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Encouraging Environmentally Sustainable Growth in Sweden

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ENCOURAGING ENVIRONMENTALLY SUSTAINABLE GROWTH IN SWEDEN

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by
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ABSTRACT/RÉSUMÉ

This paper analyses Sweden's policies for addressing a range of key environmental challenges. Although Sweden has a deliberately comprehensive approach to establishing its environmental objectives and policies, some issues have received particular attention. These include acidification and climate change arising from harmful cross-border and global air emissions, damage to waterways stemming from nutrient run-off from farming, and solid waste management. This review concentrates on the scope for Sweden to refine and extend the use of economic instruments to achieve better environmental outcomes in each of these areas. At the same time, more systematic and rigorous use of cost-benefit analysis in designing policies and in evaluating measures that have been put in place, would help Sweden to achieve its desired environmental objectives in the least costly way, or alternatively, to achieve the best environmental results for a given economic sacrifice.

JEL classification: H23, Q00, Q20, Q28, Q40, Q48
Keywords: Sweden, sustainable development, environmental policy

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Ce document analyse les politiques développées par la Suède dans son effort pour répondre à plusieurs questions clés sur l'environnement. Malgré l'approche très globale utilisée par la Suède pour l'établissement de ses objectifs environnementaux, quelques aspects en sont ici traités de façon particulière. Il en est ainsi des problèmes de l'acidification et du réchauffement de la planète résultant des émissions de gaz aux niveaux transfrontières ou globaux, l'endommagement des cours d'eau provoqué par les excédents nutritifs du secteur agricole, et la gestion des déchets. La présente étude se concentre sur les possibilités pour la Suède d'affiner et d'élargir l'utilisation d'instruments économiques afin de parvenir aux meilleurs résultats dans chacun de ces domaines. En même temps, une application des techniques d'analyse coût-bénéfice plus rigoureuse et systématique, aussi bien pour le choix de nouvelles politiques que pour l'évaluation des approches actuelles aiderait la Suède à achever ses objectifs environnementaux au moindre coût ou, en d'autres termes, à obtenir de meilleurs résultats environnementaux pour un moindre niveau de sacrifice économique.

Classification JEL : H23, Q00, Q20, Q28, Q40, Q48
Mots clés : Suède, développement durable, politique environnementale

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ENCOURAGING ENVIRONMENTALLY SUSTAINABLE GROWTH IN SWEDEN

Deborah Roseveare[1]

Background

1. Sweden's policies place a great deal of emphasis on sustainable development.[2] The environment forms one important part of this approach and is the focus of this chapter. Environmental concerns began in Sweden with nature protection in the first half of the twentieth century, and dealing with the local effects of industrial emissions became important already in the 1960s. Acidification problems were identified in the early 1970s and led to growing awareness of the international dimension of pollution. Sweden hosted the first UN Environment and Development Conference in 1972 and has been active in promoting international agreements for addressing cross-border environmental problems. These efforts have been extended to promoting international action to deal with climate change. Concern about the environmental effects of the production and use of chemicals, eutrophication and dealing with waste have also been major pre-occupations of Swedish environmental policies. Its environmental performance is already good by OECD standards, and significant progress has been made in a number of dimensions (OECD, 1998). Notwithstanding these achievements, the authorities remain dedicated to seeking further improvement in environmental outcomes but almost inevitably, the costs and challenges of achieving further environmental improvements rise with the progress already made.

2. Sweden has taken an integrated approach to environmental issues, and has recently adopted a new framework of environmental objectives. This approach has made more apparent some of the difficult choices and trade-offs that arise in reaching several different environmental outcomes — the most striking example perhaps being the difficulty of simultaneously reducing global greenhouse gas (GHG) emissions, closing nuclear power plants and renouncing further hydro-electric development. It has also helped to make the inter-linkages between policies more transparent. In light of these particular features, and the contrast with the more fragmented approach to these issues observed in some other OECD countries, the institutional settings for environmental policy-making will be discussed in some detail in the next section of this chapter.

3. Although the Swedish framework for environmental policies is deliberately comprehensive, a set of specific environmental issues have been the main focus of attention and debate. This chapter will also concentrate on these concerns, organised according to desired environmental outcomes. While a sectoral approach is often adopted when discussing environmental issues in OECD Member countries, including Sweden, focusing on the goals to be achieved reinforces the importance of choosing policies that do so in the least-cost manner across different sectors. Thus, without implying that these are the only issues relevant to environmentally sustainable growth, the rest of this chapter focuses in turn on: reducing airborne emissions affecting acidification and climate change; addressing the damage from eutrophication; and dealing with waste. The final section will provide an overall assessment and policy recommendations.

