood fuel production. Continuous development of technology and harvesting logistics has resulted in reductions in production costs. Most of the commercial experience in Sweden and Finland has been gained in roadside chipping of collected logging residues from final felling of mature spruce stands. In the thinnings, the accumulation of biomass is typically relatively low and extraction for fuel use is generally not profitable. Thinning, however, is regarded primarily as part of silviculture, and use of the collected biomass as fuel may be regarded as a bonus (Savolainen and Berggren, 2000).

Used wood fractions are relatively new on the wood fuel market and comprise chemically untreated wood, such as loading pallets, and some chemically treated wood[3] such as demolition wood. Larger volumes of used wood have been made available to the fuel market due to increased source separation and bans on landfilling combustible waste in Sweden and several other European countries.

Pellets excluded, nominal wood fuel prices in Sweden have been stable since the 1980s, which means a decrease in real prices equivalent to 2.5% annually in the 1990s. Pellets, which have in principal only been used since the early 1990s, have fluctuated in price and, on the whole, the nominal price has increased slightly. In Finland, where the commercial use of wood fuels started later, nominal prices are still

[2] According to the ECE/FAO definition of forest land.

[3] Used wood that may contain halogenated organic compounds or heavy metals is not classified as biofuel, but as solid recovered fuels.

decreasing. The drop in prices is due to a general decline in the procurement costs of timber, technological advances in both the production of forest chips and the related procurement logistics and an increase in production volumes (Hakkila et al., 2000). In Sweden, indigenous wood fuels have also faced competition from imported wood fuels. The average wood fuel prices paid by heating plants are generally lower in Finland, except for pellets. Pellets are the most expensive wood fuel, followed by wood chips from logging residues, industrial by-products, such as wood chips, sawdust and bark, and used wood. Table 1 gives the prices for 1999. Since then the price of used wood has declined further in Sweden, reaching about 1.9 €/GJ[4] (17.2 SEK/GJ) in 2002 (Swedish Energy Agency, 2002), which explains its competitiveness. Note that the prices given are average prices paid by district heating plants or industries and they include transport to the plant. According to Hakkila et al. (2000) the higher prices in Sweden are due to the higher demand in general, longer average road transportation distance and heavier taxation on fossil fuels.

Table 1. Wood fuel prices in Sweden and Finland in 1999. The Finnish prices are average prices, while the price intervals given for Sweden apply to industry (lower) and district heating (higher). (Swedish Energy Agency, 2002; VTT Energy, 2001)

	Sweden €/GJ	Finland €/GJ
Pellets	5.06	8.87
Logging residues	3.33-3.54	2.48
Industrial by-products	2.5-2.97	1.71
Used wood	2.41	1.17

Biomass from agricultural land, such as energy crops and agricultural residues, plays a minor role in the Swedish energy system despite earlier expectations and various efforts in research and development, and in creating economic incentives. The annual harvest of willow (*Salix viminalis*) amounts to less than 0.5 PJ (Swedish Energy Agency, 2001a). In Finland the agricultural contribution to the energy supply is negligible.

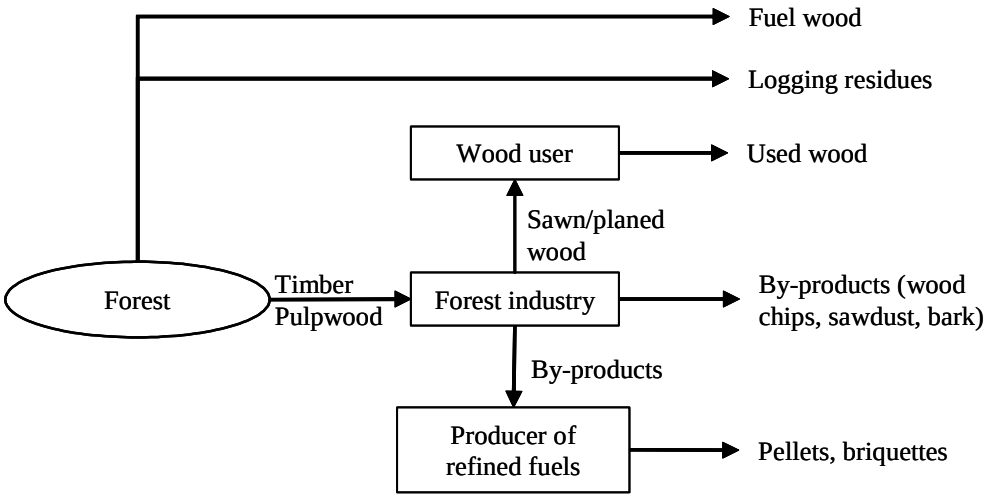

Figure 3. Schematic over the supply of wood fuels from forests.

