Economic Instruments in Practice 1: Carbon Tax in Sweden

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1) **Abstract**-In 1991 a carbon tax was introduced in Sweden as a complement to the existing system of energy taxes, which simultaneously were reduced by 50%. Since then the system has changed several times but a common feature is lower taxes for industry and electricity production than for other sectors. Currently, industrial consumers pay no energy tax and only 50% of the general carbon tax. Neither energy nor carbon tax are applied on electricty production. Today the general carbon tax level is 36.5 öre/kg CO2 (approximately $ 150/tonne C). The most obvious effect of the carbon tax has been an increased use of biomass in the Swedish district heating system. Biofuels peat etc. currently contribute about 50% of the energy supply to the Swedish district heating systems. The demand for biomass has encouraged the development of new methods for utilising wood fuels which in turn has led to price reductions on these fuels. The impact of the carbon tax on the energy and resource efficiency of the Swedish industry has probably been rather limited for three reasons: 1) the carbon tax on industry is only 50% of the general level and, 2) only a relatively small fraction (30%) of the energy supply to industry was fossil fuel-based when the tax was introduced and 3) for most industrial companies the energy cost is a relatively small fraction of the total cost and has therefore low priority.

INTRODUCTION

In 1999 the Swedish Parliament established 15 environmental quality objectives. The overall aim is to be able to hand over a society to the next generation in which the major environmental problems have been solved (Swedish Environmental Protection Agency, 2000). The climate target has been considered to be the most difficult one to achieve (Swedish Environmental Protection Agency, 1999).

Carbon dioxide emission is responsible for approximately 80% of the Swedish anthropogenic contribution to the greenhouse effect (Government Commission of Measures against Climate Change, 2000) and about 93% of the CO_2 emission is the result of fossil fuel combustion.

Taxes on energy have for many years played an important role in Sweden, both as a fiscal tax source and as a policy instrument. In 1991 the energy taxation system was reformed and a carbon tax was introduced. The carbon tax and the energy tax are very closely connected and have to be regarded together. Other economic incentives that affect the energy sector are the sulphur tax and the nitrogen oxides charge. Regulations have historically been important for the possibility to reduce the emissions from both stationary and mobile sources. Regulations have so far had relatively small effect on CO_2 emissions.

The purpose of this paper is to describe the structure of the Swedish carbon and energy tax system and the consequences this system has had on the structure of the Swedish energy system. The relation of this tax system to other policy instruments is discussed. Finally there is a brief discussion of what effect the carbon tax or other policy instruments is likely to have had on innovation in Sweden.

CHARACTERISTICS OF THE SWEDISH ENERGY SYSTEM

The swedish energy supply can be summarised according to Figure 1.

