The Potential of Eco-Taxes as Instruments for Sustainability.

An Analysis of the Critical Design Elements.

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Abstract: *Eco-taxes attach a cost to particular polluting activities, thereby internalising the negative external environmental effects of the production process, which in turn stimulates target groups to adopt more environmentally benign techniques and technologies in order to reduce polluting emissions and hence their tax burden. Through a comparative analysis of two case studies of eco-taxes, generally recognised as being successful, this paper attempts to isolate the design features of both policies that have resulted in the successful fulfilment of environmental objectives. The paper analyses what can be expected of these instruments if properly designed and an assessment of the potential of such instruments, as tools to aid a transition to more sustainable industrial sectors is explored. To this end, the Swedish charge on nitrogen oxide emissions from energy production and the Dutch Minas system targeting nutrient surpluses from agriculture provide a basis for assessment.*
The study concludes that by designing instruments to the individual contextual circumstances to which they will be applied, by considering the potential pitfalls of the policy-making process and the barriers to technical and technological change within target groups, eco-taxes can indeed spur technical change and incremental innovation through the imposition of a charge that is greater than the marginal abatement costs for individual firms. Well-designed policies can thus result in an enduring eco-upgrading of the particular sector, to which the instrument is applied.

Key Words: Eco-taxes, policy design, technical change, environmental sustainability.

1. Introduction

It is generally accepted that the path towards sustainable development requires profound changes within the industrialised countries of the north (Andersen, 1994; Sachs *et al*, 1998), in order to reduce massive over-consumption of resources in the face of a rapidly growing global population demanding the satisfaction of needs and wants from a finite resource base. Environmental policy within the industrialised countries focuses on technology as a key to transforming industrial sectors as a strategy for sustainable development. This is achieved through policy aimed at spurring the adoption of cleaner production methods and environmentally beneficial technology amongst target groups, which in turn results in reductions in pollution.

In recent years, environmental policy has afforded an increasingly important role to eco-taxes for achieving environmental objectives. The basis of this popularity rests with certain advantages they are said to possess over command-and-control policies, which are regarded as inefficient due to the fact that such measures impose a uniform reduction level across the sector, regardless of the differing pollution abatement costs that the various actors face. According to Golub, "This results in some firms regulating too much and others not enough" (Golub, 1998:3). Conversely, a tax or charge levied on pollution results in the marginal abatement costs being equalised amongst the firms and thereby, the total abatement costs across the target sector are minimised resulting in the cost-effective achievement of environmental objectives.

Perhaps more importantly, command-and-control regulations, which implement static target levels for the reduction of pollution are said to impede any incentive to continuously reduce pollution levels, since the firm will only incur costs and competitive disadvantages if it were to continue pollution reduction once the target level is reached (OECD, 1997). Environmental economists claim that a continuous incentive to reduce pollution is a built-in feature of eco-taxes, as by imposing a cost on particular polluting activities, actors behaving as profit maximisers, will be bound to implement measures that reduce their emissions of the polluting substance in order to minimise their exposure to the tax. Through this imposition of a cost on polluting activities, environmental economists attempt to internalise the negative external environmental effects of the production process and correct the failure in the market to allocate resources in the best interests of society (Pearce *et al*, 1993).

Ecotaxes and charges have been heralded as being essential tools for sustainability and for this reason have been advocated by organisations such as Friends of the Earth. The line of enquiry followed in this research thus focuses on the potential of 'best case' eco-taxes: to what extent are they capable of spurring technical change and fulfilling environmental objectives? If these instruments can indeed spur targeted actors to continuously search for new techniques and technologies in order to minimise pollution, then their role in aiding a transition to a more sustainable society takes on a greater significance.

Through a comparative analysis of two 'text book' cases, the intention of the study was to identify the crucial design elements that ensured that the policies were effective in achieving their original objectives. Furthermore, the study aimed to establish the extent of technical change that has occurred as a result of the instruments. In addition, through the analysis of these successful cases, the potential of eco-taxes might be established. Also, the possibility existed that design weaknesses may be identified.

The cases selected for the purpose of the study were the Swedish charge on emissions of nitrogen oxides (NO_x) in energy production and the Dutch MINeral Accounting System (MINAS), targeting nutrient surpluses from agriculture. These two instruments have been generally acknowledged to be successful in terms of environmental results, which would indicate a well-designed policy, thus increasing the likelihood of observing technical changes and/or the implementation of management practices amongst the target group as they search for ways to minimize their tax burden.

2. The Swedish Charge on NO_x Emissions from Energy Production

2.1. The Policy Design

The Swedish charge on NO_x emissions from energy production was implemented against the background of the acid rain issue. Nitrogen oxides and sulphur dioxide are the main constituents of acid rain, which has been a major environmental concern since the 1980s. The transboundary nature of the problem has led to the formulation of a number of international protocols under the Convention on Long-Range Transboundary Air Pollution (UNECE, 1979; Levy, 1995) and extensive national regulation over the years (EU, 2003).

The Swedish charge on NO_x emissions from energy production was implemented in order to reduce domestic emissions of this pollutant. Sweden's environment is particularly sensitive to acidification and billions of Swedish kroner (SEK) are spent annually maintaining corroded structures, treating acidified drinking water, liming lakes and watercourses, and conducting trials on acidified forest soils (SEPA, 1995).

The charge was implemented in 1992 as part of a major tax reform, and its main aim was to provide "an incentive for introducing nitrogen oxide reducing technology" and improving processes and controls (Nordic Council of Ministers, 1999: 140). A system of quantitative standards on NO_x emissions, set by region and varying in level, strictness and design, has also been in place since 1988 (Höglund, 2000).

The policy aims to reduce emissions from power generation plants and large combustion plants, such as industrial boilers and incinerators, with an annual production of useful energy of at least 25 GWh. The systems liable to this charge constitute only 5% of domestic sources of NO_x emissions (SEPA 2000: 6), and the affected sectors vary from the energy production and waste incineration sectors to the chemical, food, and pulp and paper industries.

The policy necessitated the installation of expensive monitoring equipment in order to accurately measure the NO_x emissions, since these vary with the combustion conditions of the process and are not directly dependent on the type of fuel used. The installation and monitoring costs of the measuring equipment were estimated to be approximately SEK 300,000 per plant (SEPA, 2000), which was quite substantial. For this reason, the charge was initially limited to the larger plants, with an annual utilised energy production of at least 50GWh. In order to safeguard the competitiveness of the sector it was decided to redistribute the collected revenue amongst the target actors in proportion to the final production of useful energy, thus rewarding the energy-efficient plants. Therefore there was a reduced incentive for the larger plants to take strategic measures and exit the scheme by investing in smaller, less efficient units that were not liable to the charge. As monitoring costs fell and effectiveness regarding emission reductions became apparent, the system was extended to smaller plants: in 1996 to units with a production of at least 40 GWh, and in 1997 to those with a production of 25 GWh or over.

