NO_x and SO_2 taxes[1] in Sweden[i]

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Brief summary of the case

With marginal tax levels surpassing 80% in the late 1980s there was political will in Sweden to reduce income taxes without incurring too large a budget deficit (Sterner, 1994). Additionally, during the 1980s there was an increased focus in Swedish society on environmental problems, for example soil acidification. In 1989, an Environmental Tax Commission with broad involvement of different stakeholders proposed an environmental tax reform that led *inter alia* to the introduction of a sulphur tax (1991) and a NO_x tax (1992) after a hearing process with affected stakeholders. Both taxes are designed with reimbursement mechanisms to the regulated entities. The taxes have contributed substantially to a rapid decline in Swedish NO_x and sulphur emissions.

1 Description of the design, scope and effectiveness of the instruments

1.1 Design of the instruments

For decades, Sweden has regulated emissions of pollutants which contribute to acid rain - mainly sulphur and nitrogen (OECD, 2013).

Simultaneously with the introduction of a CO_2 tax primo 1991, Sweden introduced a sulphur tax, levied on the fuels with the highest sulphur content. The aim was to reduce SO_2 emissions from combustion of peat, coal, coke and other solid fuels or gaseous products (SEPA and SEA, 2006). Since the introduction of the tax 25 years ago, the rates have remained unchanged at SEK 30/kg sulphur (€ 3,0 – November 2016 prices) for solid fuels and SEK 27/kg (€ 2,7 – November 2016 prices) for each thousandth of sulphur content by weight in oils (OECD, 2014). Fuels with sulphur content below 0.05% by weight are exempted from the tax. The following are also exempted: fuels for production of lime, stone and cement, fuels used in boilers for recovering soda in forestry, diesel and fuel oils in shipping and trains, and aviation fuels. If SO_2 emissions are reduced through cleaning or binding to the ash, a part of the tax proportionate with the saved amount of SO_2 emissions is reimbursed (SEPA and SEA, 2006).

In 1992, the year after the introduction of the sulphur tax, a tax on NO_x emissions from stationary combustion facilities was introduced. The primary aim of the tax was to provide incentives to reduce emissions beyond the limit values, to combat acidification (OECD, 2014). The tax was applied to energy produced for space heating, electricity production and industrial processes – all uses are covered whether production is for power and heat production, waste incineration, metal manufacturing, pulp and paper, food and wood industry or chemical production etc. (SEPA and SEA, 2006; OECD, 2013). From the start, the tax was imposed on all combustion plants with a minimum input of 10 MW/year and generating more than 50 GWh/year of so-called 'useful energy'[2]. In 1996, the effect limit was

[1] In the literature, there is some disagreement whether the Swedish NOx tax is a charge or a tax. Based on the OECD definition (OECD 2001), the terms sulphur tax and NOx tax are used in this analysis.

[2] OECD (2013) describes 'useful energy produced' as a relevant and neutral yardstick for measuring output from this heterogeneous group of industries since the main goal is to affect combustion technologies. For power

removed and the GWh/year limit was lowered to 40. In 1997, it was further lowered to 25 GWh/year (SEPA and SEA, 2006). Initially, the tax rate was SEK 40/kg NO_x (ECU 5,4 - 1993 prices) emitted for all types of fuel[3] (SEPA, 1997). In 2008, the rate was raised to 50 SEK/kg (€ 5,3 - 2008 prices) (SEPA, 2012[4]). The total revenue (minus administrative costs) is reimbursed to the group of taxed plants to reduce any potentially negative impact on competitiveness. The reimbursement mechanism is based on how energy efficient the plants are. According to the OECD (2013): "This means that firms emitting low volumes of NO_x per unit of energy produced are net beneficiaries of the scheme – only firms with large NO_x emissions per energy unit are net tax payers" (see also OECD, 2014; SEPA, 1997). The reimbursement mechanism means that the distortion between the group of companies covered by the tax and those companies exempted from the tax is avoided. The system is based on mandatory continuous monitoring of NO_x emissions. Initially approximately 200 companies were regulated by the tax, with around 400 regulated from 1997, where the GW/year limit was lowered (OECD, 2013).