[4] Currency conversion throughout the article: 1 €=9 SEK

3.2. Use of biofuels

The forest industry accounts for about 60% of the industrial energy demand in both Finland and Sweden. Roughly 59% and 64%, respectively, of this energy demand is met by the use of internal wood-derived by-products and the rest is mainly electricity. This makes the forest industry the largest biofuel user, see Figure and Figure . For example, sawmills and wood material industries are completely self-sufficient in fuel, which is comprised mainly of bark and sawdust. Their surplus wood fuels are used in other industries including pulp mills, in district heating plants, and in the case of pellets, also in households and the service sector. In chemical pulp mills most of the process energy comes from the spent pulping liquor, black liquor, which is burnt in the chemical recovery cycle. Other biofuels such as bark, tall oil and discarded wood chips are also used. One of the few differences between the two countries regarding the forest industry is that industrial combined heat and power (CHP) generation is more extensively used for electricity production in Finland. While Finnish biomass-based CHP in industry amounted to 7.8 TWh of electricity in 2000 (Statistics Finland, 2001), the Swedish production was 2.9 TWh (Swedish Energy Agency, 2001a).

District heating systems (DHS) are of strategic importance in Sweden and Finland, supplying over 40% of the heating in buildings in each country. Most of the district heating in Finland (80%) is produced in CHP plants, which annually produce 12.7 TWh of electricity on the basis of 104 PJ of delivered heat (2000) (Statistics Finland, 2001). In Sweden, on the other hand, the capacity to produce electricity in the DHS is poorly utilized. Only 4.2 TWh of electricity is produced on the basis of 144 PJ of delivered heat (2000) (Swedish Energy Agency, 2001a).

Since the introduction of large-scale district heating in the 1960s, the Swedish fuel mix has gone through major changes, from being completely dominated by oil until the early 1980s, to a greater variety of fuels. Today, wood fuels make up a third of the energy supply (Swedish Energy Agency, 2001a). The remaining two thirds is a combination of heat pumps (16%), refuse (12%), waste heat (8%), peat (6%), oil (6%), natural gas (5%), coal (5%), electricity (4%) and tall oil (3%). In the Finnish DHS the fuel switch has not been as far reaching as in Sweden and the expansion of wood fuels not as great, still only accounting for 8% of the fuel supply. Peat accounts for 18% of the fuel supply in district heating in Finland, in addition to coal (27%) and natural gas (38%) (Statistics Finland, 2001).

Small-scale use of biomass for heating of single houses has a long history in Finland and Sweden, and annually amounts to approximately 40 PJ in each country (Swedish Energy Agency, 2001; Statistics Finland, 2001). These systems are particularly common in less densely populated areas and villages. The dominating fuel is still firewood, although in recent years, a market for small-scale use of wood pellets has rapidly developed in Sweden, totalling about 1.5 PJ (Swedish National Board of Forestry, 2001), whereas pellet expansion has just started in Finland.

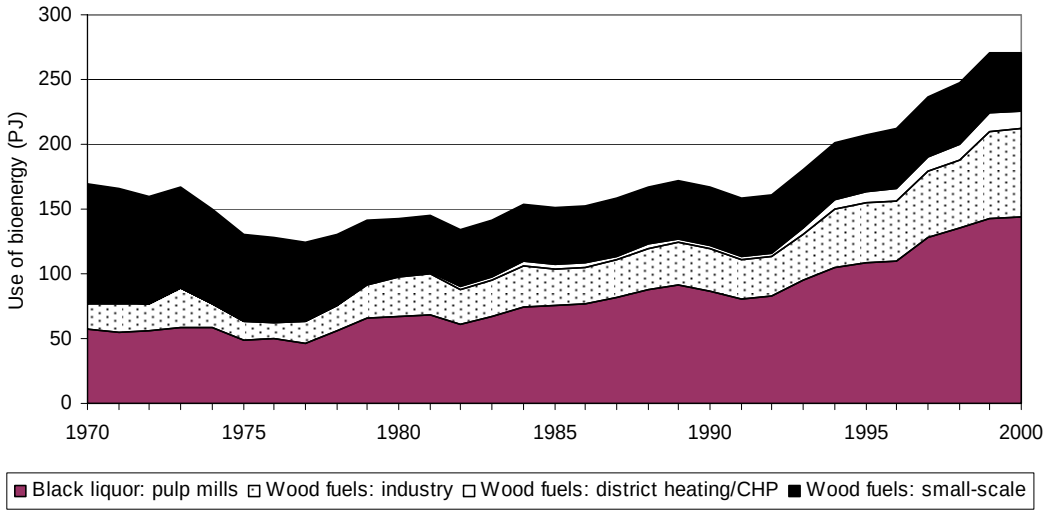

Figure 4. Use of wood fuels and black liquor in different sectors in Finland during the past thirty years (Statistics Finland, 2001).

