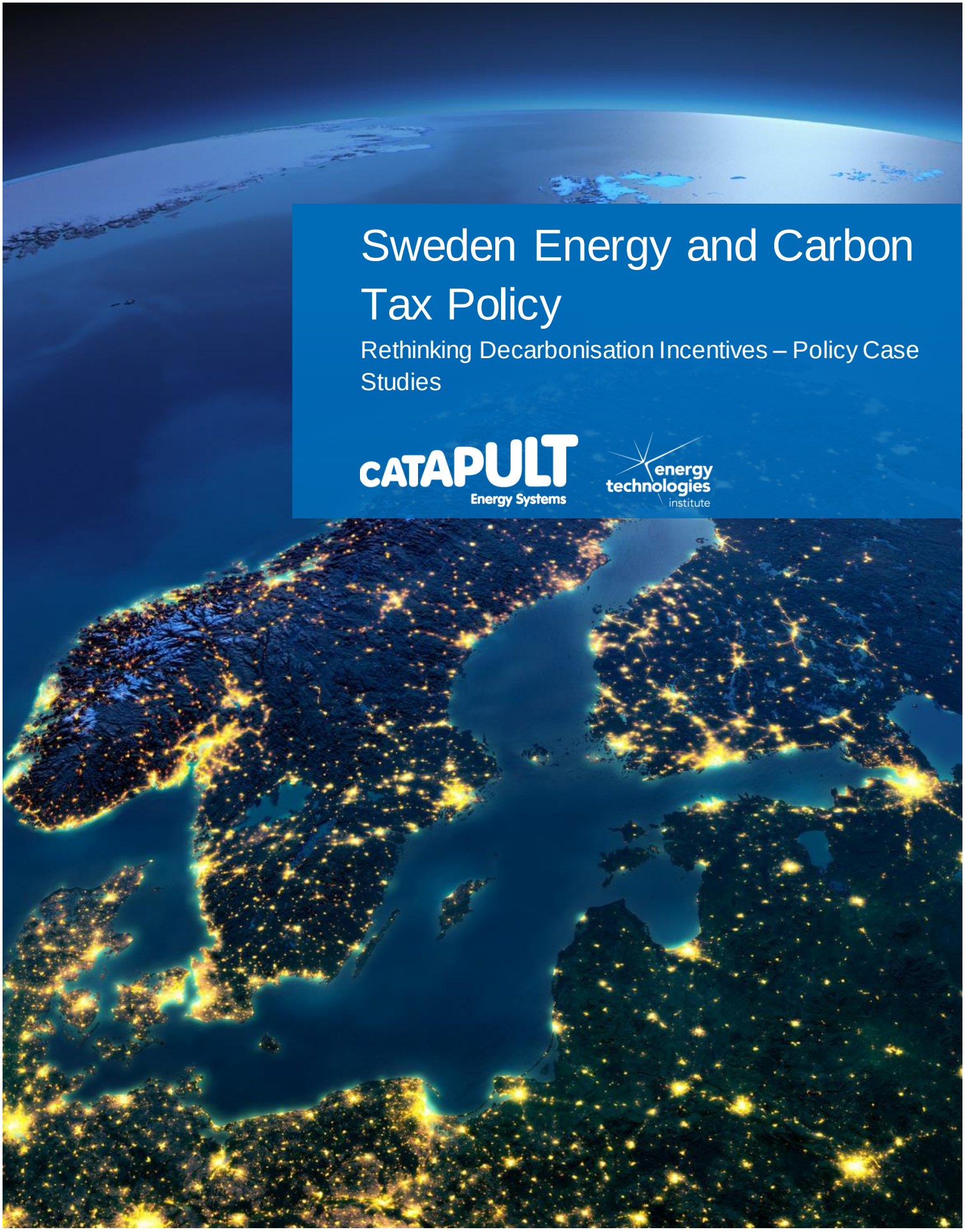

Sweden Energy and Carbon Tax Policy

Rethinking Decarbonisation Incentives – Policy Case Studies

CATAPULT Energy Systems

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Sweden Energy and Carbon Tax Policy

This case study has been developed for the UK's Energy Systems Catapult under the *Rethinking Decarbonisation Incentives* project, aiming to draw lessons from international experience of policies to improve the framework of economic drivers for decarbonisation in the UK.

Sweden's longstanding energy and carbon taxation policy has been through numerous evolutions in its lifetime. Since it covers all fuel consuming sectors in the Swedish economy including electricity consumption, the treatment of different sectors under the policy will be instructive for the UK. Sweden's policies were also heavily influenced by EU regulations such as the minimum tax directive for electricity use and the Emissions Trading System (ETS), so provide an example of how these interactions can be treated.

This case study explores the evolution of the tax policy and key drivers behind this, including whether policy makers were able to achieve consistency in the decarbonisation price signal between sectors and the rationale for any deviations. In addition, the government's measures to maintain political, commercial and public acceptance of the policy are explored. Finally, the issue of the tax policy's interaction with complementary policies is also examined, including attempts to harmonise in areas of overlap.