The charge is levied at a rate of SEK 40 / kg NO_x, which has remained unchanged since implementation in 1992. This figure was arrived at on the basis of engineering data on effectiveness and abatement costs: the abatement costs were estimated to range from SEK 3 to SEK 84 / kg reduced NO_x (SEPA, 2000:5). The average cost to reduce 1 kg of NO_x was estimated to be SEK 10 (IISD 1994: 25) so that there was a strong economic incentive for the target group to invest in pollution-abatement measures. The financial aspect of the charge can be significant; in 2001, one company made a net payment of approximately SEK 7,800,000 whilst another company received a net refund of around SEK 16,000,000 (SEPA).

The Swedish Environment Protection Agency (SEPA) is the taxation authority for the NO_x charge. Prior to introducing the charge, SEPA worked together with the targeted sector to make the implementation of the system as smooth as possible. Preparations included the compiling and publishing of information regarding NO_x measuring techniques and equipment, which was sent to the liable plants together with the relevant forms, information about the charge, and reports on the determination of NO_x emissions and utilised energy.

[Sources: Bergstrom, 1999; Höglund, 2000; SEPA, 2000]

2.2. Environmental Effectiveness and the Response of the Target Group

The reductions achieved within the targeted industry were substantial. As shown in figure 1, total emissions for the sector are estimated to have been reduced by 40% since 1990. The relative increase noted in 1996 is due to the extension of the scheme to units of a lower capacity. An earlier evaluation of the policy concluded that 50% of the reductions took place between 1990 and 1992, in anticipation of the implementation of the charge. A reduction

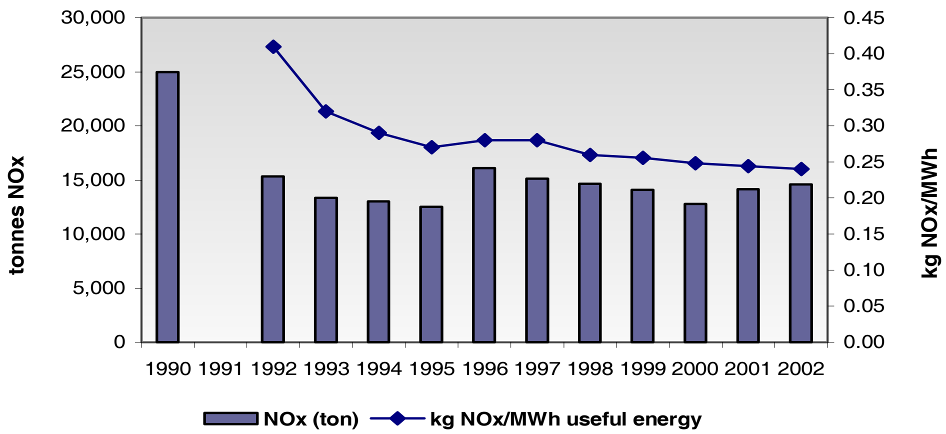

Figure 1. *Total and specific NO_x emissions from boilers subject to the charge between 1992 and 2002, and total estimated emissions in 1990 (Source: SEPA)*

in emissions took place amongst all the targeted sectors, with the exception of the metal industry. [SEPA, 2000]

The reduction in emissions was achieved by an increase in eco-efficiency, as indicated by the trends shown below. The specific emissions, i.e. the amount of NO_x emitted per unit energy output, decreased irrespective of plant size (figure 2) and fuel type (figure 3), even though the magnitude of these reductions varied by plant size and fuel type.

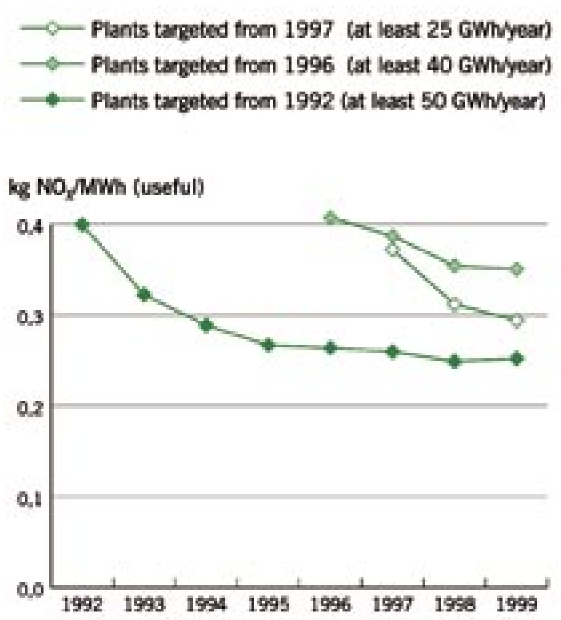

Figure 2. *Average NO_x emissions in kg NOx/ MWh useful energy produced by targeted plants in 1992-1999 (Source: SEPA, 2000:11)*

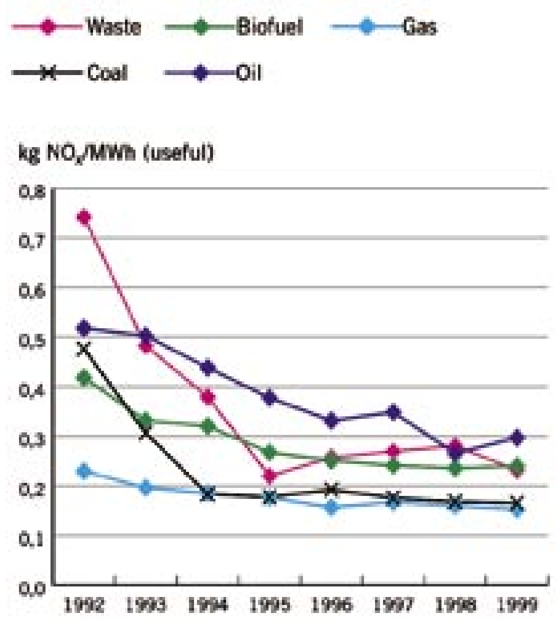

Figure 3. *Trend of emission reduction by fuel type (Source: SEPA, 2000:11)*

Various technologies and techniques for reducing NO_x emissions have been available to the power producers. These included primary measures (i.e. changes to the combustion process) and secondary measures (i.e. flue-gas denitrification). Primary measures such as low-NO_x burners can achieve reductions of 30% (EEB *et al*, 1998). Secondary measures such as Selective Non-Catalytic Reduction and Selective Catalytic Reduction can reduce emissions by 20-70% and up to 90% respectively (SEPA, 2000). Apart from investments in pollution-abatement equipment, measures to increase the efficiency of the processes by purely technical means were also employed, such as improvements involving parameter optimisation ('trimming').