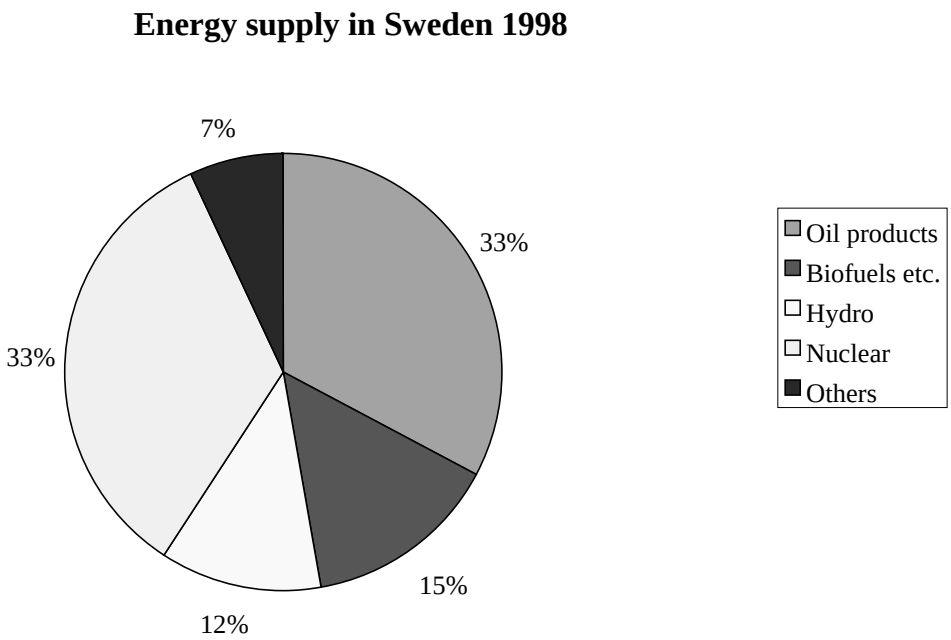

Figure 1. Swedish energy supply in 1998 (Swedish National Energy Administration, 1999a).

The Swedish energy system has at least three characteristics that makes it different from most other industrialised countries:

1) Swedish electrcity production is almost entirely fossil free and is based on nuclear and hydro power. There is also some electricity production in cogeneration plants in industry and district heating.
2) Renewable energy contributes with 27% to the Swedish energy supply. Biomass is together with hydro power the dominating source and provides approximately 15% of the energy supply. The great importance of renewable energy is a result of favourable geographical conditions, industrial structure and governmental policies. The Swedish population density is low with large forests from which large amounts of bioenergy can be extracted. Energy use in industry is heavily dominated by the forest industry which have excellent opportunities to utilise by-products for the internal energy demand and finally governmental policies have historically supported the development of hydro power and bioenergy.
3) The per-capita electricity use in Sweden is very high partly becasuse of the rapid expansion of electric space heating during the 1980s and partly because of a large electricity intensive industry. Currently about 35 TWh/yr electricity used for space heating (Johansson, 1995; Swedish National Energy Administration, 1999b). This is equal to approximately 25 % of the total electricity demand.

TAXES ON ENERGY IN SWEDEN

The Swedish energy tax system was reformed in 1991. During the 1980s much focus had been on oil substitution and the tax system was therefore designed to discourage oil use. The reformed taxation system was based on a carbon tax and a energy tax on fuels, the latter not directly connected to the carbon content of the fuel. Simultanously as the carbon tax was introduced general energy taxes was reduced by 50% (Energidata Göteborg et al., 1995).

Apart from these two taxes there were other taxes applied to electricity production, consumption etc., see Table 1. In 1991 value added tax was introduced on energy consumption.

Table 1. Summary of current taxes and charges applied on energy in Sweden.

Type of tax	Tax level	Comments
Energy tax	Differs among the fossil fuels, see Fig. 1	Applied on all fossil fuels. No tax on fuels used in industry or for electricity production
Carbon tax	General level 0.36 SEK/kg CO_2 ($ 150/tonne CO_2)	No tax is applied fuels used for electricity production and 50% of the general level on fuels used in industry
Sulphur tax	30 SEK/kg S ($ 3.3 /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 ($ 4.4/kg)	Applied on heat and power plants which use more than 25 GWh/yr. The charge is refunded to the group in proportion to their energy use
Tax on nuclear electricity production	2.7 öre/kWh ($ 0.003/KWh)	
Electricity consumer tax	11-16 öre/kWh ($ 0.012-0.017/kWh)	No tax on electricity used in the industrial sector
Value added tax		Applied on all energy consumed

When the new taxation system was introduced industry was exempted from energy tax and had to pay only 50% of the general carbon tax level. In 1993 this fraction was reduced to 25%. In 1997 the fraction was once again raised to 50%. For energy intensive industries there are special rules that allows further reductions of the carbon tax. The total effect of the 1991 tax reform on industry was reduced tax levels, for some fuels by more than 50% (Energidata Götrborg et al, 1995). There is no energy or carbon tax on electricity production but non-industrial consumers have to pay a tax on electricity consumption tax.