1.2 Drivers and barriers of the instrument

With marginal tax levels surpassing 80% in the late 1980s there was a political will in Sweden to reduce income taxes without incurring too large a budget deficit (Sterner, 1994). Additionally, during the 1980s there was an increased focus in Swedish society on environmental problems, exemplified by the establishment of a Green Party in 1981 (Lundqvist, 1996), by a government (Social Democratic Party taking office in 1982) that was more interested in cooperating with environmental organisations than previous governments (Rothstein, 1992), and by public concern for e.g. climate change problems as early as the mid-1980s (Guardian, 2008). Major events in the marine environment also attracted attention (Sterner, 1994) and soil acidification too became a major political issue in Sweden in the 1980s; Sweden is more sensitive to acid deposition than most other countries due to naturally acidic soils (OECD, 2013; interviewee 1). The Left Party and the Green Party proposed the introduction of environmental taxes in 1985 (TT Nyhetsbyrån 1985a; 1985b). For a number of years before 1985, environmental taxes had also been discussed in the Swedish Environmental Protection Agency where the focus was on designing effective taxes with a high acceptance in civil society (interviewee 1). In 1985, the Swedish Parliament adopted a strategy to reduce NO_x emissions by 30% between 1985 and 1995 (OECD, 2013). In 1988, the Swedish Parliament decided to reduce sulphur emissions by 65% between 1980 and 1995, and by 80% between 1980 and 2000 (Swedish Government, 1989a). In the 1988 election campaign environmental issues were entirely dominant and the Green Party became the first new party in 70 years to break into the Swedish party system (Lundqvist, 1996; Sterner, 1994).

The year before, in 1987, an Environmental Tax Commission (ETC) was initiated and started analysing a possible introduction of environmental taxes. In accordance with a Swedish tradition for broad involvement of stakeholder interests, the ETC involved politicians,

plants and district heating plants it is equal to the energy sold. For other industries, the energy is defined as steam, hot water or electricity produced in the boiler and used in production processes or heating of factory buildings" (Sterner and Höglund-Isaksson, 2006).

[3] The tax level corresponds to USD 6,000/tonne, which is much higher than the US programmes for NO_x permits (Sterner and Höglund-Isaksson, 2006 cited in OECD, 2013).

[4] OECD (2014) refers the introduction year as being 2009.

bureaucrats, and experts from different interest groups, and the proposals went through a public hearing process (Pedersen, 2000). This type of investigative commission, with broad representation of interests, is in general an important tool in Swedish politics for producing consensual policy proposals (Lundqvist, 1996). Two years later, the ETC proposed specific environmental taxes on e.g. CO_2, NO_x, SO_2 and chlorine (Swedish Government, 1989a; 1989b). Following recommendations from the ETC, Sweden was one of the first countries in the world to take the first steps towards an environmental tax reform (ETR) as part of a large 1990/91 tax reform, even before the concept of ETR found common ground (Swedish Government, 2005). The most highlighted (and contested) part of the reform was probably the introduction of a CO_2 tax, but there were other elements such as the NO_x and SO_2 taxes (Sterner, 1994). In 2001, Sweden started a new tax reform (Pedersen and Nielsen, 2014).

Before the introduction of the taxes in 1991-92 there was quite a lot of debate around the CO_2 tax. For example, Swedish industrial organisations fought against the CO_2 tax due to fears of negative effects on competitiveness (Pedersen, 2000). There was also opposition from Swedish industries when the first taxes on chlorine and sulphur were proposed by the ETC (TT Nyhetsbyrån, 1989a), whilst the Swedish Society for Nature Conservation was positive towards environmental taxes in general (TT Nyhetsbyrån 1989b).Overall, due to acidification problems there was a high acceptance of the need for a sulphur tax (interviewee 1). By contrast, the NO_x tax only met little resistance from the regulated entities due to its reimbursement mechanism (interviewee 1).