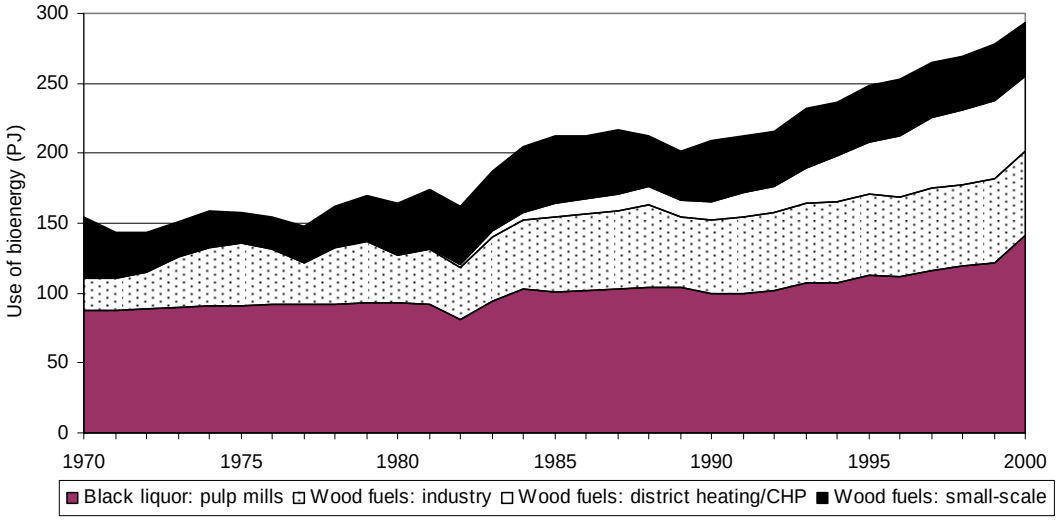

Figure 5. Use of wood fuels and black liquor in different sectors in Sweden during the past thirty years (Swedish Energy Agency, 2001a).

3.3. International biofuel trade

Biofuels have traditionally been used mainly in the region where they are produced. This pattern has changed in Northern Europe through the large-scale use of biofuels in district heating during the 1990s. The largest volumes of wood fuels are traded from the Baltic countries to the Nordic countries, notably Sweden and Denmark. One survey by Vinterbäck and Hillring (2000) estimated the Swedish biofuel import to be 20-32 PJ in 1997, equivalent to 29-47% of the total biofuel use in district heating, see Table 2. The import flows from the Baltic countries include pellets, wood chips and stem wood/firewood. Pellets are also imported from Canada. Virtually all Swedish pellet exports go to Denmark. Tall oil, both crude and refined, is imported to Sweden from the USA and Finland (Statistics Sweden, 2002). An important share of total biofuel imports is made up of used wood, mainly from Germany and the Netherlands.

Extensive waste legislation in these countries, in combination with modest domestic demand for waste fuels, has stimulated the export of used wood (Profu, 2002). In general, higher taxes on fossil fuels in Sweden, compared with other countries, constitute the major driving force behind the biofuel export to Sweden. Finnish biofuel imports are estimated to be much less, about 1.3 PJ in 1999 (VTT Energy, 2001), which just about equals their exports, see Table 2. About 80% of the pellet production in Finland is exported to Denmark and Sweden. Wood chips are imported to Finland from Russia (Alakangas and Paju, 2002; VTT Energy, 2001).

Table 2. Estimates of Swedish (Vinterbäck and Hillring, 2000; Statistics Sweden, 2002) and Finnish (VTT Energy, 2001) biofuel imports and exports.

	Sweden		Finland	
	Imports	Exports	Imports	Exports
Total estimate (PJ)	20-31 (1997)	0.2 (1998) 0.4 (2001)	1.3 (1999)	1.1 (1999)
Fuel	Pellets Wood chips Stem wood/firewood Tall oil Used wood	Pellets	Wood chips	Pellets Wood chips Tall oil

4. Bioenergy policy

Bioenergy in Finland and Sweden has received long-standing government policy support. Relevant policies include RD&D support and economic instruments such as investment grants, and energy and environmental taxes. In addition, various administrative instruments have influenced the development of bioenergy. Both countries have strong frameworks for monitoring the forestry sector and enforcing legislation. For example, the Swedish National Board of Forestry has issued guidelines since 1986 on the extraction of biomass for different types of soils and forest stands. An example pertaining to the energy sector is the Solid Fuel Act in Sweden which, between 1982 and 1994 required that new plants producing more than 50 GWh thermal per year should be designed so that they could be fired with solid fuels (SFS 1981:599). This is likely to have facilitated some of the changeover to biomass. Laws and regulations may facilitate or hinder certain developments. However, the discussion here focuses on economic instruments and RD&D priorities.

4.1. Taxes

Taxation has been an important means of realising energy policy in both countries ever since the introduction of taxes on oil products in the 1970s as one of the means of reducing oil dependence. Since then, the taxation of energy has gone through many changes but as a clear trend, the taxes on fossil fuels have increased. Biofuels have been exempt from taxes, except value-added tax (VAT). Biomass became less expensive than coal in 1991 in Sweden and in 1997 in Finland as a result of carbon and energy taxes, see Figure 4. Finland was actually the first country to introduce a carbon-based tax in 1990 but it took some time before it reached levels where the scale tipped in favour of biomass. The general carbon tax in 2002 in Finland was 17.2 €/tonne CO_2, except for natural gas where it was half of this, and in Sweden 70

€/tonne CO_2 (630 SEK/tonne). Peat in Sweden is taxed only for its sulphur content at 4.4 €/tonne of peat (40 SEK), or about 1.7 €/MWh (15 SEK/MWh). Peat in Finland is subject to an energy tax of about 1.5 €/MWh.