Environmental policy making

The policy making process and its key players

4. The Swedish approach to policy-making in general could be characterised as a process of study, consultation and collective decision-making, followed by decentralised implementation, sectoral responsibility, and public information and education. There are many players in the policy-setting process (OECD, 1996), including a number of central government ministries and agencies, as well as local authorities and a range of non-governmental organisations. Public submissions and the co-opting of experts from outside the government are both ways in which a wider range of views are harnessed. The heavy emphasis on consultation and discussion means that the issues are thoroughly considered and results in relatively coherent actions rather than a fragmentation of effort. It also means that policies finally adopted usually enjoy a relatively high degree of support.

5. The Ministry of the Environment has responsibility for co-ordination of the government's environmental policy and the promotion of efforts to achieve sustainable development both within Sweden and internationally. Following the general structure for organising government responsibilities, the Ministry is small and deals only with policy issues, while the 13 agencies under its aegis are responsible for different aspects concerning the implementation of policies. In principle, these agencies are independent of the Ministry and are able to take decisions within the framework of the guidelines, laws and ordinances issued by the parliament and the government. The key central government agency is the Environmental Protection Agency, whose mandate is to:

- Promote ecologically sustainable development and contribute to achieving the objectives by taking on the role of co-ordinator and driving-force in environmental work both nationally and internationally.

- Compile and disseminate knowledge about the environment, *i.e*. the current situation and its development.

- Promote sustainability in trade and industry, products, waste and infrastructure in co-operation with the sectoral authorities, as well as regional and local authorities.

- Contribute to the realisation of environmental policy and the achievement of established goals.

- Follow up and evaluate the condition of the environment and the work done to form the basis for further development of environmental policy.

6. Three other ministries are also heavily involved in setting environmental policies. The Ministry of Finance is especially concerned with environmental taxation and environmental programmes that involve public spending. The Ministry of Agriculture and the Ministry of Industry, Employment and Communications, have sectoral responsibilities with important environmental dimensions, in the latter case for energy and transport.

7. The Swedish Environmental Advisory Council, which advises the Government on environmental issues, has representatives of relevant sectors of the Swedish Cabinet Office and Ministries and provides advice to the government either on its own initiative or on issues assigned to it. It fulfils an important role in developing the government's position on the overall management of environmental issues. Most ministries have some environmental responsibilities, above and beyond the general requirement to take environmental dimensions into account in setting policies and managing their own affairs.

8. Local authorities also play an active part in environmental action, mostly using the framework of Agenda 21,[3] and, by the end of 1998, just over half the municipalities had adopted a local Agenda 21 plan. Initially plans focused primarily on waste and water management, together with "green" public procurement, but more recently the range of issues has expanded to include renewable energy, biological diversity, environmental management and auditing systems and sustainability indicators (Brundin and Eckerberg, 1999). Municipal boards for environmental protection and health also issue licences for small installations under the Environment Code and are charged with actively promoting nature conservation in their area. County administrative boards have major responsibility for the administration of environmental policies within their jurisdiction, including licences for medium-sized installations, and inspection also of those licences issued at the national level. They also manage national parks and nature reserves and co-ordinate policies within their areas.

9. Local authorities also assume a major role in Local Investment Programmes. These programmes were initiated in 1998 and have two key objectives: to reduce local environmental problems; and to create employment. They are based on the belief that the local authorities know most about the local environmental problems and conditions for sustainably-oriented development and are best suited to decide which measures are most important and useful in their local area. Project proposals from local authorities must show evidence of co-operation with the public, the business community and non-government organisations. In Sweden, local authorities play a major role in environmental protection and Local Investment Programmes constitute one way for the government to stimulate the shift towards an ecologically sustainable society. Parliament has now allocated SKr 7.2 billion in total to this programme, of which SKr 5 billion has already been disbursed, and the scheme has been extended to 2003. Both the environmental and economic value of these subsidies could be questioned, however, on three grounds. *First*, the employment-creation requirement may exclude some projects that would generate greater benefit for the environment. *Second*, the subsidies may be paid to projects that would have been privately funded anyway, and, third, an examination of the types of projects funded suggests that many of the environmental benefits are local and might be more appropriately funded through local revenue sources[4] (Table 1). However, the Local Investment Programmes are expected to have important effects on the environment, even at the national level, for example in reducing CO_2 emissions by almost 3 per cent. The first programmes were completed in 2000 and a broad review of the whole scheme is planned during 2001-04. Such a review should include a rigorous analysis of all the economic costs relative to the environmental and economic benefits obtained.

Table 1. **Local Investment Programmes**
Funding by type of project,1999

	Per cent
Conversion to renewable energy sources	20.5
Multi-dimensional projects	17.4
Waste management	10.2
Water and sewerage	9.6
Energy efficiency/energy saving projects	9.5
Remedial measures	9.5
Traffic	8.9
Nature conservation/biological diversity	6.3
Building projects	4.3
Other	3.8

Source: Ministry of the Environment.