Key findings

- The simple design of the Swedish tax enabled an efficient implementation and consistent application. The use of common units for denomination of tax rates and reducing the need for monitoring, reporting and verifying (MRV) through carbon content calculation, has drastically reduced administration costs and allowed a broad consistent application.
- Although significant exemptions were granted to certain industries, these sought to reduce policy duplication and protect competitiveness, and ultimately achieved environmental targets. In the period of 2005-2011, industries were subject to the EU ETS, carbon tax and electricity tax. As such, only 20% of the carbon tax rate applied to industries. In the final decade of the carbon tax, when the industry rate remained at approximately 20€/tCO_2e, while for remaining sectors this was ramped up from 40-120€/tCO_2e.
- Further deviations to a uniform application were granted based on geographical variation, motivated by social equity priorities. Sweden displays geographic variations in tax rates, suggesting a progressive approach to achieving equity amongst price signals.
- The tax has been successful in driving demand for alternatives fuels, and the UK can learn in particular from the success in the residential sector. Promoting biomass use for residential and commercial heating as Sweden has done, could be an alternative and more effective policy to CHP investment in the UK.
- While Sweden's tax rates are the highest in the world, political acceptance has remained high since environmental concerns are a priority and significant discounts have been granted to industry avoiding adverse economic impacts.

Abbreviations

ETS	Emissions trading scheme
GDP	Gross domestic product
SEK	Swedish krona
PFE	Programme for energy efficiency in energy industry
GHG	Greenhouse gases
MRV	Monitoring, reporting and verification
CHP	Combined heat power

Nomenclature

tCO_2e	Tonnes of carbon dioxide equivalent
$MtCO_2e$	Million tonnes of carbon dioxide equivalent
kWh	Kilowatt hour
TWh/yr	Terawatt-hour per year

Policy overview

Policy narrative

Sweden's carbon tax was introduced following a heightened social and political awareness of environmental issues and the need to further economise the use of fossil fuels following the 1970s oil crisis. Sweden was one of the first countries to introduce a carbon tax (1991) and the drive to reduce CO_2 emissions was not an international obligation but rather a political directive of Sweden's commitment to being more environmentally friendly. Its joining of the EU in 1995 meant Sweden introduced further changes to its energy and carbon rates due to EU regulatory requirements. Subsequent policy changes were therefore made as a result of the EU policy affecting electricity prices for industrials and the EUETS.

Coverage, obligated entities and eligibility

Figure 1 shows the total emissions in Sweden in 2014 (note that net land-use change and forestry emissions are excluded). The current carbon tax applies to all energy based emissions in Sweden, which was equivalent to 77% of total emissions in 2014. It is placed upstream on the supply of fossil fuels by the fuel and energy industries. In particular, industries supplying natural gas, gasoline, coal, fuel oil, liquefied petroleum gas and home heating oil are covered. However, with an already existing energy tax, some downstream sectors were compelled to pay only part (25-50%) of the carbon tax. These included: manufacturing, agriculture, co-generation plants, forestry, aquaculture. The residential and service sectors are fully covered by the carbon tax.

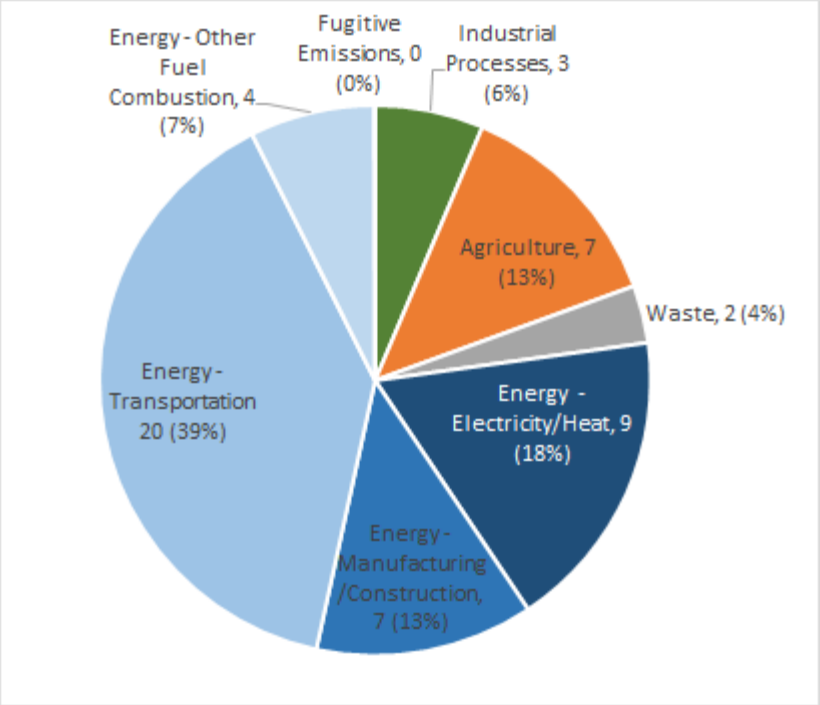


Figure 1 Total GHG emissions in Sweden 2014 ($MtCO_2e$)[1]

Currently, electricity production is exempt from both the carbon and energy tax and until 2005 industrial electricity consumption was also exempt. The reason for the exemption was simply because Sweden relies very little on fossil fuels for electricity production (Table 1). Therefore, the emissions produced from fossil fuels are relatively insignificant (~4% of total CO_2 emissions in 2014) and therefore a decarbonisation price signal would have little impact on overall CO_2 reductions but nevertheless would incur costs for electricity producers.