It has been a challenge in both countries to support biomass through taxes on fossil fuels without endangering the competitiveness of their industries (Vehmas et al, 1999). Consequently, there are special rules for reducing the tax burden. In Finland, energy-intensive industry receives a refund, corresponding to 85% of the tax that exceeds 3.7% of the company's value added. This is paid out for the part exceeding 50,000 €. In Sweden, the general carbon tax for industry is 20 €/tonne CO_2 (180 SEK) and energy-intensive industry has special tax rules for additional reductions.

Electricity is taxed at the consumption level in both Finland and Sweden[5], a consequence of the internal electricity market and concern for industrial competitiveness. Thus, fuels used for electricity production are not taxed. The electricity consumption tax is 12-20 €/MWh (120-180 SEK/MWh) (2002) in Sweden, apart from industry, for which it is zero. The corresponding tax in Finland is 6.9 €/MWh for all users except industry and greenhouse owners who pay 4.2 €/MWh.

In summary, the high level of taxation on fossil fuels has clearly made biomass the least costly fuel for heat production in district heating systems in Sweden, while the difference between natural gas, peat and biomass is marginal in Finland. The effect of taxes on the choice of fuel in industry is difficult to assess due to the complexity of the schemes for lowering the taxes effectively paid by industry, the use of process-specific fuels and due to the fact that prices are not transparent since much of the biofuel is generated and used within the same industry.

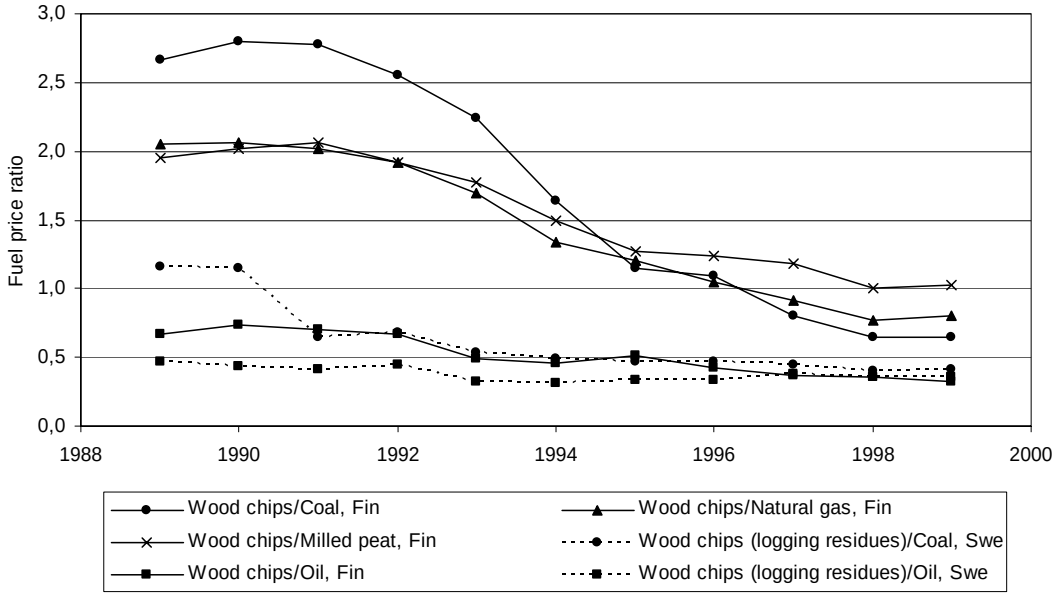

Figure 4. Relative prices of wood chips and fossil fuels in Finland (Fin) and Sweden (Swe) for heat consumers who pay full energy and environmental taxes. Whether the Finnish wood chips are sawmill by-products or logging residues was not specified. (Statistics Finland, 2001; Swedish Energy Agency, 2001)

[5] To be exact, nuclear power in Sweden is subject to a tax based on installed capacity, which is equivalent to approximately 2.8 €/MWh (25 SEK/MWh), and hydropower is subject to a small real-estate tax.

4.2. Subsidies and other support schemes

Both countries have employed various investment and production support schemes in parallel with the use of taxes. Initially, in the 1970s, much effort was aimed at reducing oil dependence, mainly through investment grants for coal-, peat- and biomass-fired plants. However, the focus on biomass has increased notably since around 1985 in Sweden and 1990 in Finland, at the expense of first coal and then peat.

Investment support in Sweden since 1991 has targeted biomass-based CHP and initially amounted to 444 €/kW (4000 SEK/kW) of installed electric capacity. This level was lowered in 1997 to 333 €/kW (3000 SEK/kW), or a maximum of 25% of the investment cost. This is equivalent to a subsidy of approximately 9-11 €/MWh produced (80-100 SEK/MWh). Investment support in Finland is granted to both peat- and biomass-using plants, for both heat production and CHP, although the focus has shifted to biomass during the past decade. The subsidy level in the 1990s corresponded to 10 to 25% of the investment cost (Tamminen and Nousiainen, 1997). The maximum available investment subsidy since 1999 is 30%, contingent on the type of project. In addition, biomass-based electricity production (as well as wind and small-scale peat or hydropower) receives a subsidy per kWh produced, equivalent to the Finnish electricity tax.