The current general carbon dioxide tax is 36.5 öre/kg CO2/ (~USD 150/tonne C). The energy tax on fossil fuels, especially on petrol but also on other oil products, are rather high and is therefore, outside the industrial sector, a powerful complement to the

carbon tax. Current energy, carbon and sulphur taxes for different fossil fuels are shown in Figure 2.

Energy, carbon and sulphur taxes in Sweden

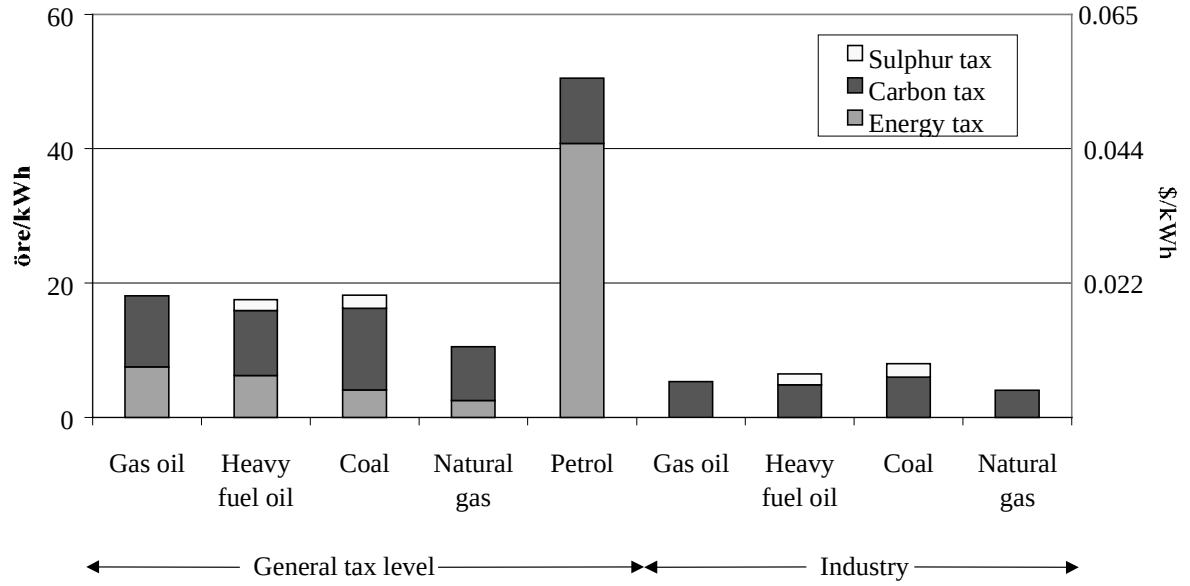

Figure 2. Energy, carbon and sulphur taxes in the energy sector (Swedish Energy Administration, 1999).

EFFECT OF CARBON AND ENERGY TAXES

The most obvious effect of the reformed taxation system has been the expansion of biomass use in the district heating system, Figure 3. Since 1990 biomass use have increased in industry as well, however to a lesser extent, from 45 TWh/yr to 54 TWh/yr (Swedish National Energy Administration, 1999).

The reason for the expansion can easily be understood when comparing heat production cost for biomass-based heat plants is compared with the heat production cost for fossil-fuel based plants, Figure 4.