The incentive effect of the NO_x charge on the target group can be construed from the diffusion in pollution abatement technology that came about during the period of implementation. Figure 4 shows how the number of combustion plants equipped with NO_x-reducing measures in Sweden increased by a factor of 16 between 1982 and 1994 (IISD, 1994).

The Swedish EPA note that an early evaluation of the charge concluded that 50% of the reductions actually took place between 1990 and 1992, in anticipation of the implementation of the charge (SEPA, 2000).

A study by Höglund (2000, Essay II) on 114 plants targeted by the Swedish NO_x charge concluded that almost half of the162 pollution abatement measures taken would not have been implemented without the introduction of the charge. An overview of the type of response by sector is shown in table 1.

As can be seen, the measures implemented varied from low-cost trimming to a fuel switch, which often necessitates investment in a new boiler; however in the latter cases other considerations were also involved (ibid, 2000).

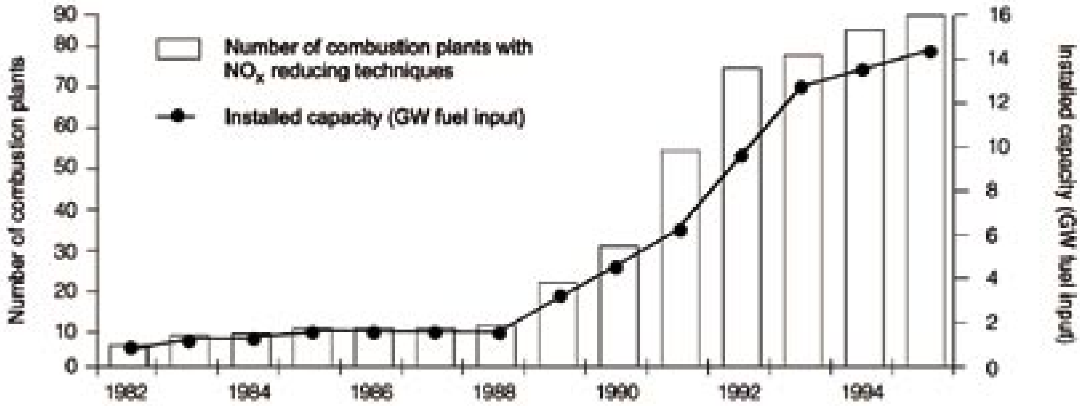

Figure 4. *Installations of present and planned NO_x reducing techniques during 1982 – 1994, (Source: IISD, 1994:25)*

Table 1. *NO_x-reducing measures implemented by sector between 1990 and 1996; based on a sample of 114 plants. (Data source: Höglund in SEPA, 2000)*

Type of Measure	*Sector*				*All Sectors*	
	Energy	*Pulp and Paper*	*Chemical and Food*	*Waste Combustion*	*%*	*Qty.*
Trimming	28%	35%	43%	38%	**33**	**53**
Other Combustion measures	38%	35%	48%	31%	**38**	**62**
Flue Gas Treatment (SNCR & SCR)	22%	29%	4%	31%	**22**	**35**
Fuel Switch	12%	4%	4%	0%	**7**	**12**

2.3. Wider Effects

The extent of an instrument's effect is dependent on the response generated within the target group, as well as the ability of the supporting sectors to adapt. Development has certainly occurred over the last decade within the spheres of NO_x-abatement and monitoring equipment, including a number of Swedish firms. Due to the influence of interrelated international policies that have been developing since the early 1980s, the influence of the charge on these developments is inextricable. However, the creation of a market of hundreds of plants, due to the necessity of implementing measuring and abatement equipment in conjunction with the charge, may well have given a boost to the sector. It also resulted in a source of empirical information regarding the equipment performance in the field, providing an impetus for further improvement and development.

2.4. Drawbacks of the Policy

Despite the significant results achieved, this policy is by no means flawless. Limiting the policy to emissions from energy generation entails the exemption of a number of industrial processes that contribute 16% of the total Swedish NO_x emissions (SEPA, 2000:6). Also, the smaller producers are more heavily burdened by the measuring costs, since these are relatively high (ibid, 2000). Thus, the polluters with the larger environmental impacts have an indirect cost advantage over the smaller polluters. The environmental effectiveness is somewhat diminished by the fact that a number of the NO_x-reduction measures can have undesirable secondary effects and lead to increased emissions of other pollutants and greenhouse gases. SEPA (2000) estimated that in 1995 the increase in carbon monoxide and ammonia as a result of the implementation of the charge was 0.5% of the total Swedish emissions, whereas that of nitrous oxide is 5%. The noted increase in such secondary emissions was mostly "due to the pronounced influence of the NO_x charge in combination with the lack of instruments governing other emissions" (ibid, 2000: 16). Very few plants have permit levels for these emissions. Although the estimated increase of these emissions is equivalent to 25% of the reduced NO_x, it is difficult to compare the corresponding benefits and damages, due to the different "exposure-response functions" of these emissions (Ecotec, 2001a: 56). The fact that most of these increased emissions can be avoided (SEPA 2000), is a further negative feature.

