BIOMASS AND SWEDISH ENERGY POLICY

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Abstract – The use of biomass in Sweden has increased by 44% between 1990 and 1999. In 1999 it was 85 TWh, equivalent to 14% of the total Swedish energy supply. The existence of large forest industry and district heating systems has been an essential condition for this expansion. The tax reform in 1991 seems, however, to have been the most important factor responsible for the rapid bioenergy expansion. Through this reform, the taxation of fossil fuels in district heating systems increased by approximately 30-160%, depending on fuel, whereas bioenergy remained untaxed. Industry is exempted from the energy tax and pays reduced carbon tax. No tax is levied on fossil fuels used for electricity production. Investment grants have existed for biomass-based electricity production but these grants have not been large enough to make biomass-based electricity production economically competitive in a period of falling electricity prices. Despite this, the biomass-based electricity production has increased slightly between 1990 and 1999. A new taxation system aiming at a removal of the tax difference between the industry, district heating and electricity sectors has recently been analysed by the Swedish government. One risk with such a system is that it reduces the competitiveness for biomass in district heating systems as it seems unlikely that the taxes on fossil fuels in the industry and electricity sectors will increase to a level much higher than in other countries. A new system, based on green certificates, for supporting electricity from renewable energy sources has also been proposed by the government.

Keywords: biomass, policy instruments, taxes, investment grants

1. INTRODUCTION

During the last decade Swedish energy policy has been characterised by the conflict between phasing out the existing nuclear power and the goal to reduce the emissions of greenhouse gases and other pollutants. In a referendum in 1980 and a subsequent decision by the Swedish parliament it was decided that nuclear power should be phased out by 2010. Nuclear power production increased even after the referendum and it reached its highest electricity production, 73.5 TWh_e/yr, in 1991. Although the final date for the phase-out has been removed, the closure of nuclear power plants commenced in 1999 when the first of the twelve reactors was closed. Furthermore**,** during the 1990s the electricity market was deregulated which resulted in falling electricity prices.

Another central target of the energy policy has been to reduce the oil dependence. Oil was in 1980 responsible for 60% of the Swedish energy supply. During the 1990s the climate change issue has grown to one of most important factors in the energy policy debate.

Bioenergy could play an important role in solving the conflict between the different goals of Swedish energy and environmental policy. Renewable energy currently contributes 27% to the total Swedish energy supply. Biomass is the dominating source, together with hydro power, and provides 14% of the energy supply [1].

The extensive use of renewable energy is a result of favourable geographical conditions, industrial structure and governmental policies. The Swedish population density is low and the country has large forests

from which significant amounts of biomass energy can be extracted. Energy use in industry is heavily dominated by the forestry industry which enjoys excellent opportunities to utilise its by-products to respond to internal energy demand. Finally, government policies have historically supported the development of hydro power and biomass energy.

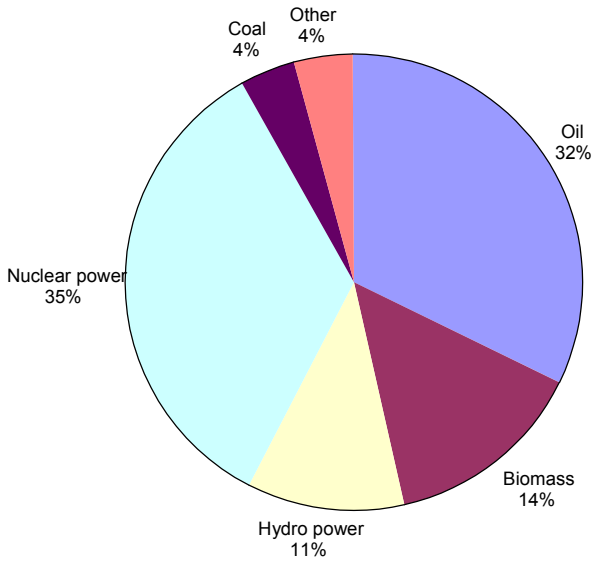
The most cost-effective way to use biomass is in large scale heating plants. The well developed district heating systems in Sweden therefore provide an important possibility to utilise biomass. Approximately 35% of the energy used for heating buildings comes from district heating today [1]. District heating systems are also strategically important for producing electricity efficiently in cogeneration.