In Sweden, the current support scheme will be replaced by a quota-based system with certificate trading to promote electricity production from new renewable sources. The target is to increase the use of electricity from renewable sources, i.e., biomass, wind and small hydro, by 10 TWh between 2002 and 2010. It is expected that biomass will be highly competitive in this scheme and thus electricity produced from biomass in CHP plants will increase (SOU 2001:77).

In addition to the key investment and production subsidies, there have been several other direct or indirect subsidies aimed, at varying degrees, to supporting bioenergy. For example, in Finland, a subsidy has been in place since 1991 to encourage thinning and it was complemented in 1999 to encourage chipping of the extracted wood. Part of the Swedish funds for local investment programmes for the implementation of ecological sustainability have been used to support biomass projects or, for example, district heating projects that may facilitate biomass expansion (Hanberger et al., 2002).

4.3. Research, development and demonstration

Bioenergy RD&D has represented a major share of total government energy RD&D since the 1980s; about 10-20% in both countries. This corresponds to about 5.5-7.8 million € per year (50-70 MSEK) during the 1990s. In addition, energy companies and the forest industry have made considerable contributions to RD&D, which together have probably matched government spending (Elforsk, 1995). A study for 1993 showed that per capita bioenergy RD&D spending was 4-5 times higher in Finland and Sweden than the EU average, although the spending per hectare of forest and agricultural land area was close to the average (Blok et al., 1996). RD&D efforts have targeted all steps in the fuel chain, from biomass extraction or harvest to ash handling and recycling. There is now a basic body of knowledge and experience facilitating the use of bioenergy in an environmentally acceptable manner (Swedish

Energy Agency, 2001b), and increased use of biomass does not appear to be hindered by considerable knowledge gaps or R&D needs.

It should be noted that the expansion of biomass use has occurred through applying relatively conventional technologies. Long-standing and important R&D priorities, such as the production of ethanol from lignocellulosic biomass using enzymatic hydrolysis or biomass-integrated gasification combined cycle (BIGCC) technology, have not yet resulted in commercial applications. Gasification, for example, has been a high priority in both countries since the late 1980s and also attracted considerable interest from the industry, as illustrated by the co-operation during the early 1990s between Sweden's Vattenfall and Finland's Tampella in a company called Enviropower, or Sweden's Sydkraft and Finland,s Ahlström (now Foster Wheeler Energia) in Bioflow. Bioflow, with 6 MW_e and 9 MW_{th}, was the world's first BIGCC demonstration in the early 1990s (VTT, 2002). However, electricity market reforms and technological risks associated with gasification technology have made investors opt for more robust and proven combustion technologies for commercial applications.

5. Structures and actors

It is important to consider several factors to understand the development of biomass use. Some structural factors relevant to biomass use in Finland and Sweden are presented below, together with a discussion of how different actors have responded to, or influenced, changes in policy and the market. To some extent, we utilize the reference frame presented by (Roos et al., 1999), presenting certain critical factors for bioenergy development.

5.1. The forest sector

Sweden and Finland have a long history of economical exploitation of forest resources. Forest land has been regarded foremost as an economic resource, and legislation has been in place for almost a century to ensure that productive forest land is managed to preserve long-term economic output. Forest products represented 13% and 26% of total exports in 2000 in Sweden and Finland, respectively, indicating the sector's importance to the economies of these countries.

Forest management legislation used to focus one-sidedly on economic output. Through rules governing rejuvenation, the forest stock has grown steadily, although biodiversity has suffered. In 1993 Swedish legislation was changed, however, making environmental considerations and economic output equally important, and a corresponding legislative change occurred in Finland 1997. In recent years, international forest certificate systems (PEFC and FSC)[6] have been introduced in both countries, further emphasizing the importance of sustainable forest management.

The forest ownership structure is characterized by a relatively high share of non-industrial, private owners - 49% of the forest land in Sweden and 61% in Finland. Companies own 40% in Sweden and 9% in Finland. The Finnish state owns 25%. The Swedish state owns only 3% directly, but it controls more than a third of the company forests through a government-owned company. The remaining shares in Sweden and

[6] Pan European Forest Certification and Forest Stewardship Council

Finland are owned by other public interests, such as parishes, municipalities and other collective bodies (Swedish National Board of Forestry, 2001).

About one third of the 344,000 private Swedish forest owners belong to one of the three forest owners' associations. In Finland most of the 920,000 private forest owners belong to forest management associations. There are about 200 associations in total, organized in 12 regional groups. The associations provide professional assistance in forest management, harvesting operations and planning timber sales for their members. They also play a role in informing their members on the harvesting of logging residues. One of the Swedish associations, Södra, owns sawmills and pulp and paper mills, and operates similarly to other forest companies. In Finland, some 130,000 forest owners are connected to the forest industry through shared ownership in the Metsäliito group.

The forest industry, specifically the pulp and paper industry, has seen a considerable amount of restructuring in past decades. In Finland there are currently three big forest companies controlling 98% of the pulp and paper production: UPM-Kymmene, Stora-Enso (partially state owned), and the Metsäliitto group (M-real, Metsä-Botnia). For comparison, the three biggest companies controlled only 28% of the production in 1980. In Sweden, Stora-Enso, SCA and Södra are among the largest forest companies. Several of the companies also have a considerable share of their production outside Finland and Sweden (Finnish Forest Industries Federation, 2000).