3. The Dutch Mineral Accounting System

3.1. Unsustainable Nutrient Use

The Netherlands has amongst the worlds' most intensive agricultural sectors with a very large livestock population compared to the size of the country. The sheer volume of manure produced by these animals constitutes a major environmental problem with excessive amounts of nitrogen, phosphate and ammonia produced (MANMF, 2001). Whereas nitrogen (N) and phosphorous (P) are essential nutrients for plants and animals, when present above certain levels, they cause specific environmental problems. N and P are also found in artificial fertiliser and feed, as well as in organic fertilisers such as compost and sludge. Indeed, due to its over-dependence on manure, fertiliser and artificial feed, agriculture in the Netherlands is the major contributor to N contamination of groundwater, contributing almost 70% of the total N leached to surface waters, which directly threatens the quality of drinking water (ibid, 2001). On average, approximately 50% of the nutrients applied to crops are exported from agricultural fields in crop products, whilst the remaining 50% continues to be present on the field and it is this remainder that causes the pollution of ground and surface waters (Ecotec, 2001b). This clearly illustrates the potential environmental benefits to be realised through a policy aimed at increasing nutrient use efficiency.
The MINeral Accounting System (MINAS) was introduced to ensure compliance with the EU Nitrate Directive 91/676/EEC, which was implemented in order to protect water against pollution caused by N from agricultural sources. The Directive obliges governments to reduce emissions from agriculture in order to ensure the safety of drinking water by reducing the level of N present to within the maximum of 50mg per litre of groundwater, in line with the World Health Organisation (WHO) norms for drinking water quality. This reflects the possible dangers to Human health, which necessitate the thorough cleaning of drinking water. The costs of drinking water purification are high and represent an end-of-pipe measure, whereas MINAS is aimed at the prevention of the problem.

3.2. MINAS

MINAS was introduced in 1998 and it requires all farms to implement a book keeping system that records all N and P inputs and outputs and the difference between the two, i.e. the mineral surpluses (losses) to the environment, which are the cause of problems such as groundwater pollution. Figure 5 below, illustrates the simple accounting formula behind the system.

The surplus of minerals lost to the environment is allowed up to a predetermined levy-free surplus in kg/ha. Any surpluses above this, which may be due to various inefficient farm practices such as the build-up of manure, administrative error or over fertilisation, attracts a charge imposed per kg of N or P. The charge rates and levy-free surplus levels for MINAS are illustrated in table 2.

These allowable losses have been established based on assessments of the ability of the environment to absorb a certain level of excess nutrients. Mineral loss is an effective indicator of a farm's burden on the environment with respect to N and P compounds (Brinkhorst, 1999). The levy-free surplus is lower for sandy soils as they are more prone to nitrate leaching to groundwater. MINAS was expected to be a significant improvement on previous polices as the system enables farmers to get a realistic insight into the actual amounts of N and P entering and leaving the farm whilst the policy leaves the decision as to the best method of tackling nutrient surpluses with the individual farmer who is therefore free to respond in a manner that suits his particular skills and farm characteristics (MANMF, 2001). In addition, by targeting mineral surpluses, MINAS targets the true source of the problem and the instrument thus applies to animal manure, artificial fertilisers and other organic fertilisers, such as compost (MANMF, 2001).

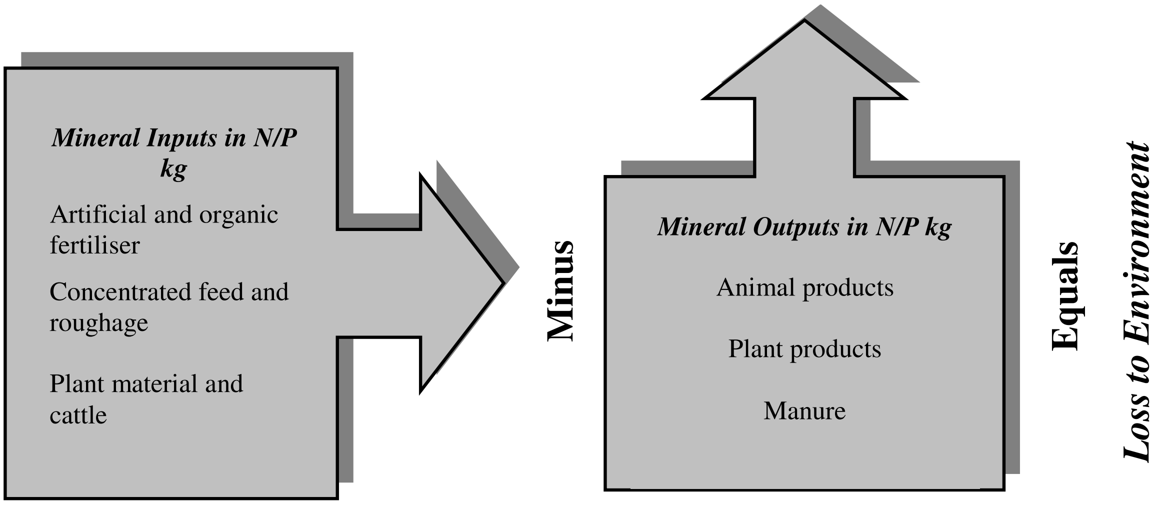

Figure 5. *The MINeral Accounting System (Adapted from MANMF, 2001)*

Table 2. *Tax rates under MINAS in the Netherlands in €/Kg (Source: Ecotec, 2001b)*

	Levy-free N surplus (Kg/H)		*Levy-free P2O5 surplus (Kg/H)*	*Tax Rate Applied €/Kg*	
Year	***Grass***	***Arable***		***Nitrogen***	***Phosphorous***
1998	300	175	40	0.7	1.1
2000	250	125	35	0.7	2.3
2002	220	110	30	0.7	2.2
2003	180	100	20	2.3	9.1
2003 sandy soils	140	60	20	2.3	9.1

The goal of the mineral accounting system is to achieve a nutrient balance on all farms, so that the input of N and P matches the demands of the crop. However, a certain amount of minerals are inevitably released into the environment but this is taken into consideration with the levy-free surpluses. As illustrated in table 2, the date by which farmers must achieve the final levy-free surplus is 2003. According to Oenema *et al* (In Ondersteijn, 2002), if farmers meet the levy-free surplus, the maximum N content of 50mg/l for groundwater, as directed by the EU, will also be met.

Until the end of 2003, the Dutch government will be providing an extensive demonstration and information programme, which has been described as a nutrient management "information dissemination" pyramid (Oenema *et al* in Ondersteijn, 2002:156). This is to facilitate the diffusion of agricultural best practice and is composed of the experimental farm DeMarke, the project Cows and Opportunities and the project Farm Data in Practice with the remaining dairy farms at the base of the pyramid.

3.3. Environmental Effectiveness and Response of Farmers

As illustrated by figure 6, between 1980 and the late 1990s, N emissions to the soil reduced by only 9%, with significant variations over time. In the same period, P emissions fell by 28%.