1.3 Revenue collection and use

Figure 1 demonstrates that the revenue from the sulphur tax has decreased substantially from SEK 187 million in 1993 (ECU 21,9 million – 1993 prices) to approximately SEK 10 million in 2014 (€1,1 million – 2014 prices). Revenue from the NOx tax was more stable from 1993-2008 (with revenues between SEK 501 million (1995) (€54,8 million – 1995 prices) and SEK 643 million (1996) €75,3 million – 1996 prices)), before it started increasing after the tax level increased from 40 to 50 SEK/kg in 2008 (see above), peaking in 2011 at SEK 794 million (€88,1 million – 2011 prices) (Statistics Sweden, 2016). The increase in 1996-97 is probably an effect of the increase in the number of taxed companies in those years (see above).

Figure 1. Revenue from sulphur tax and NOx tax, 1993-2014, million SEK, current prices

*Preliminary
Source: Statistics Sweden 2016

As mentioned above, the NOx tax revenue (minus administrative costs) is reimbursed to companies. As noted above, sulphur tax payments can be reduced through cleaning or binding to the ash. SEPA (1997) analysed this reimbursement as part of an analysis of the effects of the tax and concluded that in the years 1992-95, the reimbursement was in the range of 44-57%. The tax revenues are collected by the Swedish Environmental Protection Agency (SEPA 1997).

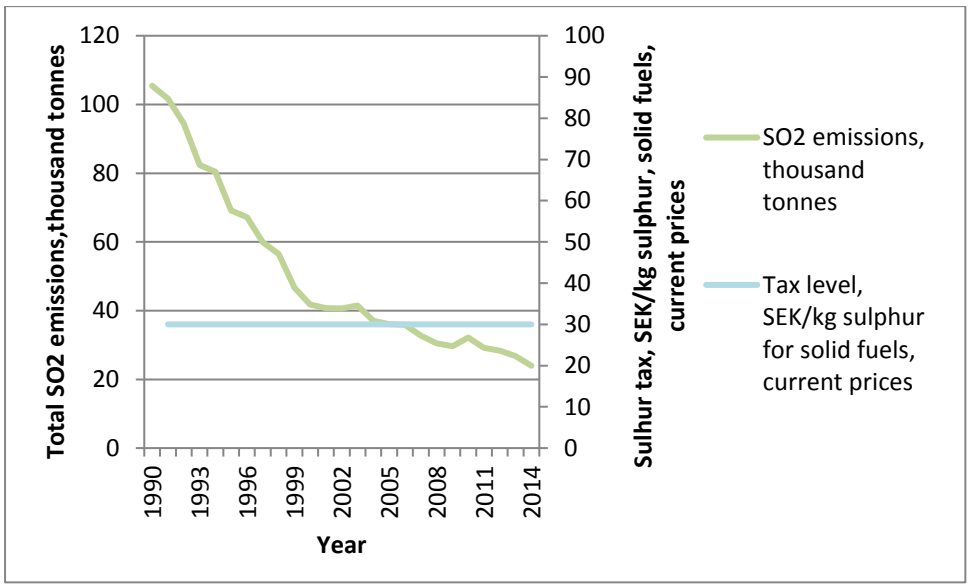
1.4 Environmental impacts and effectiveness

Figure shows a dramatic decline in SO_2 emissions from 1990 to 2014. The tax levels have remained constant in nominal terms over the years measured, meaning that the tax level measured in real prices has been declining. According to a SEPA (1997) analysis of the tax, the tax and the sulphur regulation have contributed to a lowering of the sulphur content in oils. This decline in sulphur content already started prior to the tax in 1991, in anticipation of its introduction. Additionally, the tax and the regulation have led to more cleaning of emissions from coal and peat (and thereby reimbursements to the companies) (SEPA, 1997). CO_2 and energy taxes have also contributed to the decline in SO_2 emissions, by shifting consumption from coal and oil to biofuels. Other factors such as the introduction of natural gas in Southern Sweden have also contributed to this decline in emissions (SEPA, 1997).