This paper will give an overview over the Swedish biomass use and the policy instruments that have been used to promote biomass during the last decade. Throughout the paper, kWh is used as the unit for all forms of energy. When it refers to electricity it is specified with an index (kWh_e).

2. BIOENERGY IN THE SWEDISH ENERGY SYSTEM

Biomass (including wood fuels and black liquor) currently contributes 14% of the Swedish energy supply, Fig. 1. The major fraction of this is used within the forest industry (63%) and the district heating systems (23%), Fig. 2. The remaining fraction is used in small-scale heaters in one- and two family dwellings.

Figure 1. Total Swedish primary energy supply in 1999 [1]



Total energy supply: 615 TWh

Between 1990 and 1999 biomass use in Sweden has increased by 44%. In the district heating system there has been a fourfold increase, Fig. 3. The fraction of the district heating that was based on biomass in 1999 was 39% [1].

Figure 2. Total Swedish biomass use in 1999 [2].

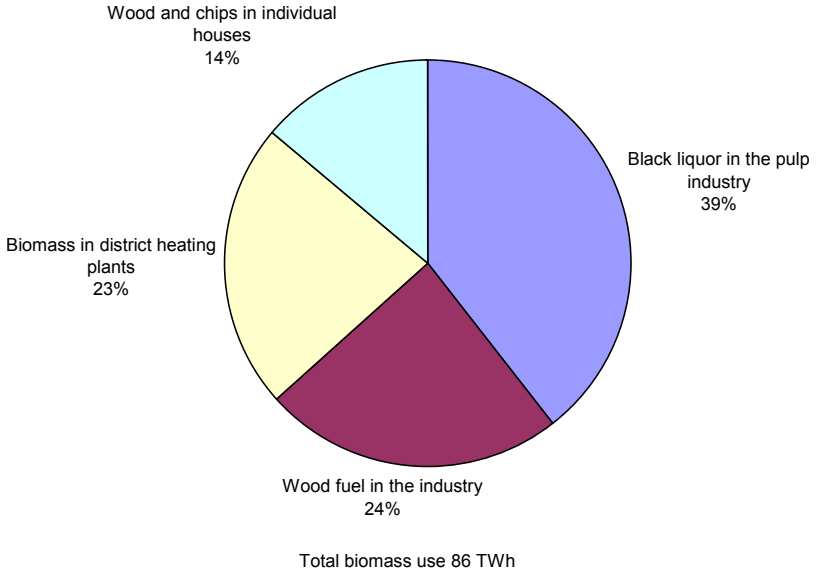
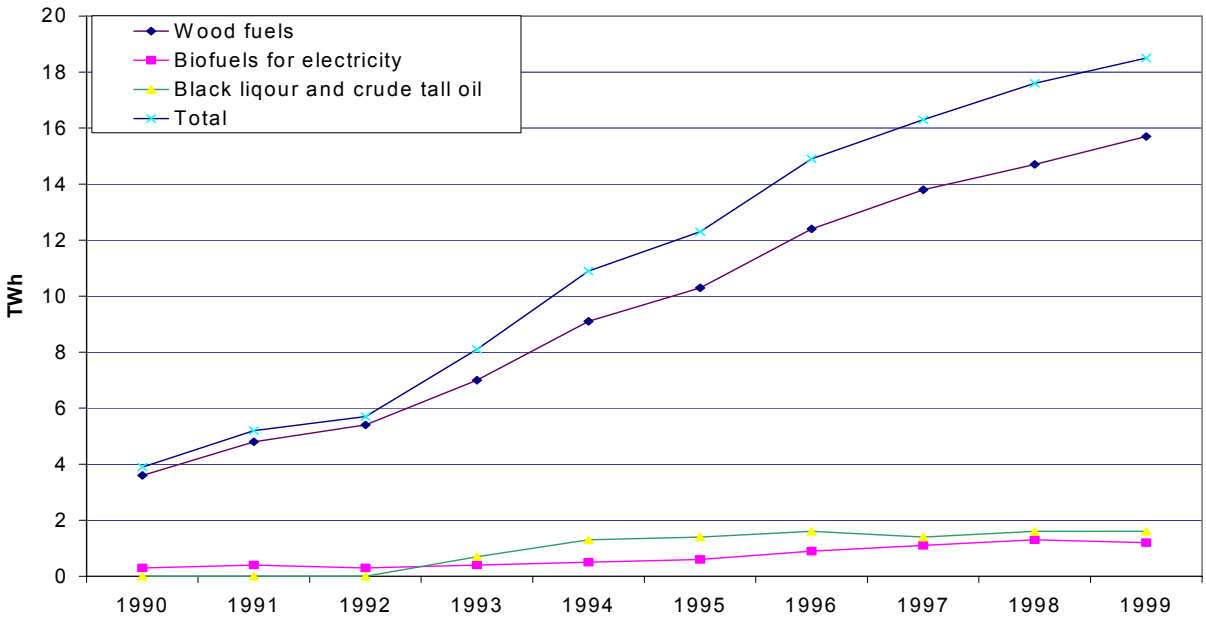