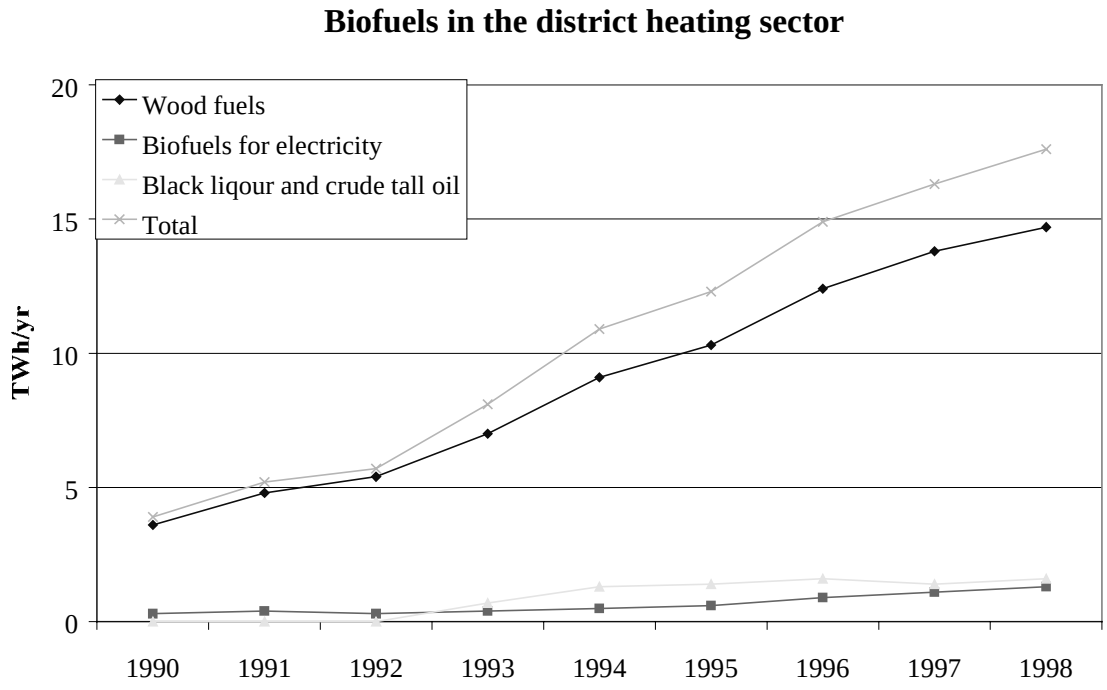

Figure 3. The use of biomass in Swedish district heating systems.