However, according to the RIVM (2002a), figures for 2000 indicate a drop of 27% in N emissions and 39% in P emissions compared to 1980 levels. More

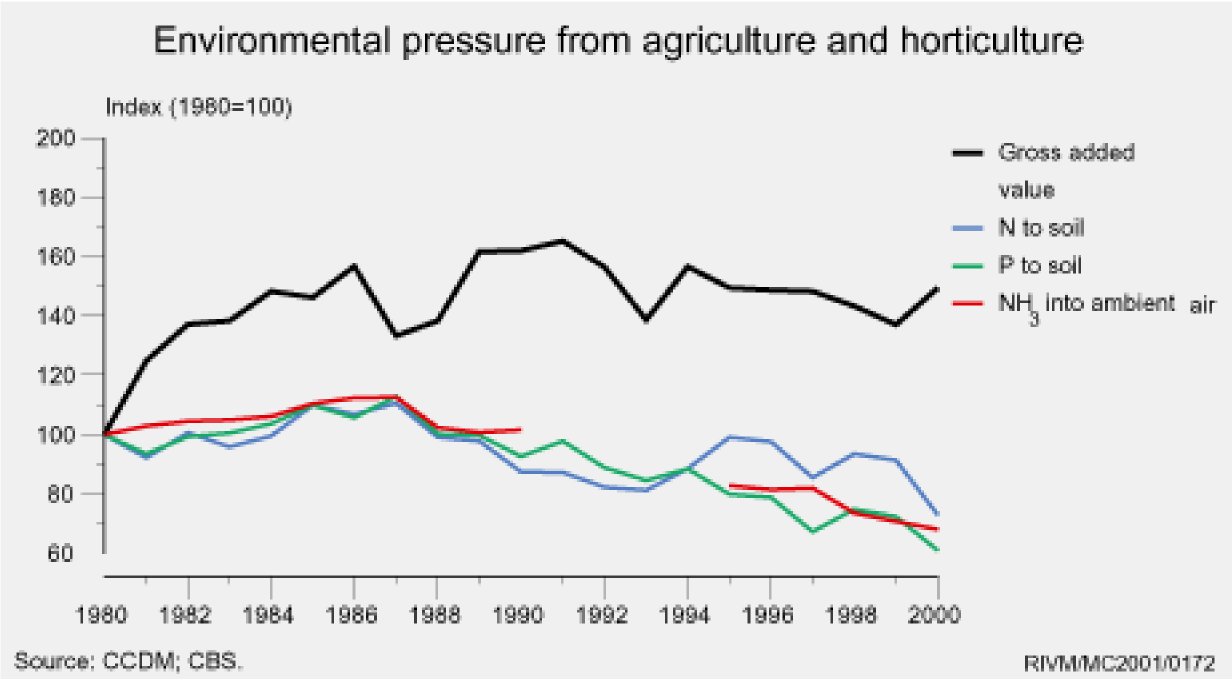

Figure 6. *Environmental pressure from agriculture and horticulture 1980-2000 (Source: RIVM, 2002a).*

than half of the sharp fall in N emissions between 1999 and 2000 was due to a reduction in the use of nitrogenous fertilizer. Figure 6 illustrates that in 1999, following the introduction of MINAS there was a substantial drop in N emissions for the first time in twenty years. The total levies charged for the year 2000 were 40% lower than in 1999, indicating a reduction in taxable surpluses (RIVM, 2002b).

According to the Dutch Ministry of Agriculture (MANMF, 2001), the levies imposed on surpluses above the levy-free standard are very high, in order to persuade farmers to take measures to reduce their losses. For example, fines could be as high as over €800 per ha and over €45,000 in total for certain individual farms (Ondersteijn, 2002:34). The imposition of the levies results in a reduction in the gross margin for farms. Furthermore, it is expected that several thousand farmers will be forced to sell up (MANMF, 2001). This confirms that the monetary incentive provided by the charge to reduce mineral surpluses is high. Economic theory would then expect farmers to respond by reducing their mineral surpluses in order to avoid paying the tax.

A study by Ondersteijn (2002), into the response of 72 dairy farms to the introduction of MINAS over a three-year period, showed the existence of a hierarchy of management measures implemented to increase nutrient efficiency and hence reduce the farmer's exposure to the tax. Table 3 illustrates the range of management techniques available to farmers that can reduce surpluses.

Farmers will attempt to reach the levy-free surplus by first optimising operational management; that is by increasing the accuracy of nutrient use. Operational management alterations are characterised as being low-cost and low-risk and are therefore the most appropriate measures to take if only a relatively small reduction in mineral surpluses is required to meet the final levy-free surplus of 2003 (Ondersteijn, 2002). Although nutrient efficiency can be increased through these steps, certain farmers may not possess the relevant skills necessary for their implementation and therefore they will look to tactical changes, defined as a reduction in nutrient inputs to the farm. If both operational and tactical measures are insufficient, then farmers may have no option but to reconsider their overall farm strategy and implement structural changes to the farm (ibid, 2002).

Table 3. *Potential management practices implemented to reduce mineral surpluses (Source: Ondersteijn, 2002: 148).*

Nutrient Management Measure
Operational Management
Improve feeding and grassland management
Improve N utilisation of organic manure
Tactical Management
Reduce number of young stock
Change grazing system to less intensive grazing
Reduce protein level in concentrates
Reduce P level in concentrates
Reduce N fertilisation from inorganic fertiliser
Reduce P fertilisation from inorganic fertiliser
Decrease grass to maize ratio
Decrease amount of concentrates per cow
Strategic Management
Decrease farm intensity
Increase milk production
Discarding pig and/or poultry and/or dairy farming

3.4. Wider Effects

Incremental innovation has been observed within upstream supporting industries, which may have responded to the demand of farmers for greater nutrient efficiency within their products. With regard to the animal feed sector, the levies imposed on nutrient surpluses make it desirable for farmers to obtain feed, which has a lower content of crude protein (nitrogen) and phosphorous. Therefore, it would seem reasonable to suggest that animal feed suppliers would respond to the changed requirements of their customers and alter the composition of feed accordingly. Indeed, according to the RIVM (2002a), both the amounts of N and P present in manure have decreased since the peak year of 1986. In recent years, the gains in this respect are due to better-balanced feed. To what extent these gains can be attributable to the suppliers of feed altering its composition is unknown. Farmers may have substituted, to a certain extent, purchased animal feed with homegrown feed, supplied by other farmers. Furthermore, if the gains are a result of suppliers altering feed contents, whether this is a direct result of MINAS cannot be established. A perhaps more plausible explanation would be the enforcement of new regulations pertaining to acceptable levels of N and P in feedstuffs, which would have stimulated such measures within the animal feed sector.