The existence of large and well organised forest owners and industries that can respond to, and influence, policy can be identified as one important factor shaping the development of bioenergy. Other factors include technical capacity through the domestic manufacturers of forestry equipment, and good transportation infrastructure, since both countries have a tradition of giving high priority to infrastructure development (Finnish Forest Industries Federation, 2000). Thus, biomass for energy has been able to piggyback on the existing forestry infrastructure.

5.2. The forest industry on the energy market

The pulp and paper industry is energy intensive and controls much of the biomass flow as producer and user. Consequently, this industry is an important player in the energy market and has a strong interest in low fuel and electricity costs. In both countries this has been manifested, for example, in strong support for nuclear power. The ties between the forest industry and the power industry are traditionally strong. Forest companies are major electricity buyers and they also own electricity generation facilities, in addition to the back-pressure steam turbines typically installed at the mills. Their presence on the energy market is most notable in Finland, where the forest companies make up the largest owner of PVO, one of the two big energy companies. On the other hand, energy companies are interested in getting access to the energy assets of forest companies, typically through outsourcing agreements.

The forest industry was initially reluctant to engage in the development of a biofuel market since they feared competition for the raw material (Hakkila and Nousiainen, 2000). Furthermore, turning to biomass for electricity instead of nuclear power could result in increased electricity prices. To ensure the future supply of wood fibres to the forest industry, the Swedish government regulated the use of roundwood for heating purposes in the Wood Fibre Act, which was passed in 1987 (SFS 1987:588). The fear

of a shortage of wood fibre proved, however, to be exaggerated. In 1993 the Act was repealed and the wood fuel market was thus administratively deregulated (SFS 1993:564).

The forest industries in both countries have adopted a positive attitude towards biofuels since the 1990s and they now account for a large part of the wood fuel market through subsidiary companies. The forest industry has also benefited from energy policies supporting biomass. For example, carbon and energy taxes have generated the market for biofuels but the industry is largely exempt from these taxes. Another example is the new Swedish renewable portfolio standard, where pulp and paper companies can issue green certificates but have no obligation to buy them.

Nowadays, the production stages in the forest industry are often integrated so that pulp and paper and also sawmills operate at the same industrial site and are owned by the same corporation. This enables efficient use of raw materials and energy in the complex. Apart from wood fuels, the mills sometimes also deliver waste heat to neighbouring communities or sell electricity (Finnish Forest Industries Federation, 2000). In Sweden, for example, there are 16 mills (2000) that supply waste heat to municipal district heating grids (Wiberg, 2001). The value of integrating the production of biofuels with the forest industry lies in the opportunity to use existing skills and transportation infrastructure in the forest industry. By coordinating the harvesting of logging residues with normal forestry operations, costs for machines and forest roads can be divided between the users (Roos et al., 1999). In addition, some industrial sites such as sawmills and pulp mills have integrated the production of refined fuels such as pellets. Swedish and Finnish forest industries have also been very active in energy RD&D programs. This has been important, for example, for the integrated extraction of timber and logging residues for fuel (Hakkila and Nousiainen, 2000).

5.3. District heating

Finland and Sweden have low average population densities but urbanization has been relatively pronounced and most of the people live in the southern parts of these countries. Relatively cold climates with seasonal heat demands, in conjunction with a widespread acceptance of centralised local authority systems, have led to a significant penetration of district heating. Due to the consistent promotion of DHS in Swedish and Finnish energy policy, the number and size of the systems have expanded considerably since the ones first built in the 1940s and 1950s. High energy efficiency, low emissions, and fuel flexibility compared with individual heating systems have been important drivers for this development.

District heating systems have been central to the development of bioenergy. Flexibility of fuel use, is one reason, which has facilitated a relatively quick response to changes in fuel prices. For example, the use of wood fuels in Swedish district heating quadrupled between 1990 and 2000 in response to the introduction of a carbon tax on fossil fuels (Swedish Energy Agency, 2001a). In Finland the economic incentives to use wood fuels in district heating are weaker and came later (see section 4.1). Consequently, the share of wood fuels is still quite small, but growing. Three different boilers dominate large-scale wood fuel combustion: grate boilers, fluidised beds and powder boilers. Fluidised beds of various designs are now the preferred

technology in large plants, mainly because of flexible fuel use, which enables a choice between different solid fuels based on prices and availability (Nuutila, 1999).

Local authorities have a central role in the physical planning and choice of heating system in both countries. Decisions are made with regard to, for example, construction in urban areas, roads and other infrastructures. Local authorities have also traditionally owned the local energy company, making the choice of fuels a municipal decision. Consequently, political considerations and other decision criteria besides direct costs can be important. For example, biomass for heat and electricity has become part of a long-term commitment through local Agenda 21 processes in some municipalities in Sweden. Växjö (Växjö municipality, 2002) and Kristianstad (Kristianstad municipality, 2002) are two examples. In others cases, the switch to biomass primarily represents a rational short-term economic decision, for example the investment in biomass for heat in Malmö (Bardouille, 2001).

