# Biomass in Sweden - Historic Development and Future Potential under New Policy Regimes

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# BIOMASS IN SWEDEN – HISTORIC DEVELOPMENT AND FUTURE POTENTIAL UNDER NEW POLICY REGIMES

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ABSTRACT: The use of biomass in Sweden has increased by 88% between 1980 and 2002. In 2002 it was 89 TWh, equivalent to 14% of the total Swedish energy supply. The existence of a 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. Last year a system with green certificates was introduced aiming at increasing annual electricity production from renewable energy by 10 TWh between 2002 and 2010. The coming EU system for emission trading will lead to increasing electricity prices thereby improving the competitiveness for renewable electricity. If, however, new fossil-fuel based cogeneration plants achieve emission rights at no cost, while taxes in the sectors included in the trading system are removed, biomass-based heat and cogeneration plants will have problems to compete with fossil-fuel based plants.
Keywords: bio-energy policy, emission trading, green electricity market

## 1 INTRODUCTION

During the last one and a half 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.

Bioenergy could play an important role in solving the conflict between the different goals of Swedish energy and environmental policy.

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. The potential effects of new policy instruments will also be discussed. Throughout the paper, kWh is used as the unit for all forms of energy.

## 2 BIOENERGY IN THE SWEDISH ENERGY SYSTEM

Biomass[1] in 2002 contributed 14% (89 TWh) of the Swedish energy supply, Fig. 1. Biomass was mainly used within the forest industry (57%) and the district heating systems (30%). The remaining 13% is used in small-scale heaters in one- and two family dwellings.

Biomass use in Sweden has increased by 88% between 1980 and 2002 with the most significant increase after 1990. In the district heating system there has been an increase from almost zero to 26 TWh in 2002, Fig. 2. The fraction of the district heating that was based on biomass was in 2002 43% [1].

In industry the biomass expansion has been less manifest with an increase by almost 40% between 1980 and 2002, Fig. 2. Today, biomass amounts to approximately 30% of the total energy use in industry [1]. 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 1980, as by-products, such as black liquors, were available at a low cost in the forest industry.

The amount of biomass used for small scale heating has remained rather constant during the period 1980-2002 and contributes about 10% of the energy used for the heating of residential and service buildings.

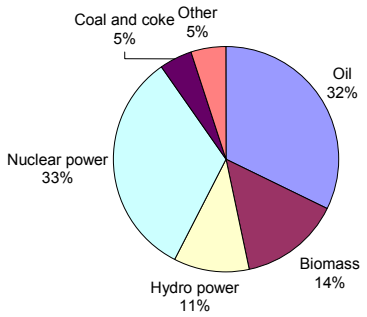


**Figure 1:** Swedish primary energy supply (615 TWh) in 2002 [1].

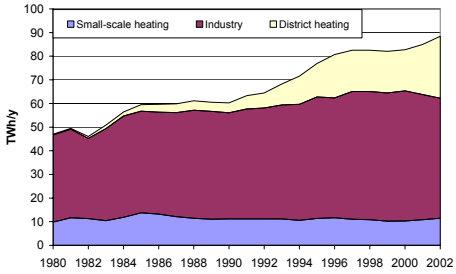


**Figure 2:** Swedish biomass use 1980-2002 [1].

The biomass used in Sweden is dominated by by-products from forestry and the Swedish forest industry,

[1] We use the term biomass in a broad sense including wood fuels, industrial by-products, wood waste and agricultural products. We do not, however, include municipal refuse or peat.

but the importation of biofuels has increased significantly during the 1990s. Data are uncertain, but studies indicate that 7% of the biomass supply in 2000 was based on imported fuels [2]. The increase in biomass demand was possible without any significant increase in biomass prices. In fact current biomass prices have remained rather stable in nominal terms since the middle of the 1980s, *i.e.* there have been substantial price reductions in real terms. 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. During the last few years there has been a slight tendency that the prices have started to increase [3].

## 3 SWEDISH ENERGY TAXATION IMPACT ON 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 carbon tax has almost quadrupled since its introduction and is today 910 SEK (100 Euro)/tonne $CO_2$ for private consumers and district heat production. The level for industry is about 20% of the general level. Fuels used for electricity production is free from both energy and carbon taxes. The taxes currently applied on energy in Sweden is summarised in Table I.

**Table I:** Summary of the current(2004) taxes and charges applied on fuel use in Sweden 2004. 10 SEK=1.1 Euro,

| Type of tax | Tax level | Comments |
|---|---|---|
| Energy tax | Differs among the fossil fuels[a] | Applied on all fossil fuels. No tax on fuels used in industry or for power generation |
| Carbon tax | General level: 910 SEK/tonne $CO_2$ Industry and heat in CHP: 190 SEK/tonne $CO_2$ | No tax is applied to fuels used for power generation. |
| Sulphur tax | 30 SEK/kg S | |
| Nitrogen oxides charge | 40 SEK/kg | Applied on heat and power plants >25 GWh/yr. The charge is refunded in proportion to their production of useful energy. |

a.The energy tax varies from levels equivalent to 100 SEK/ tonne $CO_2$ for natural gas to 1200 SEK/ tonne $CO_2$ for petrol.