[1] Based on CAIT Climate Data Explorer data. 2017. Washington, DC: World Resources Institute. Available online at: http://cait.wri.org

Table 1 Electricity production by type from 1990 to 2015[2]

Electricity production in Sweden (TWh) *production not hydro, nuclear or wind (e.g. fossil)					
Year	**Produced**	**Hydro**	**Nuclear**	**Wind**	**Other***
1990	142	71	65	0	5
1991	142	62	73	0	7
2005	154	72	70	0.9	12
2010	145	66	56	3.5	19
2011	148	68	58	6.1	17
2012	162	78	61	7.2	16
2013	150	61	64	9.9	15
2014	151	64	62	12	13
2015	159	74	55	17	14

Mechanism and economic incentive

As Table 3 will show, the applicable tax rate is based on the carbon content of the fuel, and therefore proportional to the volume of emissions produced. The tax rate varies by sector, and during the carbon tax's history, exemptions and reductions have been made to allow energy intensive industries to remain economically competitive. Up until 2011 companies who fell under the EU ETS were still obligated to pay some of the carbon tax. After a reform in 2011 those companies that fell under the EU ETS were no longer obligated to pay any carbon tax.

Compliance

The carbon tax is administered in the same way as the energy tax and follows the existing tax reporting and collection system in Sweden. Fossil fuel suppliers report their emissions to the tax authorities on an annual basis, and pay the associated tax rate per volume of emissions. Compliance is further ensured through the enforcement of tax evasion regulation.

Institutional set-up

The Swedish Ministry of Finance determine the tax rates, exemptions, reductions and the dates of implementation and policy changes. New environmental laws such as taxes involve all political parties and follow a standard parliamentary process and timescale. Typically, it can take one year from proposal to approval. The enactment of new taxes involves stakeholder engagement and public consultation to address commercial and private concerns. Additionally, close cooperation with the ministries of Industry, Transport, Agriculture and Environment is maintained.

Effectiveness and cost effectiveness

Sweden has seen a general reduction in emissions from 1990 that exceeds its Kyoto protocol goals, alongside strong growth in GDP over the same period. In 2017 revenue gained from the carbon tax was EUR 2.40billion alone and combined with the energy tax represented 1.5% of GDP[3]. The introduction of the tax also greatly increased the use of biomass for district heating which amounts to 60% of Sweden's heating demands. The carbon tax is considered the key driver behind the reduction in emissions and is considered an economic and environmental success.

[2] Swedish Energy Agency, 2015. 'Energy in Sweden 2015'.

[3] Susanne Åkerfeldt, The Benefits of a Carbon Tax - Swedish experiences and a focus on developing countries (2017) A PowerPoints published by the Ministry of Finance, Sweden. P.25