Figure 3. The use of biomass in Swedish district heating systems [1].

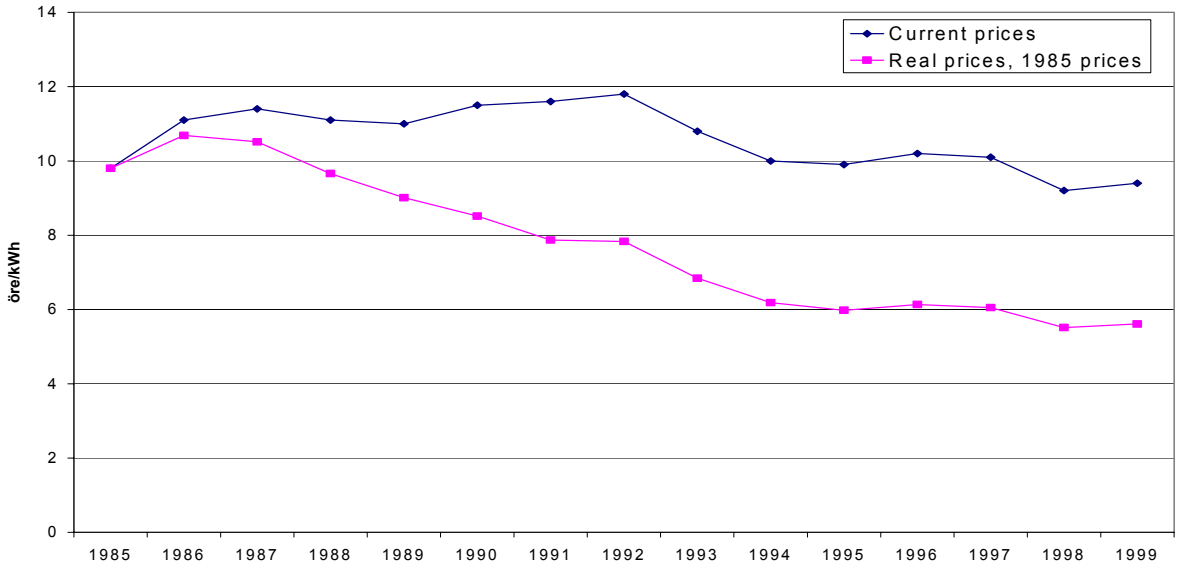


In industry the biomass expansion has been less manifest with an increase by 20% between 1990 and 1999. Today, biomass amounts to 35% of the total energy use in industry. One reason for the slower expansion rate in industry, compared to district heating, is the lower fossil fuel taxation. Another reason is the fact that a large fraction of the energy used in industry was based on biomass already in 1990, as by-products, such as black liquors, were available at a low cost in the forest industry. The Swedish forest industry has historically contributed largely to the Swedish economy and its value added corresponded in 1998 of 12% of the total value added of the manufacturing industry [2]. In 1997 the forest industry was responsible for 54% of the total energy use in Swedish industry [3]. 60% of this amount was biomass and less than 10% was fossil fuels. .