The taxation system explains much of the character of the biomass expansion in Sweden, Fig. 3. In district heating systems biomass-based heat has much lower cost than heat produced from fossil fuels. The cost difference between plants using different fuels in industry is, however, only minor.

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 (although a slight expansion has been recognised during recent years). 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.

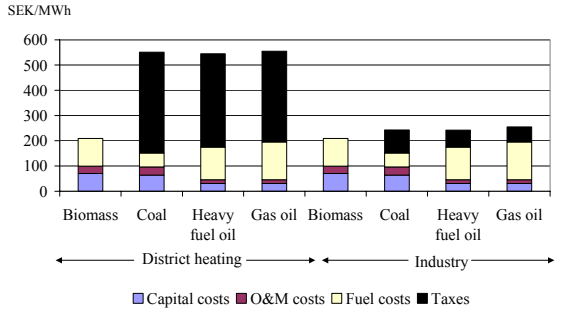


**Figure 3:** Heat production costs for new plants. 10 SEK=1.1 Euro. Plant data adopted from [4] and [5].

## 4 SUPPORT FOR BIOMASS-BASED 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/$kW_e$). In the 1997 energy policy program the level of the investment grants was reduced to 3000 SEK/$kW_e$ or a maximum 25% of the investment costs.

This system has been replaced by a new support system for electricity from renewable sources which was introduced on the 1st of May 2003. The system is based on an obligation for consumers to buy electricity certificates equivalent to a fraction of their consumption. The intention is to increase the renewable electricity production with 10 TWh/yr between 2002 and 2010 [6]. The system supports not only biomass but so far biomass-based electricity has provided approximately 75% of the issued certificates.

## 5 OTHER SUPPORT

On average 11% of energy R&D since 1975 (equivalent to approximately 100 million SEK per annum) has been spent on bioenergy. It has amongst others lead to the successful implementation of economically and environmentally acceptable methods for forest residue extraction.

During recent years significant amounts have also been spent on the development of technologies for producing ethanol from cellulose biomass. 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. With the new EU tax directive the tax exemption is no longer restricted to

pilot projects.

The use of biomass-based transportation fuels has increased rather quickly during the last years mainly through ethanol blending in petrol. Today, biofuels comprise approximately 2% of the Swedish transportation fuel consumption [7].The Swedish production capacity is less than half this size and most of the biofuel is thus imported.

## 6 STRUCTURES AND ACTORS SUPPORTING BIOMASS EXPANSION

The widespread forests of Sweden (227 000 $km^2$, 2.5 ha/capita) have been a prerequisite for forestry and the forest industry and thus for the expansion of biomass use. Forestry and the forest industry handle biomass resources (used in forest products or as energy sources) corresponding to an energy content of 150 TWh/y. This is equivalent to one fourth of the current Swedish primary energy supply. This has resulted in the technical capacity to handle large biomass flows in an efficient manner.

Efficient logistics are essential for competitive bioenergy systems. The vertically integrated forest industries and forest owner's organisations (that also own several large forest industries) have qualifications for handling new systems that include an energy assortment. The engagement of different companies and organisations has, however, varied between and within organisations [8]. On the whole, the existence of strong, and efficient actors, responsive to new market areas, has, however, facilitated an increase in the use of biomass.

The energy used for space and hot water heating accounts for a significant fraction (approximately one fourth) of the total Swedish energy demand. The existence of district heating systems has facilitated the rapid growth in biomass demand in response to policy changes. District heating systems provide low-temperature heat corresponding to approximately 40% of the heat demand in Swedish buildings [2]. These systems are quite energy efficient with distribution losses of about 10%.

District heating companies have responded very quickly during recent decades to new policy signals. During the 1980s, high taxation led to the rapid replacement of oil by an expansion of coal and electric heating. In response to new economic conditions in the 1990s interest turned to biomass. District heating companies, in contrast to households, are professional organisations that analyse the production costs of their plants much more carefully and compare them to alternatives. They can therefore be expected to react more quickly to changes in the taxation system. The fact that many of the companies are, or have until recently been, publicly owned has probably increased their sensitivity to local political environmental goals, which has led to investments also in such biomass technologies which, from a strictly business economic point, appear questionable.

In Sweden there are companies engaged in the construction of heat and power plants as well as forest machinery. In response to the increasing biomass demand, these groups of companies have been engaged in developing new modern technologies for biomass combustion and technologies for logging residue extraction. The expansion of biomass in district heating has led to the introduction of flue-gas condensation which has enabled efficiency gains in biomass plants of 10-25% [9]. Sweden, together with Finland, is one of the leading producers of forestry machinery. R&D organisations, machinery producers and forestry organisations together form an innovative environment for the development of technologies that enable the extraction of logging residues at lower, competitive costs.

## 7 PROPOSED FUTURE POLICY CHANGES – SOME POSSIBLE CONSEQUENCES

In this section the effect of some future policy changes will be discussed. The green certificates introduced last year, the coming system of tradable emission rights and possible tax changes will all affect the biomass competitiveness.