Environmental objectives

10. Environmental policies in Sweden are strongly oriented towards establishing goals and objectives. Recent efforts to identify what are the overall aims of the whole set of environmental policies are a clear strength of the institutional arrangements, particularly because they have made the potential tradeoffs between goals more transparent. In 1996 the Swedish Environmental Protection Agency identified some 170 environmental goals of various kinds that were embodied in current policy. The Agency pointed out that these goals did not fit together in a coherent fashion, and in many cases progress towards meeting them could not be monitored effectively, which made them unsuitable as a basis for developing sensible policy instruments. In response, the government developed the current framework of 15 key environmental objectives to steer policy: clean air; natural acidification only; no eutrophication; a non-toxic environment; a protective ozone layer; a safe radiation environment; high-quality groundwater; sustainable lakes and water courses; flourishing wetlands; a balanced marine environment, sustainable coastal areas and archipelagos; sustainable forests; a varied agricultural landscape; a magnificent mountain landscape; a good urban environment; and limited (influence on) climate change.

11. These were endorsed by the Parliament, and subsequent work has concentrated on developing proposed specific objectives, intermediate tasks, strategies and policy instruments. These were reported back to the Government in June 2000 (Committee on Environmental Objectives, 2000 and Klimatkommittén, 2000) which will soon deliver a bill to Parliament on these issues. It should be noted that these objectives are highly ambitious, and even if achieved in the most efficient manner, will inevitably be expensive. But this was seen as justified, given the parliamentary committee's valuation of the economic costs of ongoing environmental damage (excluding global warming) of SKr 20 billion per year (around 1 per cent of GDP) and their estimate of SKr 10 billion to achieve the goals, yielding a positive return to society of SKr 2 for each krona spent. Although the committee acknowledged the uncertainty of their estimates, they could in some sense be interpreted as an implicit, albeit crude, indication of the extent to which the Swedish public values the environment and is willing to pay for its improvement.

12. An alternative measure of the costs of sustainable development is the adjusted net national product, also known as "green" national accounts. This is obtained from the national accounts measure of net national product (*i.e*. the sum of consumption, net changes in real capital and the trade balance) plus increases in the natural capital stock, minus environmental damage. The National Institute of Economic Research has prepared estimates of adjusted net national product for 1993 and 1997 taking into account the change in natural resources, environmental damage, apart from global warming, depletion of the ozone layers, and reduced biological diversity. Their estimates indicate that Sweden's development is already very close to being environmentally sustainable, since the environmental damage and rundown of natural capital came to SKr 8.7 billion in 1997 or just over ½ per cent of net national product[5] (Table 2). While these are only estimates and preparing them has involved some difficult measurement and technical issues, they do provide a benchmark, which suggests that the policies designed to offset or avoid these environmental damages should not involve costs in excess of that amount or they would lead to an overall loss of welfare.

Environmental policy design

13. Sweden has a wide range of specific environmental policies, as would be expected in a country that had many years' head start over other nations where environmental concerns have only more recently come to the fore. There are two key features of its specific policies to address environmental concerns: the sectoral approach and the emphasis on economic instruments. Despite the orientation given to setting

Table 2. **Net national product (NNP) adjusted for the environment**
SKr million, 1997 prices

	1993	1997
Consumption	1 314.6	1 372.2
Net trade balance	78.0	161.8
Investment	209.9	244.7
Gross national product	1 602.5	1 778.7
Depreciation	-222.5	-212.6
Net national product	1 880.0	1 566.1
Increase in forestry stock	6.2	5.7
Mining	-1.2	-1.2
Natural capital erosion	-5.8	-5.4
Environmental damages	-3.4	-3.3
Adjusted national net product	1 375.7	1 561.8

Note: Natural capital degradation and environment damages are expressed in terms of real economic effects.
Source: Ministry of Finance.

environmental outcomes in terms of reducing environmental damage, specific policies tend to have a distinctly sectoral flavour and aim at reducing damage, sector by sector. To a large extent this reflects the logical organisation of government work and has been reinforced by Parliament's adoption of the principle of sectoral responsibility for the environment. While such an approach is both logical and efficient for most policies, it can present significant drawbacks for sound environmental policies, where several sectors are producing the same type of environmental damage because it becomes harder to ensure that marginal abatement costs be equalised across all economic actors. Although the extensive discussions that typically take place before any policy is adopted in Sweden should minimise this risk, there is no built-in mechanism that explicitly or implicitly "tests" sectoral policies to check that they deliver equalised marginal abatement costs.