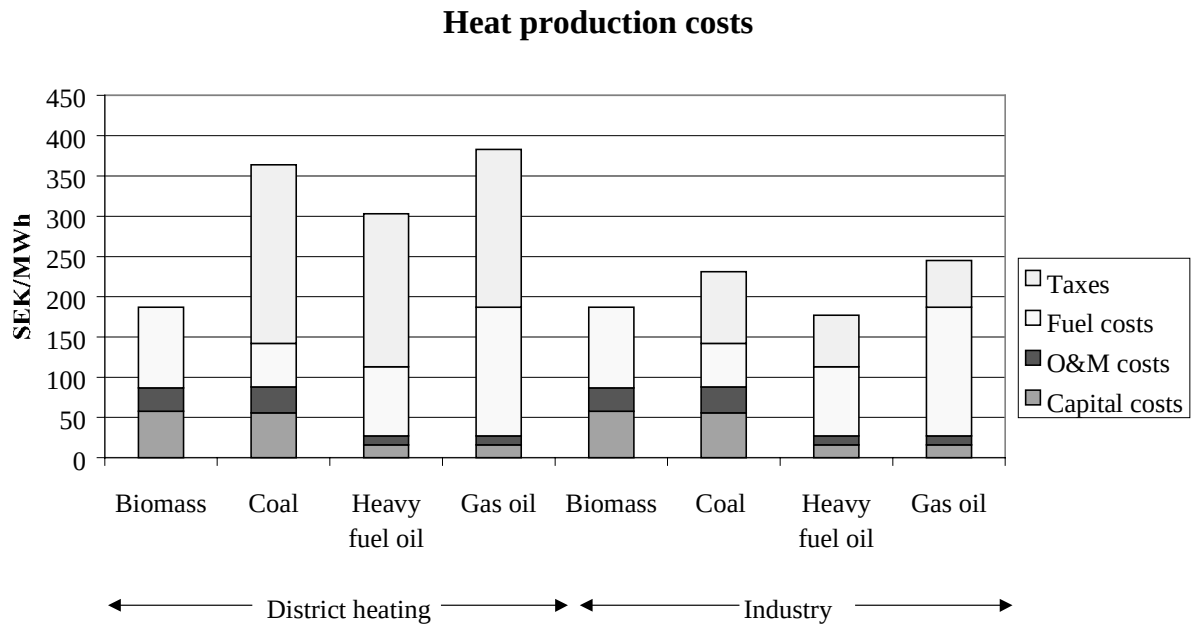

Figure 4. Heat production costs for new plants (Swedish National Energy Adminsitration, 2000).

There are several reasons why the effect of the carbon tax in industry has been rather small.

2) The industrial tax level is much lower than the tax level in district heating, see Figure 3.
3) Only a relatively small fraction (30%) of the energy supply to industry was fossil fuel-based when the tax was introduced, see Figure 5.
4) The total taxation level on fossil fuels in industry was reduced in the taxation reform 1991.
5) For most industrial companies the energy cost is a relatively small fraction of the total cost and has therefore low priority.

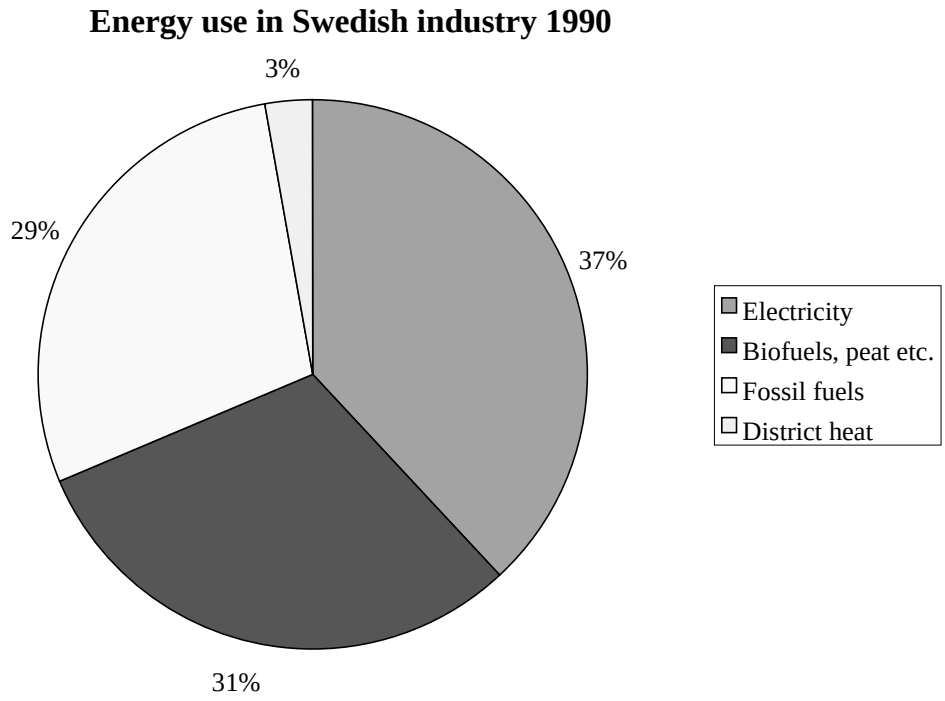

Figure 5. Energy use in industry by source 1990 (Swedish National Energy Adminstration 1999).

The differentiation of the carbon tax among sectors has had some effect on the behaviour of companies. Between 1993 and 1997 when the tax difference between fuels used in district heating systems and fuels used in industry was larger than today, some industries sold their by-products to the district heating companies while they themselves burned fossil fuels. This was not an efficient solution but an effect of the construction of the tax system.