Public ownership still dominates, although DHS in most cities have been transferred to municipal limited companies, rather than being run by city administrations. In recent years there has also been a trend in both countries towards private and large state-owned energy companies increasing their share in district heating ownership through acquisition of municipal companies. Previously traditional electric utilities are currently diversifying into other energy carriers and integrating horizontally and vertically.

The share of CHP-based electricity generation in Finland is among the highest in the world (IEA, 2000) whereas the potential in Sweden is poorly utilized (see section 3.2). An important reason is that the expansion of nuclear power in Sweden resulted in surplus electricity generation capacity (Westin and Lagergren, 2002). Kaijser (1992) explains that the largest actor in the Swedish electricity market considered CHP to pose a threat to nuclear power and therefore used its dominant position to influence the operating economics of many CHP plants. Such a surplus did not exist in Finland and consequently it was more important to utilize CHP

Wood fuels are often used as a co-fuel together with coal, peat and even used wood in Finnish district heating plants. Coal is rarely used in Sweden and then usually co-fired with wood fuels in CHP plants. On the other hand, co-firing wood fuels with different kinds of used wood is quite common. The co-firing of coal in CHP, notably in Sweden, is a peculiar effect of the tax system where heat production carries carbon taxes and electricity is taxed only at the consumption level.

Transportation costs are typically not discouraging since wood fuels can often be obtained locally. In addition, very long transport distances may be competitive, as indicated by the growth in international trade (section 3.3), especially for plants that can be reached by waterway. In general, truck is the most competitive mode of transport for short distances up to 150 km and for longer distances boat is the most competitive (Börjesson, 2001). An important factor for the transportation cost is also whether reloading is necessary.

5.4. Small-scale heating

Individual heating systems are necessary in rural and other areas where heat densities are too low for district heating to be cost effective. About a quarter of the heat supplied to such single houses in Finland and Sweden comes from wood. Electricity

and oil meet the rest of the heat demand. Electricity is used extensively for space heating, particularly in Sweden. Detached houses built in the 1980s were often equipped with direct resistance electric heating, and the installations of heat pumps was also encouraged, since there was ample supply of electricity.

Small-scale use of biomass for heating single houses has a long tradition in Finland and Sweden. The dominating technology is still various wood-burning stoves for supplementary heating, as well as conventional burning of firewood in boilers connected to a hydronic heat distribution system. Combination boilers, allowing for heating by means of oil, wood or electricity are common.

Conventional firewood heating systems are problematic with regard to pollutants, such as tar and other hydrocarbons, which have negative health effects. Most of these problems can be reduced by using modern boilers fired at full load conditions, preferably loading heat into a hot water accumulator. Fuel quality is also of importance, and a changeover to wood pellets is seen as a future opportunity to reduce emissions. In recent years, a Swedish pellet market for the residential and service sector has rapidly evolved. Local retailers usually handle the distribution with sack deliveries, whereas bulk transport (similar to fuel oil systems) is available regionally (Alakangas and Paju, 2002). The distribution networks for pellets are however, not yet fully developed and suitable fuels are not available everywhere. This is especially the case in Finland, where the pellet market took off later, and with the help of the Swedish market, which initially provided a demand for the Finnish pellet producers (Alakangas and Paju, 2002).

The potential market for pellets consists predominantly of the conversion of oil-fired systems and, to some degree, electrically heated houses. It is slightly more uncertain whether pellets will be a substitute for firewood since firewood is usually collected by the house-owners themselves, while pellets are traded commercially. Using firewood may also be regarded as a choice of lifestyle and leisure time activity. Further development of the small-scale use of pellets will be determined by prices (including taxes) of competing alternatives like electricity and oil, and whether pellets are perceived as a convenient heating choice.

In general, the ability of small-scale consumers to react to government policies is different from that of larger utilities or municipalities. Their choice of heating system is more clearly limited by the alternatives available in their specific location, and fuel flexibility in existing systems is already low. Also, information about new heating systems may be limited and positive experience of the present system may slow down a change to new systems, even if they have a long-term cost advantage.

A new form of medium- to small-scale heating, heating entrepreneurship, has developed over the past ten years. Typically, entrepreneurs provide heating services that consist of heating a municipal building or managing a whole district heating plant. The service includes procurement of fuel and operation of the heating plant. The heating entrepreneur may be a local forest owner seeking extra income or a co-operative formed by several local forest owners. Large energy companies have also turned this into a business concept. In such vertically integrated organisations the whole chain, from the forest to the final user, can be technically and economically optimized. Sometimes the entrepreneur owns the boiler or heating plant, besides being responsible for operation and maintenance. In 2000 there were about 100 heating entrepreneurs in Finland and the total capacity was 43 MW (Alakangas, 2001). Wood

chips were the most common fuel. The situation is similar in Sweden, but the total capacity that the entrepreneurs contribute with has not been estimated.