The amount of biomass used for small scale heating has remained almost constant during the period 1990-1999 and contributes about 10% of the energy used for heating of residential and service buildings.

The biomass used in Sweden is dominated by by-products from forestry and the Swedish forest industry, but the importation of biofuels has increased significantly during the 1990s. Data are uncertain, but studies indicate that 25-30% of the biomass supply to the district heating systems in 1997 was based on imported fuels [4]. The increase in biomass demand was possible without any increases in biomass prices. In fact current biomass prices have remained at the same level as in the middle of the 1980s, *i.e.* there have been substantial price reductions in real terms (Fig. 4). Larger biomass quantities and new methods for biomass extraction from the forests have reduced production costs, while competition between biomass suppliers, both nationally and internationally, have kept the prices low even as the prices of the competing fossil fuels have increased significantly.

Figure 4. Prices of forest fuels in Sweden [1].



3. SWEDISH ENERGY TAXATION –CONSEQUENCES FOR BIOMASS UTILISATION

The Swedish energy tax system underwent reform in 1991. During the 1980s, the focus had been on oil substitution and the tax system was therefore designed to discourage oil use. The new taxation system was based on a carbon tax and an energy tax on fuels (the latter is not directly connected to the carbon content of the fuel). Simultaneously with the introduction of the carbon tax, general energy taxes were reduced by 50% [5]. Through this reform the taxation of fossil fuels in district heating systems increased by approximately 30-160%, depending on fuel, whereas bioenergy remained untaxed [1].

In addition to the two taxes mentioned above, other taxes were applied to electricity nuclear production, consumption, etc. (Table 1). In 1991, a value-added tax on energy consumption was introduced.

Table 1. Summary of the taxes and charges applied on energy in Sweden in the year 2000. [a]

Type of tax	Tax level	Comments
Energy tax	Differs among the fossil fuels, see Figure 4	Applied on all fossil fuels. No tax on fuels used in industry or for power generation
Carbon tax	General level 0.36 SEK/kg CO_2 (USD 130/tonne C)	No tax is applied to fuels used for power generation and 50% of the general level on fuels used in industry
Sulphur tax	30 SEK/kg S (USD 3/kg S)	Applied on heavy fuel oils, coal and peat. If sulphur is removed from the exhaust gases the tax could be refunded in accordance with that
Nitrogen oxides charge	40 SEK/kg NO_2 (USD 4/kg)	Applied on heat and power plants which use more than 25 GWh/yr. The charge is refunded to each production unit in proportion to their production of useful energy (heat and electricity)
Tax on nuclear electricity production	2.7 öre/kWh$_e$ (USD 0.003/KWh)	
Electricity consumer tax	11-16 öre/kWh$_e$ [b] (USD 0.011-0.016/kWh)	No tax on electricity used in the industrial sector
Value added tax	25%	Applied on all energy consumed

a. On the 1 st of January 2001 the general CO_2 tax level increased to 0.53 SEK/kg CO_2 , while the energy taxes were reduced. The carbon tax in industry remained unchanged. In total, the tax level increased for fuels used in buildings and district heating systems but did not change for other fuels. The tax on electricity consumption increased by 1.9 öre/kWh.

b. The lower level is for northern Sweden and the higher for the rest of the country.

In 1993, industry was exempted from the energy tax and had to pay only 25% of the general carbon tax. This tax reduction was introduced to preserve the international competitiveness of Swedish industry. In 1997, the carbon tax on industry was raised to 50% of the general level . For energy-intensive industries special rules apply that allow further reductions of the carbon tax. The 1991 and 1993 tax reforms together led to reduced tax levels for industry, amounting to reductions of over 50% for some fuels [5]. There is no energy or carbon tax on electricity production, although non-industrial consumers pay an electricity consumption tax.