Furthermore, the fertilizer industry has witnessed a decline in demand for fertilizer in recent years within the Netherlands. The declining trend in the use of mineral fertilisers is expected to continue and the reasons attributed to this are new legislation, in the form of MINAS, and increases in on-farm nutrient efficiency (VKP, 1998). This requirement for increased nutrient efficiency has resulted in fertiliser producers manufacturing controlled release fertilisers and providing more detailed instructions as to their appropriate use. For Dutch agriculture, MINAS and the associated management techniques will impact on the level of fertiliser consumption far more than changes in the Common Agricultural Policy (CAP) or crop price movements (VKP, 1998).

3.5. Drawbacks of the Policy

Through focusing on individual farmers, MINAS highlights the negative environmental consequences of their actions and thus holds them accountable for their pollution, in line with the polluter-pays-principle. However, whilst the farmer's unsustainable use of nutrients has indeed directly led to environmental damage, indirectly it is the CAP with its supporting policies which has steered the agricultural sector onto its present unsustainable trajectory, with farmers simply responding to the drive for intensification.

MINAS requires farmers to alter their management practices within a short period of time or face heavy fines. Despite the formulation of ancillary policy designed to "soften to some extent" the dramatic social impact of the new measures, the expectation is that several thousand farmers will be forced to sell up (MANMF, 2001). Those who appear to be most threatened are small family farms, especially those of an older generation, who are less capable to meet the double challenge of substantial investment and the necessity to learn new skills. Apparently, the Dutch government has decided that the negative impacts on the environment and human health justify the social consequences of MINAS. However, the disappearance of family farms will continue to corrode the traditional social fabric of the countryside, a process of change that is currently being witnessed in many countries in Europe. MINAS may in fact lead to further intensification, as a process of consolidation occurs with the larger agribusinesses being in the best position to respond to the regulatory burden. Such a process is at odds with the Dutch government's vision of the future for its agricultural sector: a mix of high tech farms producing specific products and small farms producing for the market (Brinkhorst, 1999). This underlines the importance of policy planners being aware of the potential economic, environmental and social impacts of new instruments amongst which a balance should be sought.

4. Discussion

4.1. Barriers to Appropriate Responses

Eco-taxes rely on targeted groups being responsive to price signals as the mechanism that determines their eventual effectiveness. Economists base their theoretical explanation of how eco-taxes work on certain assumptions. They claim that imposing a tax on a specific polluting activity will by definition result in targeted actors taking measures to reduce their pollution and hence their tax burden as long as the tax exceeds the marginal abatement cost (Pearce *et al*, 1993). Therefore, it becomes apparent that the assumption underpinning the economic theory of why such taxes should succeed is based on target actors behaving solely with economic rationality, implying that they will always be responsive to price signals. This model of behaviour is then applied to all actors, be they individual farmers or large companies. Classical economists, taking the simple deductive process to its logical conclusion, then propose that in order for taxes to perform as spurs for the implementation of environmentally benign management practices and technologies all that is required is the setting of a sufficiently high charge level.

The case studies appear to fit neatly into the theoretical model provided by economics, with target actors responding with economic rationality to the imposition of the charge through the introduction of technical changes aimed at reducing the emissions that attract the charge. However, this has been dependent on a number of factors, as identified by Hogg (2000) that can impede a target's decision to respond appropriately, being successfully resolved. There follows a brief discussion of these issues, which serves to further explain the rational response.

Firstly, Hogg attributes some importance to the seniority of management dealing with the cost factor affected by the tax. In the case of MINAS, the target groups are mainly family businesses in which the farmer and his/her family are at the same time entrepreneur, manager and main labour force of the farm (Ondersteijn, 2002). The decision to respond to MINAS therefore lies with the most senior management, ensuring that it receives the attention of those most capable of initiating action. The incentive to adopt existing techniques and technologies is also dependant on the overall cost represented by the pollution charge relative to other cost sectors within targeted firms. Traditionally, firms look to large expenditure cost sectors when seeking to economise and frequently the costs imposed by pollution charges are relatively small and therefore they do not always provide the assumed incentive effects to innovate and change behaviour. Under MINAS, the size of the levy relative to the total costs of the firm has already been established; the conclusion being that it represents a substantial proportion that warrants the implementation of measures to reduce exposure to the tax. In the case of the NO_x charge, the importance allocated to the charge varies across the target group, given the range of sectors and firms involved. However, firms continually seek to minimise indirect costs of production, such as those imposed by the NO_x charge, in order to maintain competitiveness. Therefore, since the charge is high relative to the average abatement costs, it can be expected that an assessment of possible measures would be carried out, the implementation of which would then depend on the financial significance of the charge as well as limitations imposed by existing equipment and budgetary constraints.

The remaining issues raised by Hogg relate to the knowledge possessed by firms concerning appropriate techniques and technologies and the existence, or otherwise, of the skills necessary to perform or use such techniques and technologies respectively. Therefore, the spread of knowledge and information is considered to be a key determinant in the success of the instruments. In MINAS, the existence of the 'information dissemination pyramid', which diffuses knowledge concerning various management practices, effective in reducing mineral surpluses, is an essential supporting policy that ensures that farmers are equipped with the required skills to respond appropriately to the policy. These schemes then increase the number of farm businesses that are capable of effectively responding to the instrument. For the NO_x charge, the presence of various proven pollution-reduction technologies, a supporting supplier industry, and the industrial set-up with technical staff in all companies, certainly facilitated the choice and implementation of these technologies and optimisation of existing equipment within the firms. The regulator provided further information regarding the taxing procedure and available measuring equipment.

4.2. Policy Design

Once barriers constraining the ability of actors to respond to price signals have been addressed, then a sufficiently high charge rate is indeed a crucial factor in ensuring effectiveness. In the NO_x case study, the charge was set four times higher than the average cost of pollution abatement measures, whereas in MINAS the levy threatened the viability of farms.

According to economic theory, this monetary incentive should then translate into targeted actors implementing measures to reduce their exposure to the tax until the marginal cost of further reductions in emissions is equal to the tax (Baumol and Oates, 1988). In the short term, this entails pollution abatement at minimum cost but can also have dynamic effects in the longer term by providing an incentive for continuous improvements.