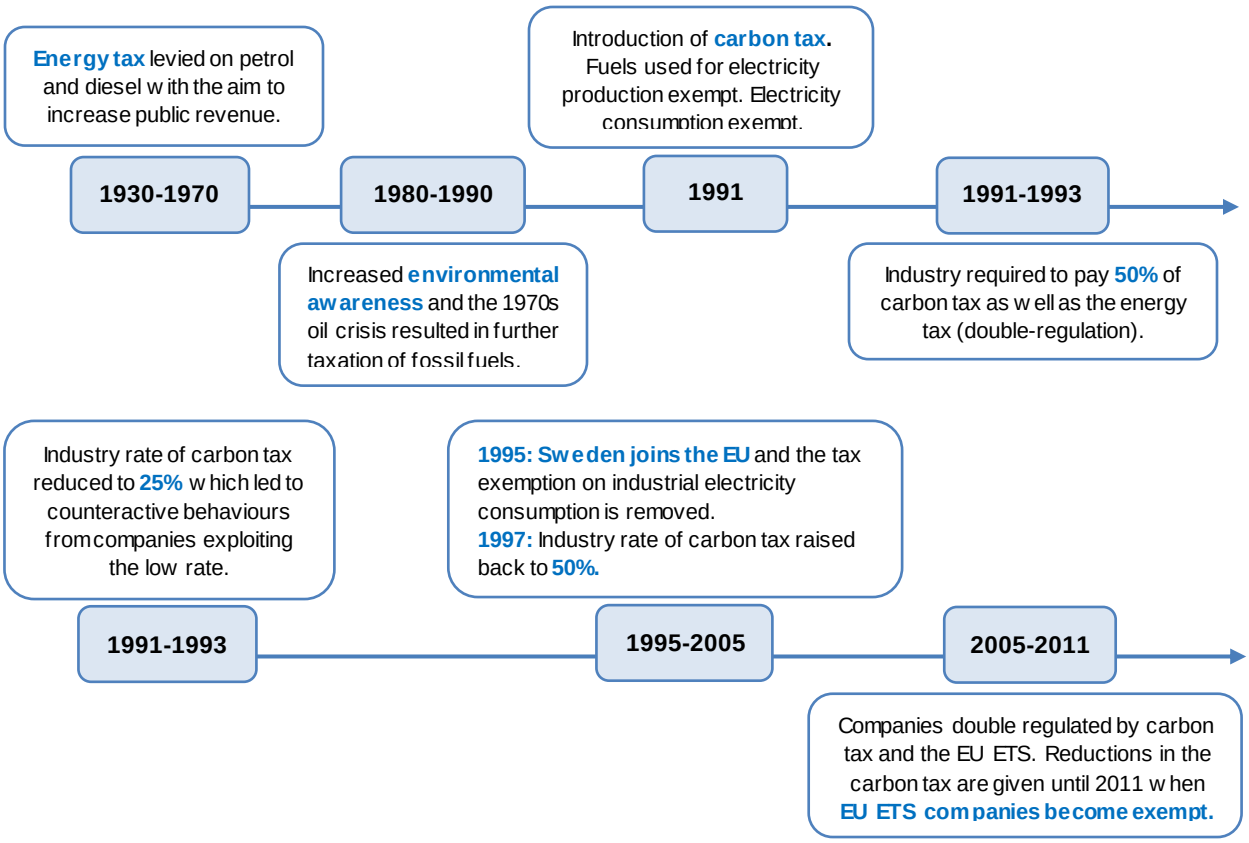
Evolution of the tax

Sweden's energy tax (Box 1) has existed since the 1930s and, amongst other reasons, was introduced to incentivise energy efficiency. A carbon tax was introduced more recently in 1991. As a longstanding regime it has been through a number of different iterations. The tax is placed upstream on the supply of fossil fuels to end consumers in any sector. However, a number of exemptions to the tax have been granted at different points in its history and for differing reasons, leading to variability in is application across all covered sectors. In most cases these deviations are due to the government's desire to avoid duplication of the decarbonisation price signal which was created by the overlap of similar policies. The section below presents the timeline of the evolution of the tax, with a visual overview is resented in Figure 2.

Box 1 – Energy tax explained

Introduced in the 1930s and originally only applying to petrol and diesel, the **energy tax** now applies to oil products (diesel and petrol), coal, coke and natural gas. The tax rate for each product varies in proportion to its energy content, but is also dependent on its use. Economic sectors affected include road transport, industry, agriculture and fishing, residential and commercial. Out of each sector the road sector is taxed at the highest rate. The electricity sector has a more complex relationship with the energy tax. Although fuels used in electricity **production** are untaxed, in 2005 a minimum electricity tax rate of SEK 0.005 per kWh (approx. 0.0005 EUR per kWh)[4] **consumed** was introduced to comply with EU legislation (minimum tax directive 2003/96/EC).

Figure 2 Timeline overview of key energy and carbon tax events



[4] 2005 average annual exchange rate 10.387 SEK:EUR, retrieved: www.fx-exchange.com

1930 - 1970: Sweden's energy taxation system has existed for a relatively long time but its purpose has changed in response to contemporary issues. Firstly, an energy tax in the form of a levy on petrol and diesel has existed from the 1930s, with fossil fuels such as fuel oil and coal as well as electricity following suit in the 1950s. Up until the 1970s there existed only the energy tax to increase public revenue. However, the 1970s oil crisis resulted in a further need discourage fossil fuel product use, to provide greater long-term energy security, so energy taxes were increased.

1980 - 1990: It wasn't until the 1980s when environmental awareness increased and there was a greater need to economise the use of fossil fuels, that further tax reforms were introduced. Environmental policy ranked high on Sweden's political agenda and was often used as an instrument to achieve policy objectives; including various energy tax changes and increased levels to achieve greater energy efficiency. Fossil fuel use in industry was already low following the 1970s oil taxation and these further tax reforms resulted in companies being encouraged to use less and less.

1991 - 1993: The introduction of carbon tax in 1991 aimed to send a price signal to reduce emissions of CO_2 by taxing certain industries at a rate per tonne of carbon dioxide emitted. However, the new carbon tax resulted in double-regulation of already highly taxed fossil fuel industries who fell under both the energy and carbon tax regulations (Table 2). This greatly impacted the competitiveness of energy intensive fossil fuel industries such as: pulp and paper, non-ferrous mineral products, basic chemicals, mining and quarrying and basic metals. Therefore, the industry sector became exempt from paying the energy tax and was only required to pay 50% of the carbon tax, to reduce double-regulation and create a more consistent environmental price signal. This requirement to pay the carbon tax was further reduced to 25% in 1993. Contrary to the purpose of the carbon tax, this additional reduction resulted in increased carbon emissions, as energy intensive industries exploited the reduced tax rates.

Table 2 Disparity in carbon taxation following the immediate introduction of the 1991 carbon tax[5]

Fully covered by the carbon tax and energy tax	Covered by the carbon tax	Excluded or exempt from the carbon and energy tax
Fuels and energy vectors	Fuel oil Natural gas Liquefied petroleum gas Gasoline Home heating oil Coal	Electricity production
Consumers	Residential Service sector Transport	Manufacturing Agriculture Co-generation plants Forestry Aquaculture

1993-1997: The reduction in carbon tax in 1993 caused actual emission reductions to be less than projected and further inconsistencies in the tax reform resulted in companies behaving counteractively to the goal of reducing CO_2 emissions. When the carbon tax was introduced in 1991 the fossil fuel energy suppliers accounted for a relatively small amount of Swedish energy supply (~30%; Figure 3). This was due to its discouraged use as a result of environmental tax policy. However, after the additional tax reform in 1993 (reduction in carbon tax to 25%) the tax level for industrial energy using companies