The general carbon tax has increased gradually from 25 öre/kg CO_2 to the level in the year 2000 of 36.5 öre/kg CO_2/ (~USD 130/tonne C). The energy tax on fossil fuels, especially on petrol but also on other oil products, is high and acts therefore as a powerful complement to the carbon tax outside the industrial sector. The rates of energy, carbon and sulphur taxes in the year 2000 are shown in Figure 5 for various fossil fuels. On the 1 st of January 2001 the general CO_2 tax level increased to 0.53 SEK/kg CO_2 , while the energy taxes were reduced. The carbon tax in industry remained unchanged. In total, the tax level increased for fuels used in buildings and district heating systems but did not change for other fuels. The tax on electricity consumption increased by 1.9 öre/kWh$_e$.

The taxation system explains much of the character of the biomass expansion in Sweden. The cost of producing heat using different fuels in the late 1990s is shown in Figure 6. In district heating systems biomass-based heat has much lower cost than heat produced from fossil fuels. In industry heat produced from oil is less costly than heat produced from biomass.

The tax advantage for biomass use in small-scale boilers are similar to those in district heating but has not been large enough to induce a major conversion to biomass. The need for decentralised distribution and, for practical and environmental reason, more costly refined fuels, and sometimes relatively high cost for conversion from fossil fuels or electric heating have all acted as obstacles for the expansion of biomass use in small scale heating.

Figure 4. Energy, carbon and sulphur taxes in the energy sector in the year 2000 [6].

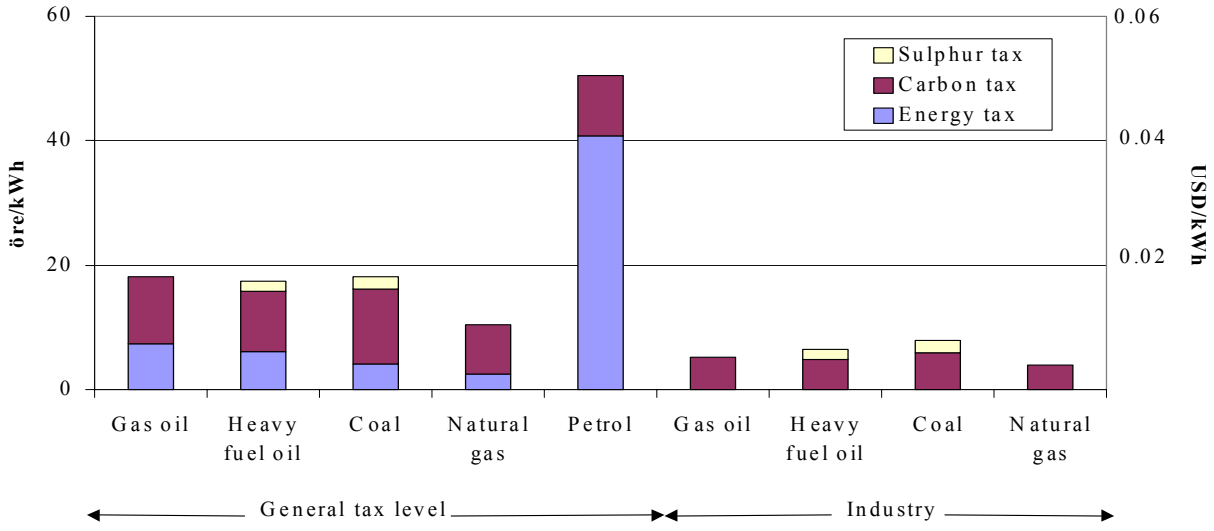
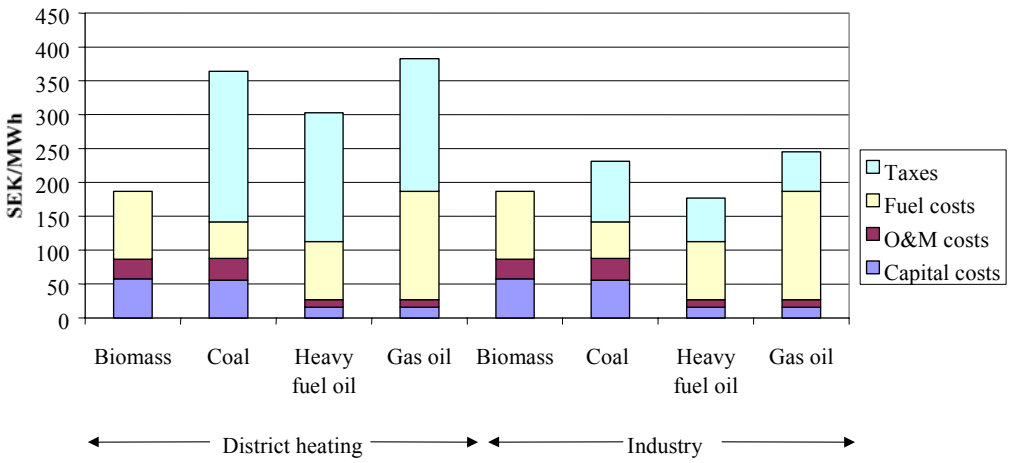