There has been some studies that have tried to quantify the impact on CO_2 emission of the policy instruments instruments implemented in the beginning of the 1990s. For example the Ministry of Environment (1997) shows in the second national report on

climate change that the CO_2 emissions in 1995 were about 15% lower than it would have been if the policy instrurments of 1990 would still have been in use. By the year 2000 it was estimated that the CO2 emissions would be 20-25% than if the 1990 policy instrument package still would have been in use. Almost 90% of this reduction was the result of the reformed tax system, whereas the remaining 10% were a result of investment grants and offical programmes on energy efficiency.

THE EFFECT OF SULPHUR TAXES, NITROGEN CHARGES, REGULATION AND INVESTMENT GRANTS

Both the sulphur tax and the nitrogen charges have had effect on emissions. The nitrogen charges are however applied only on stationary combustion plants which produce more than 25 GWh/yr (These plants are responsible for a small fraction of the total Swedish NO_x emission in Sweden) and therefore have impact on a small fraction of the total emissions. An evaluation from the Swedish Environmental Protection Agency (1997a) showes that the taxes and charges had been cost-effective. The sulphur tax was responsible for emission reductions 1989-1995 equal to about 30% of the 1989 Swedish emissions. The NOx emission from the plants on which the NOx charge was applied was reduced by 60% between 1990 and 1995 of which about 80% was a result of the nitrogen charge (Swedish Environmental Protection Agency, 1997a).

The evaluation shows, however, that regulation also have had a large effect on the emission reductions. For the measures that are in question, i. e. combustion improvements and exhaust gas treatment on large plants and reductions of the fuel sulphur content, regulations seem to be cost effective measures as well.

A new envrionmental code entered into force in Sweden on the 1st of January 1999. According to this code energy and resource efficiency as well as CO_2 emission can be regarded when considering permits for environmentally hazardous activities.

As a result of the reluctance to introduce carbon taxes on electricity production and the fact that electricity prices has fallen significantly during the 1990s the politicial aim of increasing the fraction of renewable electricity has led to the introduction of investment grants for biomass-based electricity plants as well as on wind electricity plants. Furthermore an environmental bonus has been applied on wind power electricity. These investment grants have been important for the expansion of these production technologies and wind power

systems is, with this support, competitive to other electricity production. The construction of biomass-based cogeneration plants have certainly been encouraged by the economical support, but another reason for biomass-based cogeneration is probably to been found in political desicsions in the municipalities controlling the district heating systems. The investment grants for biomass-based plants have not been large enough to make the biomass-based electricity competitive.

THE EFFECT OF ECONOMIC POLICY INSTRUMENTS ON INNOVATION

There are no studies available that show the effect of carbon taxes on innovation in industry in Sweden. There are reasons to believe that the relatively low taxation on industrial energy use has resulted in only minor improvements in energy efficiency within the industry. This conclusion was also drawn in an interview study which found that the energy tax level did not give enough incentives to invest in energy efficient technology in industry (Energidata Göteborg AB et al. 1995). Since then the carbon tax, however, has been doubled to 50% of the general taxation level.

The most important development as a result of the new taxation system is probably the development of the methods of biomass extraction and a biomass market. The increase in biomass demand has been possible without any increases in biomass prices, in fact biomass current prices are today the same as in the middle of the 1980s, i. e. there have been large cost reductions in real terms, Figure 6.