In an analysis of the sulphur tax, Hammar and Löfgren (2001) find that in the period 1989 to 1995, 59% of the reduction in sulphur emissions from manufacturing can be attributed to the announcement and implementation of the tax. Almost two thirds of the total reduction can

be attributed to substitution from oil to other energy sources – mainly electricity. The sulphur tax has induced technological progress on both the demand and supply side, and there is also a small effect from substitution between heavy and light fuel oil.

Figure 2 Total SO_2 emissions and sulphur tax level for solid fuels



This figure only includes the tax level for solid fuels. For oils, the tax level has been fixed at SEK 27/kg for each thousandth of sulphur content by weight in oils (OECD, 2014).
Source: SEPA, 2016a; OECD, 2014

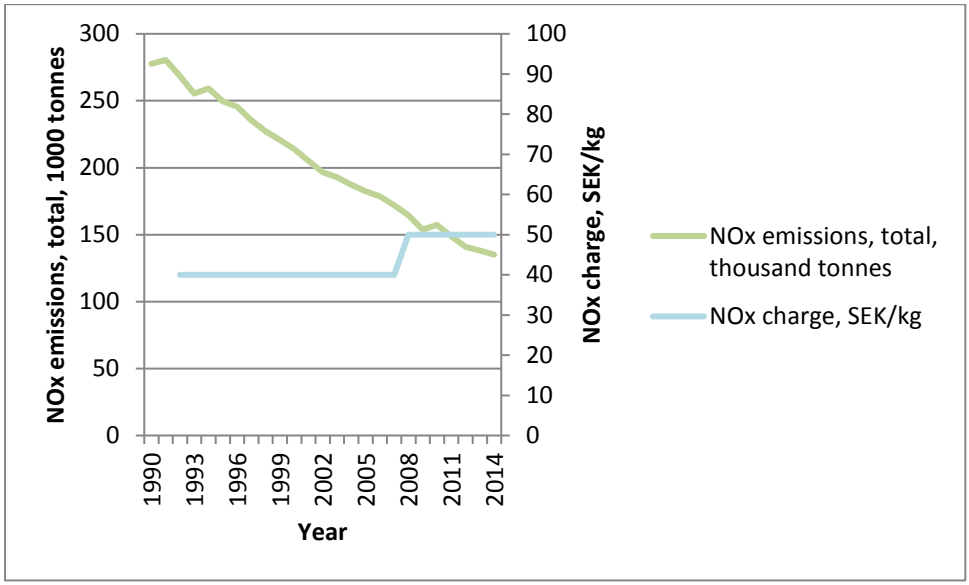
NO_x emissions have also been declining (Figure). Companies with emissions from stationary combustion facilities implemented emission reduction measures in anticipation of the 1992 introduction of the tax and the NO_x regulation. According to SEPA (1997) these reductions might have been as much as 30-40% before 1992. SEPA (1997) found that of these reductions 40% were initiated due to the expected tax introduction and 60% due to the NO_x regulation. However, for the forestry and metal industries the tax was the most important factor. CO_2 and energy taxes have also contributed to the decline in NO_x emissions, by shifting consumption from coal to biofuels. Again, other factors such as the introduction of natural gas in Southern Sweden have also contributed (SEPA, 1997; OECD, 2013).

Höglund-Isaksson and Sterner (2009) conclude that NO_x emissions per unit of useful energy produced by the regulated plants have declined by 50% since the introduction of the tax in 1992. Two factors contribute to the success: i) mandatory continuous monitoring of emissions from the regulated plants, and ii) a high tax level (made possible by the connected reimbursement mechanism) (see also SEPA, 2004b). Furthermore, it seems that the economic incentive motivates the regulated plants to achieve minimal NO_x emissions instead of aiming to be just below the limit values – the limit values give a ceiling and the tax give further economic incentives for reductions (SEPA, 2004b)

A SEPA (2012) evaluation of the 2008 increase in the tax level (from 40 to 50 SEK) finds that it has a limited effect since the decline in emissions per unit of produced energy continued on the same trajectory as before the reform. This is supported by interviews with the affected

industries. In total, NO_x emissions are increasing as the overall amount of energy produced has risen. The lack of effect can be partly explained by cold winters in 2009 and 2010 and some problems in nuclear power production (SEPA, 2012). Different sectors have been affected differently by the increase in the tax (SEPA, 2012).[5]

Figure 3 Total NO_x emissions and NO_x tax level



Source: SEPA, 2016b; 2012.