With current taxes and the system with green certificate biomass based heating is competitive in the district heating sector, see Fig. 4. The biomass based cogeneration has significantly lower costs than natural gas. This is in principle totally the result of the extra income for green certificates. It is assumed that the total income (electricity and certificates) for electricity from biomass-based CHP is determined by the production cost of wind power plants (key competitors to biomass in the certificate market).

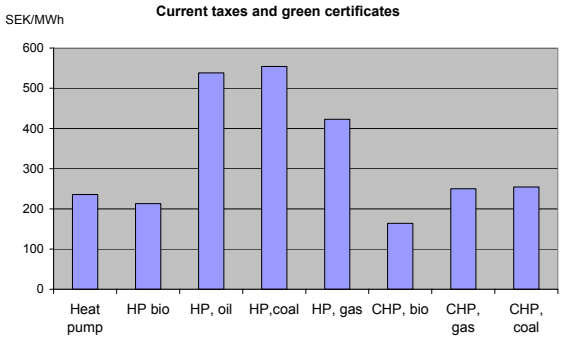


**Figure 4**: Heat production costs for heat pumps, heat plants (HP) and combined heat an power plants (CHP) in district heating systems at current taxes. The plant size is $50MW_{heat}$. Plant data adopted from [4] and [5].

The introduction of a European emission trading system by the 1st of January 2005 will affect biomass competitiveness. Carbon emission trading will pose a common price on $CO_2$ throughout the union. This could give new incentives for biomass expansion but the real consequences depend on the details of the system. The expected price on emission rights is significantly lower than the general tax level in Sweden and thus the competitiveness of biomass will be significantly reduced in the district heating systems unless carbon taxes are preserved, see Fig. 5. There are currently strong forces in Sweden working for the removal of the carbon tax for companies involved in the emission trading system.

The EU emission trading system will be based on free allocation of emission rights. One problem with a system with free allocation will arise if new fossil-fuelled CHP plants get emission rights in accordance to expected

future emissions. This means that the plant owner only will get emission rights if the plant is built and used. This means in reality that the cost for $CO_2$ emission in the new plants will be zero. In this case biomass cannot compete with fossil fuels, see Fig 6.

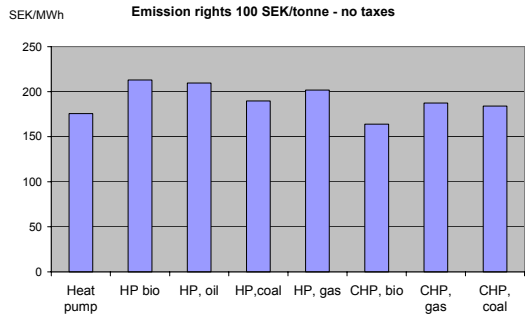


**Figure 5:** Heat production costs for heat pumps, heat plants (HP) and combined heat an power plants (CHP) at an estimated price on emission rights of 100 SEK (11 Euro)/tonne $CO_2$. The plant size is 50 $MW_{heat}$. New plants have to buy emission rights in the market. Plant data adopted from [4] and [5].

Secondly, updating of base years for historic allocation might pose a problem for biomass. An allocation based on historic emission will probably have to change base years to make the allocation more relevant. This will however reduce the incentives for converting fossil-fuel plants to biomass as the change of base years will remove the possibility to sell the emission rights that are set free as a result of the conversion.

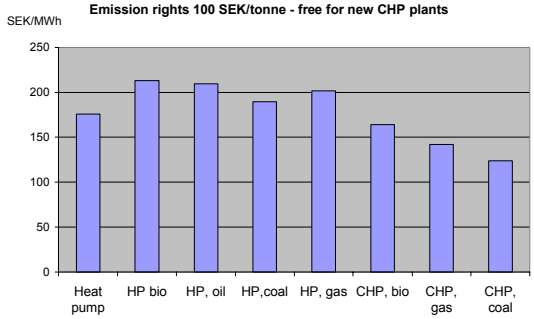


**Figure 6:** Heat production costs for heat pumps, heat plants (HP) and combined heat an power plants(CHP) at an estimated price on emission rights of 100 SEK (11 Euro)/tonne $CO_2$. New fossil fuel based plants are assumed to get emission rights at zero cost. The plants size is 50$MW_{heat}$. Plant data adopted from [4] and [5].

To avoid these disincentives for biomass use, allocation by auctioning would be preferable. If free allocation remains the preferred system a more adequate allocation system would be intensity based. In the energy sector one possible allocation factor could be usefuel energy regardless of which fuel is used for the production of this energy. The concept of useful energy is currently used in Sweden as the basis for refunding nitrogen oxides charges to the emitters.

## 7 CONCLUSION

The Swedish taxation system has been successful in fostering an expansion of biomass in Sweden for heating. The newly introduced green certificate system will improve the competitiveness of biomass-based electricity production. The construction of the allocation rules in the EU emission trading system may, however, have a negative effect on biomass-based cogeneration and make it difficult for biomass-based cogeneration to compete with fossil fuels.

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 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. A biomass market has also developed, enabling a widening of the potential biomass suppliers, to the major heat production plants.

## 8 ACKNOWLEDGEMENTS

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