[5] Table adapted from Wang and Maya, Towards a Workable and Effective Climate Regime, Chapter 19: Taxing carbon: Current state of play and prospects for future developments (2015), World Bank, p. 271 and Sumner, Jenny, Bird, Lori and Smith, Hillary, 2013. 'Carbon Taxes: A Review of Experience and Policy Design Considerations'(2013), National Renewable Energy Laboratory, p.11.

was much lower than the level for energy use in the district heating sector, leading to an overall increase in fossil fuel consumption (industry behaviour contrary to the tax's purpose). Certain industry companies would themselves burn fossil fuel and then sell their by-products to district heating companies. The result was a lower reduction in CO_2 emissions than originally intended.

Consequently, the tax rate for carbon was increased back to 50% in 1997 to retain more consistency across sectors and promote investment in energy efficient technology. It is important to note that this tax reform period did not involve an increase in overall CO_2 emissions compared with 1991, but rather a lesser reduction in CO_2 emissions overall.

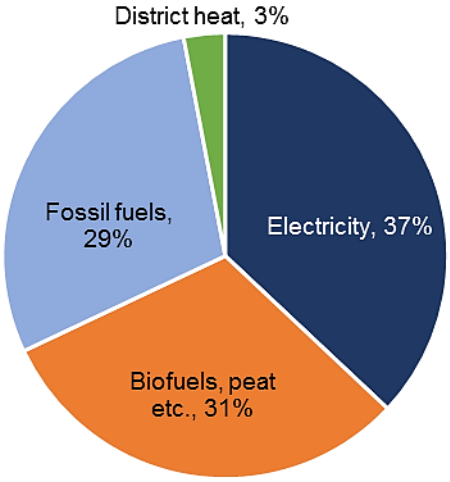


Figure 3 Proportion of energy use in Swedish Industry[6]

1995-2005: The joining of the EU in 1995 introduced new EU laws and requirements for tax levels. Most significantly was the introduction of the minimum tax directive (2003/96/EC) in 2004, which now meant industrial electricity use would be charged at a rate of SEK 0.005 per kWh (approx. 0.0005 EUR per kWh)[7]. The government responded to this tax increase by introducing the Program for energy efficiency in energy industry (PFE) in 2005 (see Box 2).

Box 2 - Overview of Sweden's the Program for energy efficiency in energy industry

The **PFE** was introduced in 2005. Companies participating in the five-year voluntary programme can receive a full rebate of the energy tax on electricity consumption. In return, they undertake an energy management system within the first two years and to perform an energy audit to determine potentials for improving the efficiency of their energy use. Within the five-year cycle, companies must apply all the energy efficiency improvement measures that have been identified, and which have a payback time of less than three years.

2005-2011: The EU ETS sets a cap for emissions from major energy intensive industries and other thermal plant. Liable companies must acquire tradable allowances equal to what they emit, the price of which is dependent on the system marginal cost of meeting the overall emissions cap. Therefore, there is an incentive to remain under the cap by emitting less Greenhouse Gases (GHG). However, some industrial fossil fuel combusting companies fell under the EU ETS, the carbon tax and the SEK 0.005/kWh electricity rate (approx. 0.0005 EUR per kWh)[8], resulting in three overlapping regulations between 2005 and 2011 (Figure 4). The response was therefore to further reduce the carbon tax on

[6] Graph reproduced from Swedish National Energy Administration. Energy in Sweden (1999a). Eskilstuna, Sweden. p.2
[7] 2005 average annual exchange rate 10.387 SEK:EUR, retrieved: www.fx-exchange.com
[8] 2005 average annual exchange rate 10.387 SEK:EUR, retrieved: www.fx-exchange.com

certain industries to approx. 20% of the overall level, to maintain competitiveness, and to maintain the PFE program for qualifying companies. During this time, the industrial sectors faced a carbon tax in Sweden of approximately 20€/tCO_2e[9], as well as EU ETS costs, which ranged from 13-23€/tCO_2e in this period. Nevertheless, even the PFE qualifying companies continued to be over-regulated, until 2011 when the government removed the carbon tax on EU ETS industries completely.