1.5 Other impacts

Overall, SEPA (1997) considers that the sulphur and NO_x taxes only have a minor effect on the competitiveness of affected industries due to the reimbursement system. However, some industries find that there is a negative effect on competitiveness.

SEPA (2004b) also conclude that there are some distributional effects of the NO_x tax between different industries – some industries have higher abatement costs, higher emissions and therefore pay a higher net tax than other industries that might have a net benefit from the tax and reimbursement mechanism. For instance, the forestry and plastic and chemical industries have complained that the system is unfair (SEPA, 2004b). Often, production units within combined heat and power plants and waste incineration are net 'winners', while industrial boilers are 'losers' in the NO_x tax system, but there are also differences between companies within the same industry (SEPA, 2004b). However, according to OECD (2013) the losers' losses are in general modest.

In an analysis of the abatement costs in response to the NO_x tax (based on 162 abatement measures at 114 combustion plants), Isaksson (2005) found that the emission reductions have been taken 'at a zero or very low cost' and concludes that low-hanging fruits are abundant in NO_x abatement, but there is little support for true win-win solutions (Isaksson, 2005). Höglund-Isaksson and Sterner (2009) analysed 626 plants that were regulated by the tax for

[5] In an assessment of the evaluation methods in the SEPA report, Söderholm criticises some of SEPA's methodological choices – e.g. that no baseline scenario is established in the analysis (Söderholm, 2013).

at least one year and found that the tax has been very important for the achieved reductions. For larger combustion plants producing at least 50 MWh/year there is a continuous drop in emission intensity levels of approximately 3% per year in the long term. Höglund-Isaksson and Sterner (2009) refer to other analyses (55 plants) of the tax showing that the marginal abatement cost curve decreases over time. For the energy sector, 'average emission intensity level attainable at no mitigation cost moves from 557 to 300 kg NO_x per GWh between 1991 and 1996' – a shift which can possibly be attributed to the adoption of innovations in NO_x abatement technology, making it possible to produce energy with lower NO_x emissions without increasing the costs. For two other sectors, pulp and paper and chemical and food, no evidence was found of innovation effects (Höglund-Isaksson and Sterner, 2009). The same authors also find that 'in 1992 regulated plants were able to produce 30,000 GWh emitting less than 550 kg NO_x per GWh. Sixteen years later in 2007, regulated plants are able to produce the same amount of energy emitting less than 181 kg NOx per GWh – an improvement by 67%' (Höglund-Isaksson and Sterner, 2009). There are three main explanations for the impressive results:

- 'Cumulative output produced by regulated plants has increased by 74% over the period. The expansion in output has to a large extent taken place in plants that are relatively emission efficient or, when increases have taken place in new plants, these are in general more emission efficient than old plants.
- Regulated plants invest in NO_x mitigation and are therefore able to produce more output with less emissions.
- Innovations in mitigation technology make it possible to reach even lower emission intensity levels for the same output level.' (Höglund-Isaksson and Sterner, 2009)

In general, the tax has stimulated innovation through the refund system and through a requirement to install monitoring equipment (OECD, 2013). When the tax was introduced in 1992, 7% of the plants subject to the tax had NO_x abatement technologies installed; this increased to 62% the year after and to 72% in 1995 (OECD, 2013).