Figure 5. Heat production costs for new plants 10 SEK=1 USD [6].



4. INVESTMENT GRANTS FOR ELECTRICITY PRODUCTION

Investment grants for plants producing electricity from biomass have been used during the 1990s. The investment grant introduced in 1991 was 4000 SEK/kW_e (USD400/kW_e) and resulted in the construction of 16 new biomass-based plants. Twelve of them were cogeneration plants in the district heating systems and four cogeneration plants in industry {7]. In the 1997 energy policy programme the level of the investment grants was reduced to 3000 SEK/kW_e or a maximum 25% of the investment costs. This investment grant corresponds to a subsidy of approximately 8-10 öre/kWh_e (0.8-1.0 US cents/kWh_e) and has been given to

another nine cogeneration plants. [7]. The electricity production based on biomass was in 2000 3.6 TWh_e [8]. The estimated future production in the nine plants that has been given grants according to the 1997 programme is approximately 0.8 TWh_e/y These levels can be compared to the total Swedish electricity production in 1999 which was 150 TWh_e.

Even with the investment grants, biomass-based cogeneration is not economically competitive in a market with falling electricity prices [4]. Still several new plants have been built in district heating systems. The reason for this might be a strong political commitment to renewable energy, an expectation of increasing electricity prices in the future or the possibility to transfer the cost to the district heating consumers through higher district heating prices. The district heating systems are still monopolies and it is difficult for consumers to change to other heating systems in response to higher prices [9].

5. SUPPORT FOR BIOMASS-BASED TRANSPORTATION FUELS

The Swedish government has supported the development of technologies for producing and using biomass-based transportation fuels in several ways. Biomass-based transportation fuels have been exempt from energy and carbon taxes in accordance to the regulation for pilot projects in the EU mineral oil directive. Furthermore, the Swedish government spent 120 million SEK (USD 12 million) on research, and development projects for the utilisation of biomass-based fuels [10]. Above that, 210 million SEK (USD 21 million) will be spent on research and development during the period 1998-2004 in the field of ethanol production from cellulosic biomass [11].

In 1999, as a result of these efforts, a few hundreds of heavy duty buses and trucks used ethanol instead of diesel and about 500-1000 light-duty vehicles used biogas or ethanol. A new plant for ethanol production from grain was opened in the year 2000 with an annual production of approximately 50 000 m^3. The amount of biomass-based transportation fuels used today in Sweden corresponds to about 0.8% of the total amount of fossil transportation fuels used [12].

The feedstock for the biomass-based transportation fuels have so far to a large extent been grain and surplus wine from the European market. Several studies have shown, however, that the preferable feedstock for transportation fuel production in Sweden is cellulosic biomass (see eg. Johansson [13]). There is, however, so far no commercial plant available for the production of liquid transportation fuel from cellulosic biomass and there is still a need for some technological development. The use of biomass for transportation fuel production seems also less efficient in a CO_2 reduction strategy than the use for heat and electricity production (see eg. [14]).