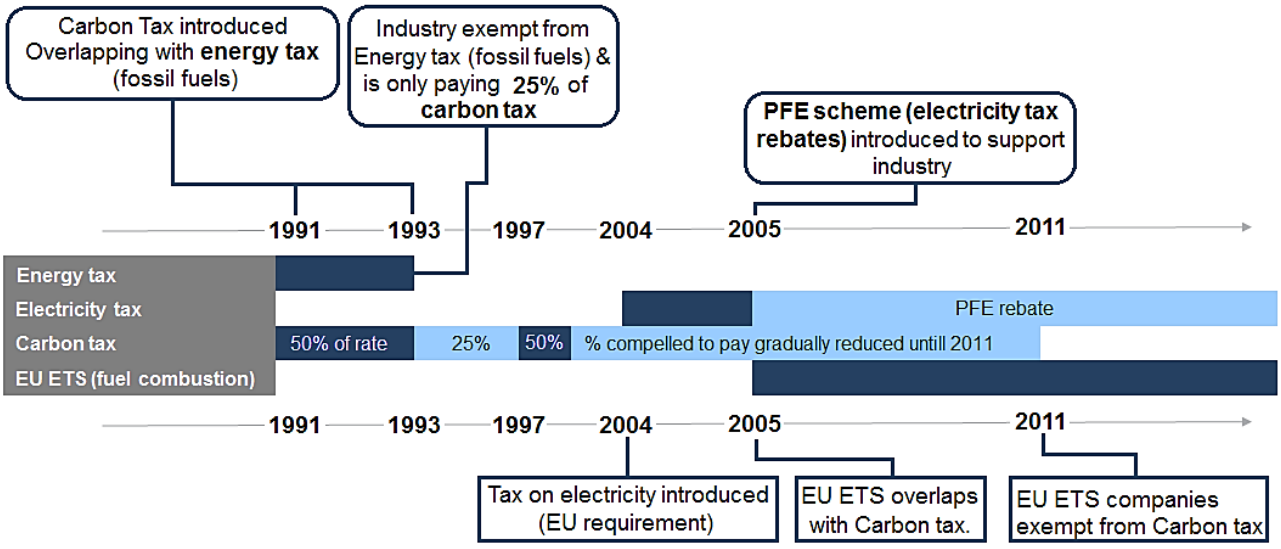


Figure 4 Overlapping energy and carbon policies faced by industrial entities in Sweden 1991 to the present

Current tax system

Simple design for efficient implementation

As previously stated, for simplicity of implementation Sweden's carbon tax regime was applied upstream on the supply of fossil fuels. While a restricted number of upstream entities need to be administered, the tax achieves a broad sectoral coverage as the price signal is passed to downstream consumers. As of 2017 90% of Sweden's carbon emissions from fossil fuels is covered either by the carbon tax or the EU ETS.

Sweden's tax regime shows that a carbon tax can be easy to administer with minimal costs to the operators and tax authorities, where an already existing and similar energy tax regime exists. Therefore, the carbon tax is largely administered in the same way as the energy tax and utilises its existing revenue collection system (e.g. duties on fuels). Further reductions in costs are obtained from using common units for denomination (volume or weight) for tax rates in Swedish tax law. This allows comparisons to be made between different policies, so price signals can be compared and reformed if needed. This efficient design means that the total costs of administering both energy and carbon tax represent 0.1% of the total generated revenue[10].

Tax rate: variations and their efficiency

[9] The Benefits of a Carbon Tax - Swedish experiences and a focus on developing countries (2017) A PowerPoints published by the Ministry of Finance, Sweden. P. 12

[10] Fedrigo-Fazio, D., Withana, S. Hirschnitz-Garbers, M., and Gradmann, A. (2013). Steps towards greening in the EU, Monitoring Member States achievements in selected environmental policy areas - EU summary report, prepared for DG Environment. Brussels.

Table 3 shows the energy and carbon tax rates for Sweden in 2015, showing variations in tax rate by fuel type. As explained previously, from 2011 industrial sectors with EU ETS obligations have been exempt from the carbon tax, to avoid double regulation across the two systems.

Additional variations in the tax rates exist, depending on the sector (e.g. households or industry) and even the geographical location of the consumer. Table 3 shows that the general electricity tax in Sweden amounted to 0.294 SEK/kWh in 2015 while at the same time in Northern Sweden the amount was 0.194 SEK/kWh (approx. 0.03 and 0.02 EUR per KWh respectively)[11]. This variation in tax could be surmised to represent the differences in climate between North and South Sweden and so a lower rate is applied to those who have to consume more electricity for heating.

Table 3 Selected energy and carbon dioxide taxes as of 1 January 2015[12][13]

Fuel	Energy tax	CO_2 tax
Fuel oil, diesel heating oil, SEK/m^3	850	3,218
Coal, SEK/tonne	646	2,800
Natural gas as vehicle fuel, SEK/1000 m^3	0	2,049
Natural gas for other purposes, SEK/1000 m^3	939	2,313
Petrol, environmental class 1, SEK/litre	3.25	2.6
Electricity, general level, SEK/kWh	0.294	0
Electricity, general level, Northern Sweden, SEK/kWh	0.194	0
Electricity, industrial processes, SEK/kWh	0.005	0

Political acceptance and effectiveness

Since its introduction in 1991 at a rate of approximately equivalent to 27€/tCO_2e[14], the tax rate for carbon dioxide emitted in Sweden has risen by 500% and is one of the highest carbon tax rates in the world at €137 per tonne in 2012[15]. During this time, industry exemptions from the carbon tax have ranged from 25-50%. The difference in treatment of sectors is particularly notable in the decade to 2011, when the industry rate remained at approximately 20€/tCO_2e[16], while for other sectors this was ramped up from 40 to 120€/tCO_2e. When the carbon tax was removed for industry in 2011, the difference was heightened further, as average annual EU ETS prices have ranged from 5-8€/tCO_2e in this period.

This increases in tax rates were implemented in a relatively gradual manner and as such made it economically (for the tax bearers) and politically feasible. To keep a stable and predictable price signal, a step-by-step approach (increases followed by plateaus) in the tax rate allows businesses and households a grace period to adapt; especially lower income households whose energy and fuel prices represent a larger proportion of their annual income.