The NOx tax clearly stimulated innovation. However, according to OECD (2013) 'a regulated firm's willingness to share innovations with other regulated plants is hampered by the refund system, since a spread of the innovation to other regulated firms will reduce the innovating firm's own tax refund. On the other hand, for firms producing NO_x emission abatement equipment – who are not themselves directly affected by the NO_x tax – there are no such obstacles'.

Administrative costs related to the NO_x tax were assessed by SEPA (1997) to be approximately SEK 1.5 million/year (€0,2 million – 1997 prices) and by SEPA (2004b) to be approximately SEK 4 million/year (€0,4 million – 2004 prices). Consequently, more than 99% of the revenue is reimbursed to the affected industries (SEPA, 2004b). Company investments for measurement equipment related to the NO_x tax are estimated at approximately SEK 60-70 million in total (€7,0 - 8,2 million – 1997 prices) (SEPA, 1997). Some companies find the NO_x tax unfair (see section 2).

The NO_x tax may have led to increases in some other types of emissions – e.g. if ammonia is used for NO_x reductions in some industries. However, reductions in NO_x are larger than

increases in ammonia. Increasing nitrous oxide is another potential problem from the so-called Selective Non-Catalytic Reduction (SNCR) technique (SEPA, 2004b; OECD, 2013).

OECD (2013) finds that there is no negative income distribution impact from the NO_x tax.

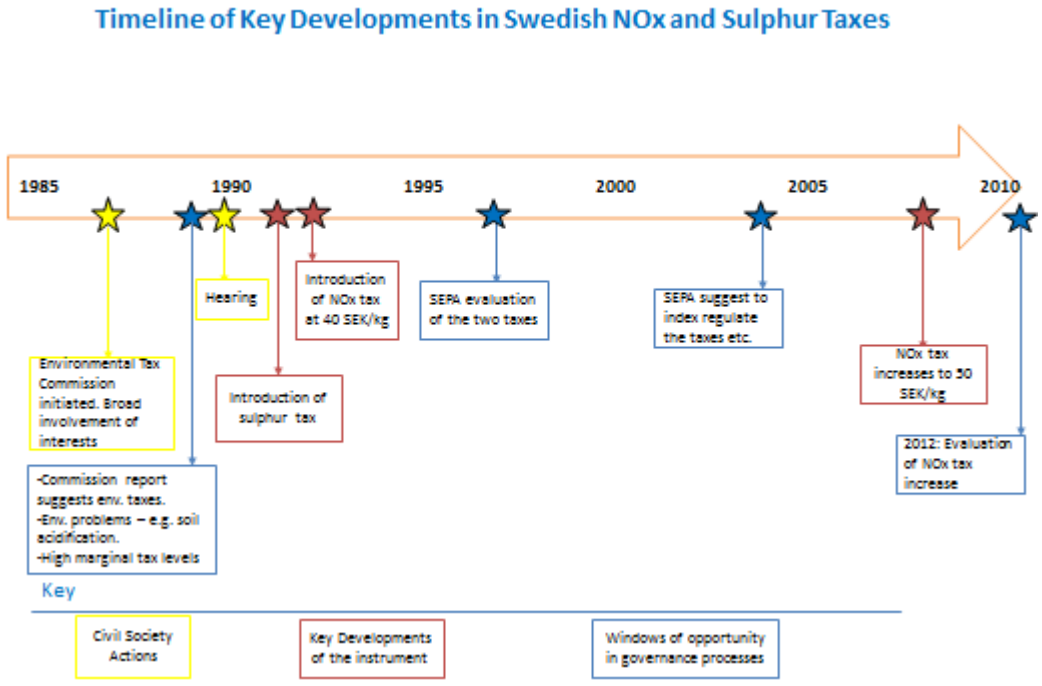
2 Stakeholder engagement

As mentioned above, the Environmental Tax Commission (ETC) involved a broad representation of interests and when the commission presented the 1989 reports on environmental taxes, the proposals for the NO_x and sulphur taxes (and other taxes) went through a broad public consultation phase, where a large number of public and private stakeholders expressed their views (OECD, 2013; Swedish Government, 1989a and 1989b).