6. Lessons learned and future challenges

Many countries have an ambition to increase their use of bioenergy. In Finland and Sweden, the key instrument employed to fulfil this ambition has been the use of environmental taxes, which have made biomass the least costly fuel in many applications. Complemented with investment subsidies, support for technology demonstrations, and longstanding RD&D efforts, this has created the conditions under which the use of bioenergy has increased. The geographical, industrial and technical structure, together with the existence of relevant actors in the forestry and energy sectors, has allowed a rapid response to the strong mix of policies. The decrease in real prices of biofuels over time indicates that there are learning effects and that the market is working.

The experience from Finland and Sweden is that relatively strong incentives appear to be needed to initiate a market. Energy market liberalisation and internationalisation trends are, at the same time, restricting the room for manoeuvre of policy makers. High taxes create tensions between countries, and between sectors within countries, leading to seemingly strange trade flows and economic inefficiency. For example, the high taxes in Sweden have had the unintentional effect of stimulating imports of used wood and other biofuels. The lower taxes paid by industry in Finland and Sweden leave a potential demand for biomass untapped; high cost opportunities are pursued in district heating systems and low cost opportunities are missed in industry. Another complication in both countries is that heat generation is subject to production taxes whereas electricity is subject to consumption taxes. Thus, carbon taxes are not levied on fuels for electricity production.

Sweden, where the carbon tax is higher, in comparison with Finland, and the differences in taxing between sectors are the greater, is now considering tax reforms. A possible way forward is to reduce the difference in carbon taxes paid by the different sectors (Government Bill 2001/02:143). This will in effect reduce the cost advantage of biofuels in the heating sector. However, complemented with other policy instruments, including a market for green electricity certificates, such a tax reform can still be consistent with continued positive development of the bioenergy market. Harmonising energy and environmental taxes between countries and sectors, is one of the greater political challenges that lie ahead.

It should be noted that unintentional effects of policy are not only negative. A positive effect of increased trade is the establishment of an international market for biofuels. This may be a valuable alternative to the domestic market for fuel producers and thus conducive to bioenergy development in general. Finland’s production of pellets for export is a case in point. The development of an international biofuel market and efficient logistics also provide opportunities for regions rich in biomass to export excess resources to other regions.

Swedish district heating systems are poorly utilized for CHP production. The initially low electricity prices that followed after the electricity market reform have not stimulated any expansion and the installed capacity has not been fully utilized in recent years. However, if electricity prices increase, and as the trade in green

electricity certificates begins, there is a potentially large demand for biomass in CHP production. The ongoing horizontal and vertical integration of energy companies that is taking place in Sweden also suggests that CHP may become more important in the future electricity supply. CHP is much more developed in Finland where the challenge lies rather in increasing the share of wood fuels in the fuel supply of district heating systems.

For small-scale heating applications, such as single-family houses, the greatest challenge may lie in technology, business and market development through which pellets, for example, can become a convenient and competitive alternative to other heating options. Heat delivery by energy service companies or heating entrepreneurs through outsourcing agreements can be one way of increasing this market.

The general trend towards clean and convenient energy carriers such as district heat, electricity and gas, underlines the importance of exploring and developing advanced technologies. Biomass gasification and black liquor gasification can increase electricity output in CHP production and have long been important R&D areas in Finland and Sweden. Fluid fuels for transportation, constitutes another important area. The focus of R&D efforts in Sweden has been on producing ethanol from cellulosic biomass, although methanol, hydrogen and dimethylether (DME) may be equally promising options. Finland has not devoted any R&D efforts to developing transportation fuels.

7. Conclusions

Finland and Sweden have succeeded in making biomass an integrated part of modern energy systems during the past 20 years. There are now relatively large, functional markets for biofuels and a rational use of biomass by-products in industry. The existence of established actors and structures in forestry and district heating has facilitated the response to strong, particularly in Sweden, and long-standing policy commitments to biomass. The support for biomass has remained relatively stable over time, although the political driving forces have changed.

Biomass energy policies have been successful in both countries, in the sense that the use of biomass has grown significantly for heat production and in industry. Learning effects, as manifested in cost reductions and price trends, have been achieved in the development of technology, organisation, markets and logistics. Growth has been strongest in Sweden where high carbon taxes create a strong price signal in addition to other policy measures. The Swedish case suggests an initial “policy overshoot”, i.e. what may seem to be overly favourable conditions for biofuels. This may be motivated in order to pump-prime the early market, and build sufficient confidence in the market initially. The development has been slower in Finland where the difference in prices between biomass fuels and competing fuels has not been as great as in Sweden.

Both countries are promoting the liberalisation and integration of energy markets through reforms. A key *political challenge* is maintaining support for biomass while the same time harmonising taxes and other policy instruments across countries or sectors. A key *policy challenge* is maintaining and expanding the use of biomass in heat production, and bringing about equally cost-efficient and rational uses of biomass

for other energy purposes in the longer term. The renewable portfolio standard for electricity that is planned to start in Sweden in 2003 is one step in this direction.

Several European Union member countries and accession countries have large potentials for the expanding use of biomass from forestry or agriculture. Finland and Sweden have specific structural and other conditions for biomass and the experience may not, in all aspects, be relevant for other countries. However, the examples given here show how policies can be effective in situations when there are actors that have the ability to respond constructively.

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