[11] 2015 average annual exchange rate 9.3563 SEK:EUR, retrieved: www.fx-exchange.com
[12] Energy Efficiency Trends and Policies report under the EU's Odyssee MURE II programme (SEA, 2015a).
[13] EUR values can be estimated by using 2015 average annual exchange rate 9.3563 SEK:EUR, retrieved: www.fx-exchange.com
[14] The Benefits of a Carbon Tax - Swedish experiences and a focus on developing countries (2017) A PowerPoints published by the Ministry of Finance, Sweden. P. 12
[15] World Bank, State and Trends of Carbon Pricing, 2017 Susanne Åkerfeldt
[16] The Benefits of a Carbon Tax - Swedish experiences and a focus on developing countries (2017) A PowerPoints published by the Ministry of Finance, Sweden. P. 12

The Swedish government and citizens have consistently supported the presence of a carbon tax because it has lowered emissions while not impacting the overall economy. Together the energy and carbon tax represented 1.5% of GDP in 2017 (Table 4) and since 1995 Sweden's GDP has continued to growth while CO_2 emissions have fallen. The carbon price revenue is used primarily for the central government budget and it is unclear on whether any is recycled for greater emission reductions.

The reduction in total CO_2 emissions post-implementation (1990-2005) of the carbon tax is estimated to be around 10.9% (2.5 million metric tons of CO_2). The tax can be considered an effective price signal as it has reduced the dependency on fossil fuels for transport and moved towards using electrically powered alternatives.

Table 4 Comparison of revenue generated between the energy and carbon taxes[17].

	Revenues Billion € 2017
A. Energy tax	**4.79**
- electricity	2.39
- petrol	1.21
- other fossil fuels than petrol	1.20
B. Carbon tax	**2.40**
- petrol	0.81
- other fossil fuels than petrol	1.59
Total of both energy and carbon tax	**7.19**

The encouragement of greener energy production and consumption is fundamental to the efficiency of environmental taxation in Sweden. Greener energy production and use are taxed at a far lower rate than conventional sources that achieve the same end and so represent tax efficient options. One of the more obvious effects of the introduction of carbon taxes in the 1990s is the rapid increase in biomass use for heating (Figure 5). Biomass is exempt from carbon and energy taxes and so there is an incentive to use biomass over other fuel sources such as oil or coal.

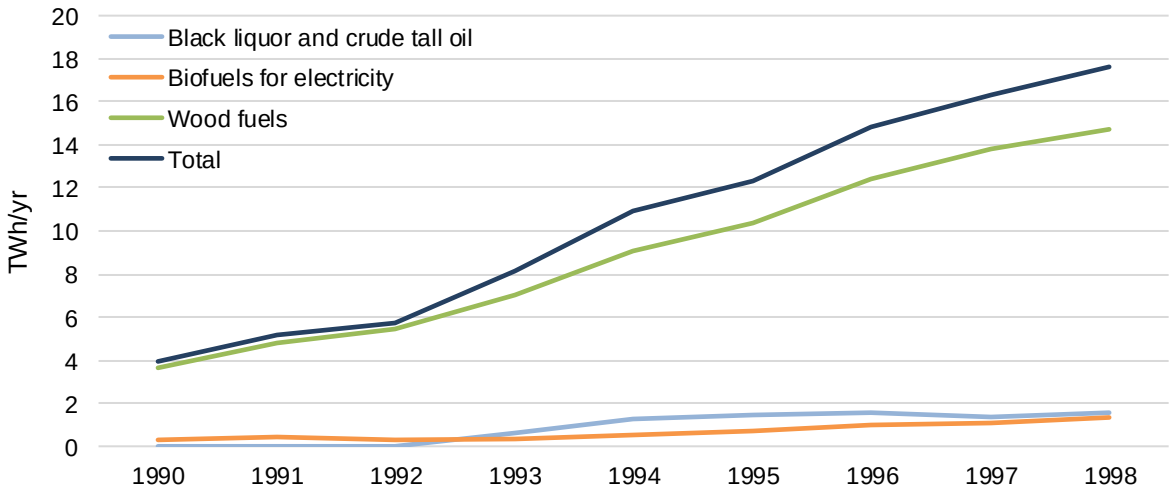


Figure 5 Changes in demands for fuel type of the district heating sector[16]

[17] Susanne Åkerfeldt, The Benefits of a Carbon Tax - Swedish experiences and a focus on developing countries (2017) A PowerPoints published by the Ministry of Finance, Sweden. P. 25

[16] Reproduced from Johansson, Bengt (2000). Economic Instruments in Practice 1: Carbon Tax in Sweden.

Political acceptance and the government's response

Sweden was one of the first countries to implement a carbon tax and so there was little precedent in terms of political acceptance or public response. The social democrat party were first to suggest the tax in 1988 and a social democrat led government signed the carbon tax into law in 1990[18]. However, despite the environmental motivations, the 1991 conservative led government raised concerns over the international competitiveness of Sweden's industry and the impacts it might have on the domestic recession that it was experiencing. As a result, the industry rate of carbon tax was lowered to 25%[19]. However, after the 'great' tax reform between 1993-1997 the carbon tax rate started to gradually increase every year alongside new greener tax reforms. This period marked a general increase in acceptance of the need to address environmental concerns and so new policies were passed.