When SEPA (1997) analysed the sulphur tax, the companies' overall assessment was that it was a fair tax. However, some companies found it unnecessary that there is *both* a tax and a regulation, and that one or the other would be enough. Today, as described above, sulphur emissions – and total tax payments – are very low.

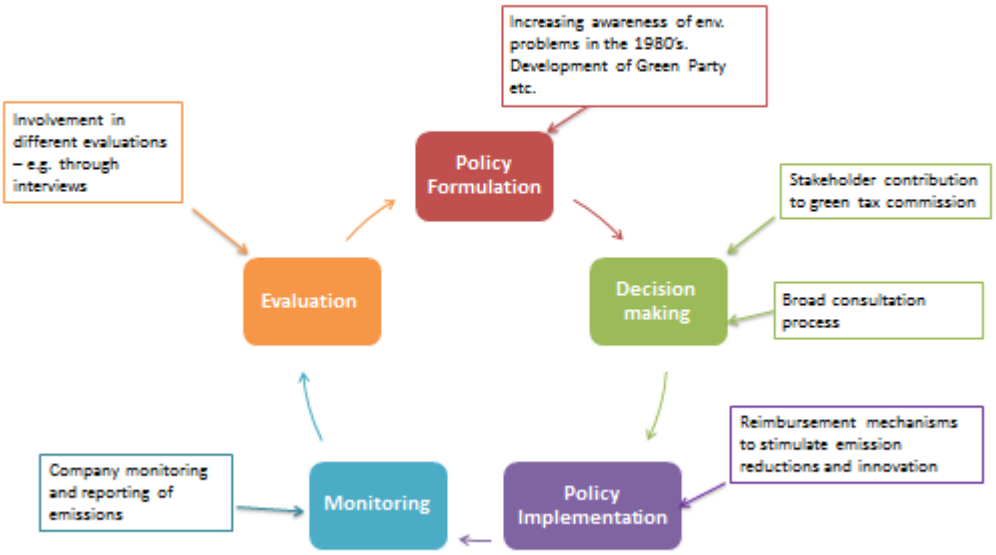
Regarding the NO_x tax, a high tax rate was needed, and was made more acceptable by introducing the reimbursement mechanism, by informing the public and by involving all parliamentary parties in the work of the ETC (OECD, 2013).

When SEPA analysed the tax in 1997, the energy sector and the Swedish District Heating Association found that the tax works very well and has a good steering effect. Some other trades, in particular forestry, found the tax unfair. Furthermore, some companies found it unnecessary that there is *both* a tax and a regulation. Some companies felt there was a risk that the tax could cause other non-taxed pollutants to increase (SEPA, 1997).



3 Windows of opportunity

Civil society engagement with Swedish NOx and sulphur tax



4 Insights into future potential/reform

4.1 Actual Planned reforms and stakeholder engagement

In 2004, SEPA suggested to expand the NO_x tax to also include industrial combustion processes, and to increase the tax level to 50 SEK/kg to (SEPA, 2004a; 2004b; 2005; interviewee 1). The tax had lost some effect over the years, since the tax level had been fixed at 40 SEK/kg (€4,2 – 2008 prices) and was not corrected according to the development in the general price index. Consequently, the tax level was increased to 50 SEK/kg in 2008 (€5,3 – 2008 prices) (see above). Similarly, regarding the sulphur tax, SEPA (2004a) suggested to index the tax to avoid weakening the incentives. In 2004 an adjustment of the tax according to the development in the price index would have changed the level from 30 SEK to 37 SEK/kg. However, the tax level was not adjusted and has remained at 30 SEK/kg (€3,0 – November 2016 prices).

4.2 Suggestions for future reforms – instrument design and civil society engagement

Based on the analysis above, an indexing of the taxes could be recommended to avoid a weakening of incentives.

4.3 Suggestions for replicability

Basically, there should be no large technical barriers for replicating the Swedish model of NO_x and sulphur taxes in other EU Member States. However, as history demonstrates, industry protests against new taxes can make implementation politically difficult.

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