Certainly, in the MINAS case, farmers have had to respond in order to reduce surpluses to the levy-free surplus of 2003 or face crippling fines. However, once this standard is reached there is no further financial incentive, at least none supplied by the charge, to continue to reduce surpluses. With regards to environmental effectiveness, it then becomes important that the final levy-free surplus reflects a sustainable environmental level for mineral surpluses, illustrated by the WHO safety limit of 50 mg N/litre of groundwater, as the levies do not provide any financial incentive to exceed the standards.

In contrast, the companies targeted by the NO_x charge have acted on the basis of maximising profits rather than doing so to remain in business. The trend in emission reductions appears to have stabilised, indicating that the firms have invested sufficiently to minimise their emissions, and hence the charge burden, as far as is economically appropriate. Although this may not correspond to the best possible environmental result, it takes into account the limited response that can be made with existing installations and equipment turnover rates.

The setting of a sufficiently high charge rate is prone to a number of recognised pitfalls that can materialise during the policy design stage. Environmental economics theory assumes that policy-making involves a "process of choice for a single actor's pursuit of maximum cost-effectiveness" (Bressers *et al*, 2000: 79). In reality, the policy-making process is open to the influence of a number of different actors all pursuing their own individual goals, of which cost-effectiveness may not be one, which can result in the less than optimal implementation of the instrument.

The "Fiscal syndrome" (Andersen 2000:36) refers to a situation in which the government sets the tax rate according to fiscal requirements instead of a desired environmental target. In such cases the charge is levied at a lower rate than the pollution abatement costs, because the policy is not designed with the final aim of altering the environmentally damaging behaviour, thereby creating a situation in which it becomes cheaper for the targeted industry to simply pay the tax. This appears to have been avoided with regards to MINAS, as demonstrated by the fact that the total levies charged for the year 2000 were 40% lower than in 1999, indicating a reduction in taxable surpluses. The revenue generated by the NO_x charge is returned to the producers and therefore there was no incentive for the regulator to set the charge at a low level merely to collect revenue.

The "Linkage syndrome" (ibid, 2000:38) refers to a situation in which those liable for the tax manage to gain a refund, known as a feebate, which matches the original amount paid in tax. Although the redistribution aspect of the NO_x charge falls into this category, it was deemed necessary in order to safeguard the competitiveness of the sector. Moreover, since the revenues are returned in proportion to the plants' energy efficiency, there still exists a strong monetary incentive to increase eco-efficiency.

Another design pitfall that may affect the policy's environmental effectiveness, termed the "Bakermaster syndrome" (ibid, 2000:36), is the granting of exemptions to the largest polluters, which can take place due to effective interventions from powerful lobby groups. This cannot be said to have occurred in the MINAS case; indeed the largest polluters receive correspondingly large levies. Similarly, the larger polluters were primarily targeted by the NO_x charge, since they were considered to be best able to cope with the expense of installing, operating and maintaining the measuring equipment required.

What this discussion highlights is the importance of the presence of the necessary political will to implement an effective policy and to withstand the pressures of lobbying during the policy making process. In the studied cases, the gravity of the individual issues within the countries, and the parallel financial costs required to treat the symptoms, must have provided the state with a strong case for implementing the measures. Indeed a weighing-up process always occurs within governments when deciding between interests of economic activities and interests of environmental quality. The contributions made by specific polluting activities to the economy are compared to the risks to human health and nature and a political balance is struck. This finally determines whether there will be sufficient support for the application of stringent policy measures

4.3. Environmental Performance

The environmental results of the policies are notable: an estimated overall reduction of 40% in total NO_x emissions from the targeted sector since 1990, and with regards to MINAS, there was a substantial drop in nitrogen emissions for the first time in twenty years following the introduction of the policy. Both instruments demonstrate the theory of environmental economics working in practice, by prompting a change from treating the symptoms of the pollution through publicly funded investment, to switching to prevention of pollution by internalising the external cost and making the polluter pay (Pearce *et al*, 1993).

With regards to environmental effectiveness, the potential of the two case studies varies due to the different basis on which the policies have been developed. In MINAS, the designated standard is the WHO safety level of 50mg nitrates per litre of groundwater. The system of prohibitive charges is then used to provide the incentive for farmers to implement management practices aimed at reducing nutrient surpluses to this level, with the prospect of making nutrient use within agriculture sustainable.

In contrast, technological capabilities, rather than ecological limits, form the basis of the Swedish NO_x emission regulation, both in terms of the standards defined in the individual licensing permits and in the setting of the charge rate. The use of the charge as an economic incentive to reduce emissions to and below the levels defined in the permits is more cost-effective, since considerable knowledge and monitoring of the individual plants would be required by the regulator to maintain a system based solely on standards. However, the necessity of taking the ecological limits into consideration in order to develop an environmentally effective policy is clear in view of the significant reductions from all sectors that are still necessary if Sweden is to meet its targets as defined in the Gothenburg Protocol and EU National Emission Ceilings Directive.

The environmental objectives of the policies have largely been achieved through stimulating technical change and the diffusion of existing technologies. The question that can then be asked is whether the instruments can have dynamic effects, manifested by continued improvement over time, and a continuous reduction of the firm's environmental impact. A theoretical advantage of eco-taxes over command-and-control approaches is the built-in continuous incentive provided by the charge, which is levied on each unit of pollution.

The potential of MINAS to generate continuous measures to reduce surpluses appears limited in one sense, due to the lack of financial incentive provided by the instrument once the levy-free surplus is reached. However, the possibility exists that MINAS may offer a win-win situation to those able to rise to the challenge, in so far as increases in efficiency may result in a decrease in cost, and thus both economic and environmental gains can be realised. This then presents the possibility that farmers may continue to implement changes, which reduce their nutrient surpluses beyond the final levy-free surplus, a learning process that may have been triggered by the instrument.

The NO_x charge can be said to have upgraded the environmental performance of the targeted sector, by focusing attention on the issue and encouraging investment in pollution abatement measures. The charge has a relatively limited scope since it was primarily designed to curtail emissions from existing installations, given the long turnover rates associated with energy production equipment. The performance of the sector may very well improve further as the higher standards become normalised, and become a factor for consideration in future equipment investments.

The influence of eco-taxes is also expected to extend beyond the immediate target group to upstream supporting industries. This is a result of these supporting industries adapting to the changing demands of their customers, which can then result in incremental innovation as upstream actors improve technologies to minimize the environmental impact. This appears to have happened in both case studies, but due to other complimentary policies the effect of the charge is not easily extricable.