6. PROPOSED FUTURE POLICY CHANGES – SOME EXAMPLES

Since the 1991 tax reform the government has used different ad hoc solutions to solve problems resulting from the differences in tax level between the district heating, electricity and the industrial sectors. For example, biomass has been sold by the forest industry to the district heating systems where the use of biomass was more profitable as a result of the taxation system. Furthermore, the heat production in industrial companies have been organised in separate companies to get access to some subsidies that the government was providing the district heating companies to compensate them for their higher taxes. The differences in taxation between heat and electricity production have also encouraged the owners of cogeneration plants to mix biomass and fossil fuels to minimise production costs. This behaviour has the disadvantage that the ashes from biomass combustion are contaminated and cannot be returned to the forests, which is usually recommended [4]. The system furthermore reduces the advantage of cogeneration compared to separate electricity production.

Therefore, a new tax system structure was proposed in 1997 and its details have been analysed since then [4]. The main idea of this system is to apply the same tax level on fuels used for production of electricity and district heating and for industrial production. This level is proposed to be lower than for fuels used directly in the residential, service and transportation sectors. Consumer taxes are in addition proposed to be levied on district heating and electricity used in these sectors in order to preserve the relative competitiveness of the various energy carriers

A maintained tax difference between biomass and fossil fuels is essential for the competitiveness of biomass. It seems unlikely that taxation on fuels used for industrial purposes will increase significantly compared to the current level in order to maintain international competitiveness. The consequences of the proposed system may therefore be a radically reduced taxation on fossil fuels in district heating system. This

would halt the expansion of biomass in these systems unless other policy instruments e.g. investment grants are introduced also for heat production [4].

The proposed EU directive on renewable energy has set a target for increasing the use of renewable energy for electricity production to a level corresponding to 22% of the total electricity production by 2010 [15]. For Sweden, an indicative target has been proposed implying an increase in renewable electricity production with approximately 25 TWh/yr. The support for renewable electricity production will probably be reformed in the coming years. A system based on green certificates on renewable energy has been proposed by the government [16] The advantage of such a system would be the elimination of the subsidies from the state budget and the introduction of competition between different producers of electricity from renewable sources which in turn is expected to reduce the total costs of the system. The system is based on a legal requirement on the consumer or the electricity distributor to buy an amount of certificates equivalent to a certain fraction of their electricity consumption. The certificates will be given to new hydro, wind and biomass plants in accordance to their electricity production. The technical aspects of the system is currently being analysed and the analysis will be presented in a Swedish Government Official Report by October 2001.

7. DISCUSSION AND CONCLUSION

The Swedish taxation system has been successful in fostering an expansion of biomass in Sweden for heating. The large existing electricity production capacity (mainly hydro and nuclear), and decreasing electricity prices as a result of electricity market liberalisation, have hindered a similar development in the electricity sector.

The increased demand of biomass has in turn led to reduced biomass production costs as new methods and technical solutions for biomass has continuously been introduced during the last decade. These include multi-treehandling/felling in smallwood thinning, compaction equipment for logging residue, and heavy duty chippers [17]. New methods for simultaneous extraction of log and logging residues are being developed. These methods, including for example a harvester technology that accumulates the tops and branches as the stems are processed and then compacts the material into composite residue logs, could reduce both the demand for machinery and costs by 20-40% [18].

A biomass market has also developed, enabling a widening of the potential biomass suppliers, to the major heat production plants. An increasing fraction of the used bioenergy is now imported fuels. The market pressure has made a combination of increasing demand and falling prices possible but there is a risk that the relatively low profitability of the Swedish biomass suppliers will result in that some of them will leave the market or at least reduce their effort to expand their activity.

The existence of a large forest industry and well-developed district heating systems have provided a good organisational basis for the biomass expansion. Professional structures for handling products from the large forests and strong consumers in the district heating systems have probably helped the expansion significantly.

The further expansion is less certain Since the most advantageous markets for biomass are already utilised and there may be a new taxation system which might be less supportive to biomass than the current,. It seems to be a potential to increase the annual biomass use in district heating systems by a few TWh in the coming 10 years [3]. Expected new incentives for expanding renewable energy in electricity production might also provide a possibility to increase electricity production from biomass.

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