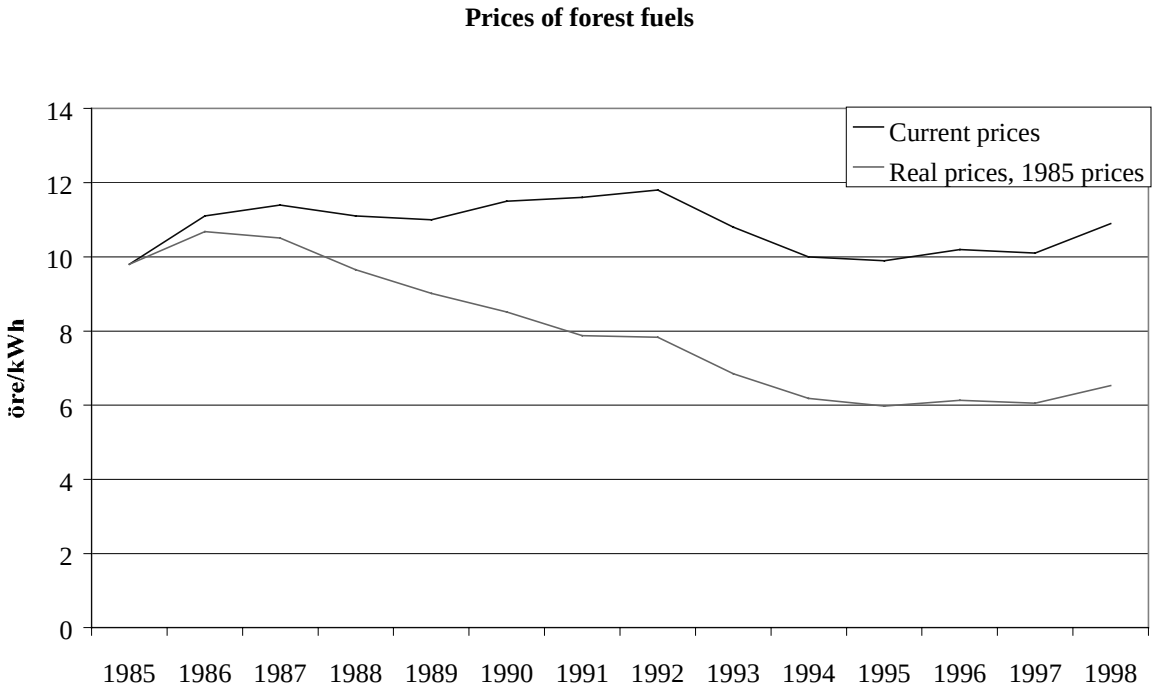

Figure 6. Prices of forest fuels in Sweden (Swedish National Energy Administration 1999).

As the demand for biofuels increased during the 1990s several new technical solutions have been introduced. The technical solutions include multitree-handling felling in smallwood thinning, compaction equipment for logging residue, and heavy duty chippers (Brunberg et al., 1998). New methods for simultaneous extraction of log and logging residues are under development. These methods, 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 the demand for machinery and could reduce the cost by 20-40% (The Forest Research Institute of Sweden, 2000)

A biomass market has also been developed which has enabled a widening of the potential biomass suppliers to the major heat production plants. The combination of an increased demand for biomass with a simultaneous market pressure has probably been important for the possibility to combine increased demand with falling prices.

The expansion of biomass in district heating has given way to a major introduction of flue gas condensation. This technology has enabled an increased efficiency in biomass plants by 10-25% (Swedish Environmental Protection Agency, 1993)

There are technical developments that can be attributed to the introduction of the sulphur taxes and nitrogen charges (Swedish Environmental Protection Agency, 1997). There has been a development of simpler and cheaper instruments for emission measurements,

calcuations and evaluations. The SCNR-systems for nitrogen oxides reductions have also been developed as a direct effect of the nitrogen charges. The sulphur tax has resulted in that existing exhaust gas desulphurisation devices reduces the emissions to much lower emission levels than they once were designed for (Swedish Environmental Protection Agency, 1997).

CONCLUSION

The carbon tax has together with other taxes been important in the limitation of the CO_2 emissions during the 1990s. The main effect has been the expansion of biomass in the district heating systems. This expansion has in turn led to a development of the technology for biomass extraction in forestry and in the implementation of more efficient heat plants in the district heating system.

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