5. Conclusion

Through designing instruments to the individual contextual circumstances to which they will be applied, by considering the potential pitfalls of the policy-making process and the barriers to technical change within target groups, eco-taxes can indeed prioritise the issue for target groups, through the imposition of a high charge. This then can result in an enduring eco-upgrading of the particular sector to which the instrument is applied, achieved in the main through increased efficiency and the diffusion of higher standards that then become normalised and institutionalised within companies. Such results can be a starting point for a transition to a more sustainable society, by limiting the environmental damage of current systems, and forcing a learning process on polluters about their environmental impacts.

The role of the state within environmental policy should not be limited merely to designing and implementing effective measures to diffuse cleaner technologies, but should involve guiding and supporting the path of development and innovation. This is in recognition of the failure of the market to allocate resources in the best interests of society. There is no guarantee that companies will select the appropriate development trajectory, indeed as Ayres asserts, "unfettered markets have not, and will not, create technology to solve environmental problems except by accident" (1998:148).

These requirements seem to suggest that the state has an important role to play in formulating policies aimed at steering industrial sectors onto more sustainable development trajectories, but also the emphasis is on the market to provide a balanced approach. In this context, eco-taxes have a definite value as instruments for the diffusion of environmentally beneficial techniques and technologies and incremental innovation.

References

Andersen, M.S. (1994) *Governance by green taxes – Making pollution prevention pay.* Manchester, Manchester University Press

Andersen, M.S., Sprenger, R-U. (eds) (2000) *Market-Based Instruments for Environmental Management - Politics and Institutions*. Cheltenham, Edward Elgar.

Ayres, R.U. (1998) *Turning Point. An End to the Growth Paradigm*. London, Earthscan.

Baumol, W.J., Oates, W.E. (1988). *The Theory of Environmental Policy,* (2nd Edition). Cambridge. Cambridge University Press.

Bergström, T. (1999) *Steering effects of the Swedish NO_x charge*, Masters Thesis International Institute for Industrial Environmental Economics, Lund University, Sweden

Bressers, H.T.A., Huitema, D. (2000) 'What the doctor should know; politicians are special patients. The impact of the policy making process on the design of economic instruments' In: Andersen, M.S., Sprenger, R-U. (eds) (2000) *Market-Based Instruments for Environmental Management - Politics and Institutions*. Cheltenham, Edward Elgar.

Brinkhorst, L. J., Pronk, J.P. (1999) Integrated Approach to the Manure Problem. Letter to the Dutch Parliament. http://www.minlnv.nl/international/info/parliament/03.htm

Ecotec Research and Consulting, (2001a) 'Nitrogen Oxides (NO_x) Taxes and Charges' In: *Study on the Economic and Environmental Implications of the Use of Environmental Taxes and Charges in the European Union and its Member States.* Birmingham.

Ecotec Research and Consulting (2001b) 'Taxes on Fertilizers and Mineral Surpluses' In: *Study on the Economic and Environmental Implications of the Use of Environmental Taxes and Charges in the European Union and its Member States*. Birmingham.

EEB (The European Environmental Bureau), The Swedish NGO Secretariat on Acid Rain, and The European Federation for Transport and Environment (T&E), (1998), *The Large Combustion Plants Directive - Comments to the Commission's proposed revision.* http://www.acidrain.org/lcp.pdf

European Union (2003) EU Air Pollution Legislation http://www.europa.eu.int/scadplus/leg/en/s15004.htm

Hogg. D. (2000) The Limitations of Economic Instruments as Stimuli for Technical Change, Technological Change and Innovation. In Andersen M. S. Sprenger, R-U. (Eds) (2001). *Market-Based Instruments for Environmental Management.* Edward Elgar.

Höglund L., (2000) *Essays on Environmental Regulation with Applications to Sweden.* PhD Thesis, Department of Economics, Göteborg University, Sweden

IISD (International Institute for Sustainable Development) (1994) Making Budgets Green. Leading Practices in Taxation and Subsidy Reform. Winnipeg, IISD.

Levy, M (1995) *International Co-operation to Combat Acid Rain*, In: Green Globe Yearbook of International Co-operation on Environment and Development, Oxford, Oxford University Press

Ministry of Agriculture, Nature Management and Fisheries. (2001) *Manure and the Environment. The Dutch Approach to Reduce the Mineral Surplus and Ammonia Volatisation.* The Hague, Department of Agriculture. http://www.minlnv.nl/international/policy/environ/

Nordic Council of Ministers (1999) *The Use of Economic Instruments in Nordic Environmental Policy 1997-1998*, Copenhagen, TemaNord.

OECD (1997) *Evaluating Economic Instruments for Environmental Policy*. Paris, OECD.

Ondersteijn, C.J.M. (2002) *Nutrient Management Strategies on Dutch Dairy Farms. An Empirical Analysis*. PhD Thesis, Wageningen University, The Netherlands

Opschoor, J. B., de Savornin Lohman, A.F. Vos, H.B. (1994). *Managing the Environment. The Role of Economic Instruments.* Paris, OECD.

Pearce D., Turner, R.K., Bateman, I., (1993). *Environmental Economics. An Elementary Introduction*. The John Hopkins University Press. Baltimore.

Rijksinstituut voor Volksgezondheid en Milieu (2002a) The Dutch Environmental Data Compendium. Office for Environmental Assessment. RIVM. http://arch.rivm.nl/environmentaldata/C_Environmental_pressure/C2_Agriculture_and_horticulture/index.html

Rijksinstituut voor Volksgezondheid en Milieu (2002b) Minas en Mileau. Balans en Verkenning. Milieu en Natuurplanbureau, RIVM.

Sachs, W. Loske, R. Linz, M. (1998) Greening the North. A Post-Industrial Blueprint for Ecology and Equity. Zed Books, London.

SEPA (Swedish Environmental Protection Agency) (1995) A *review of action taken by the Swedish authorities to achieve nine environmental objectives*, Stockholm, SEPA

SEPA (Swedish Environment Protection Agency) http://www.naturvardsverket.se/

SEPA (Swedish Environmental Protection Agency) (2000) *The Swedish Charge on Nitrogen Oxides*. http://www.internat.environ.se/documents/pollutants/nox/nox.pdf

United Nations Economic Commission for Europe (UNECE) (1979) *Convention on Long-range Transboundary Air Pollution.* http://www.unece.org/env/lrtap/lrtap_h1.htm

VKP (The Association of Fertiliser Producers) (1998) *Challenges Facing the Dutch Fertiliser Sector.* http://www.kunstmest.com/ENG/index.html