The Swedish tax law system involves stakeholder engagement and public consultation and therefore both commercial and private concerns can be addressed. An example of this was in 1996 when tax rates for electricity increased, and further increases were planned for 1997. The proposal faced strong objection citing the potential strain on the competitiveness of manufacturing companies. Therefore, the proposal was replaced with higher taxes on electricity and fossil fuels not used in industry, illustrating a direct response to concerns raised through stakeholder engagement.

Additionally, while not without any opposition, the long standing public acceptance of continuous increases in tax is also in part attributed to Sweden having no fossil fuel resources of its own. Without a large fossil fuel production industry and the associated jobs, tax increase on their use has remained far less controversial than in countries for which the sector plays a larger part in the economy.

Key findings

The simple design of the tax enabled an efficient implementation and consistent application. As an upstream tax placed on all fuels and electricity consumed in the country, it has an economy wide impact, which is a key advantage of upstream regulation. Further, monitoring, reporting and verifying (MRV) costs were kept down since the tax is applied to fossil fuels based on their carbon content, and using emission factors, CO_2 emissions can be estimated based on fuel consumption rather than measuring emissions emitted downstream. In addition, administrative costs were relatively low as the tax made use of existing institutional infrastructure. Finally, the use of common units for denomination (volume or weight) for tax rates in Swedish allows comparisons to be made between different policies, so price signals can be compared and reformed if needed.

Although significant exemptions were granted to certain industries, these sought to reduce policy duplication and protect competitiveness, and ultimately achieved environmental targets. Significant deviations from uniform pricing signal were required as a result of the need to protect industrial competitiveness and avoid policy overlaps. In the period of 2005-2011 for example, industries were subject to the EU ETS, carbon tax and electricity tax. As such, only 20% of the carbon tax rate applied to industries, and in addition they could still have a rebate from the electricity tax through the PFE. In 2011, the carbon tax was removed as this was considered too burdensome to industry given the direct overlap with the EU ETS. This has means however that a significant discrepancy in the rates of the carbon tax between industrial and non-industrial sectors. The discrepancy is particularly notable in the final decade of the carbon tax, when the industry rate remained at approximately 20€/tCO_2e, while for remaining sectors this was ramped up from 40-120€/tCO_2e. Therefore, reforms were made to keep certain sectors competitive, so as not to negatively impact Sweden's industrial economy. The UK adopts a similar approach with regard to keeping businesses

[18] Andersson, J. (2017). Grantham Research Institute on Climate Change and the Environment. Cars, carbon taxes and CO2 emissions. P.7
[19] Ericsson, K., (2009). Introduction and development of the Swedish district heating systems Critical factors and lessons learned. P.46

internationally competitive as it imposes lighter taxes on electricity usage in larger businesses. However, Sweden has proved that while reducing carbon emissions, maintaining a stable national economy is also possible through exemptions and reductions to keep industries internationally competitive.

Further deviations to a uniform application were granted based on geographical variation and motivated by social equity priorities. Variations (such as geographic) suggest an attempt to achieve greater equity between households based on energy consumed. These variations in price signals seem to have done little to hinder Sweden's reductions in CO_2 and increase in GDP, and lean towards more a progressive tax system.

The tax has been successful in driving demand for alternatives fuels, and the UK can learn in particular from the success in the residential sector. As a result of decarbonising price signals certain sectors have seen a great increase in alternative fuel use. This is a huge step towards reducing climate change and is one of the more obvious results of the implementation of a carbon tax in Sweden. The main change in alternative fuel use is from Sweden's district heating sector which accounts for 60% of Sweden's heating demand. In the UK and Sweden the residential sector accounts for a large source of emissions and so in Sweden it is not exempt from the carbon tax. As a result of this decarbonising price signal there has been a great increase in the demand for biomass as a fuel for use in the district heating sector, greatly reducing emissions. The UK's residential sector appears to be under taxed and it offers reduced tax rates for Combined Heat Power facilities (CHP). Promoting biomass use for residential and commercial heating as Sweden has done, could be an alternative and more effective policy to CHP investment in the UK. Additionally, decarbonising price signals in the transport sector has promoted alternatively powered transport such as electric, reducing CO_2 emissions from the largest contributor.

While Sweden's tax rates are the highest in the world, political acceptance has remained high since environmental concerns are a priority and significant discounts have been granted to industry avoiding adverse economic impacts. Since its introduction in 1991 the tax rate for carbon dioxide emitted has risen by 500% and is one of the highest carbon tax rates in the world at EUR 137 per tonne. This increase was implemented in a relatively gradual manner, using a predictably a step-by-step approach (increases followed by plateaus), allowing businesses and households a grace period to adapt. The Swedish government and citizens have consistently supported the presence of a carbon tax because it has lowered emissions while not impacting the overall economy. As mentioned above, significant discounts have been given to industry throughout. Both the energy and carbon tax represented 1.5% of GDP in 2017 (Table 2) and since 1995 Sweden's GDP has continued to grow while emission of CO_2 have fallen. However, the longstanding acceptance is also partially part attributed to Sweden having no fossil fuel industry of its own.

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