14. A particular issue arises over exemptions or other special treatment for specific sectors, in particular the special rules for energy-intensive enterprises and the lower rates of CO_2 taxes for industry and agriculture. These are used in Sweden and elsewhere, in relation to products that are, or may be, internationally traded. The argument, put forward in support of special treatment, is that without exemptions, unilateral efforts to internalise environmental costs will penalise exporters and favour imports from less stringent countries relative to domestic producers, both hurting local producers and leading to an increase in global environmental damage by shifting production to enterprises and countries with lower environmental standards. But allowing tax breaks for some producers means that others must face higher taxes and the approach encourages rent-seeking behaviour. Moreover, whether leakage of harmful emissions would actually occur is essentially an empirical matter and depends on the responses across all

sectors of the economy to the removal of exemptions and the production functions of alternative foreign producers given the emission reduction policies that apply in their countries.

15. Another relevant issue, particularly in Sweden, is switching taxation from labour to environmental taxes, especially on energy. This change is often assumed to provide a "double dividend" by simultaneously generating both environmental and economic benefits. However, this is an empirical question that depends on the industrial structure of the economy, its mix of exports and imports, and the elasticities of demand and supply for labour and energy and the existing tax structure. Results from computable general equilibrium models for Sweden suggest that making such a shift might leave the country economically worse off, even if the switch were revenue-neutral and involved lowering labour taxes, which are among the most distortionary (Swedish Green Tax Commission, 1997). For example, a doubling of the carbon tax (approximately SKr 1 000 per household) offset by lower labour taxes would incur a "welfare" loss of SKr 4 billion and reduce carbon dioxide emissions by around 0.1 per cent.[6] Moreover, subsequent work indicates that with the current set of exemptions and reductions for some sectors, such a tax swap would provide limited environmental benefits, because emissions could actually increase in exempted sectors (Bränlund and Kriström, 1997). Depending on trade elasticities, it is possible that global emissions would actually rise, as a result. Notwithstanding these analyses, the Swedish Government has decided to go ahead with such a tax switch from labour to CO_2 taxes, amounting to around SKr 30 billion (1½ per cent of GDP in 2000) over 10 years; the first SKr 3.35 billion of which is incorporated in the 2001 budget. While this approach may satisfy political commitments, there is a danger that it proceeds in a piecemeal fashion that over time drifts away from sound tax principles and it would be better instead to evaluate each tax on its own merits and only raise CO_2 taxes after the exemptions had been removed.

Policy instruments

16. Along with its Nordic neighbours, Sweden was one of the first countries to develop and implement economic instruments. Indeed, the OECD's judgement in 1996 was that Sweden probably had more economic instruments in place than any other Member country (OECD, 1996). Economic instruments currently in place cover a range of incentives, including taxes and charges on emissions (*e.g.* CO_2, nitrogen oxide and sulphur), pollutants (*e.g.* pesticides tax), environmentally differentiated charges (*e.g.* fairway dues for shipping), and subsidies (*e.g.* energy technology funds and investments). Notably absent are tradable emissions permit schemes, which are more extensively used in North America. However, last Spring an inquiry into the feasibility of using flexible mechanisms recommended that Sweden immediately begin developing a trading system with other EU members and applicants, and EEA countries. A well-designed set of environmental taxes or tradable permits are both cost-efficient ways of achieving desired environmental outcomes.

17. Sweden also relies quite extensively on regulation and control in certain areas. This is perhaps most evident in controls over agricultural farming practices, land use more generally, hazardous chemicals, licences for certain emissions from stationary sources and waste management. The legislation governing these and other aspects of environment regulation is the Environmental Code that came into force on 1 January 1999, which replaced some 15 separate pieces of legislation. The purpose of implementing the Code was threefold: to put more emphasis on goals and results management; to provide a more coherent and integrated treatment across the environment; and to integrate more recently developed instruments, such as eco-labelling and environmental management systems, into environmental legislation. However, although the Environmental Protection Agency is charged with undertaking cost-benefit analysis of central government regulations, mechanisms to ensure that regulations applied by regional and local authorities are based on rigorous cost-benefit analysis remain lacking.

18. Public funding of research into environmental matters is also a high policy priority. Together with an early preoccupation with environmental issues, this has meant both ample financing and significant results. However, most of this funding has come from the taxpayer. It is generally accepted that because of the externalities involved, governments have a clear role and responsibility for funding basic scientific research, and much of the research into environmental damage and its causes clearly falls into this category and makes an important contribution to international scientific understanding. However, it is less clear whether the government should also be financing projects with commercial potential. Access to quality research about environmental damage and its causes would certainly make it easier for policy-makers to design sensible policies. However, there is also a risk that the present broader research programme might lead to an over-emphasis on technical solutions without sufficient analysis of the economic consequences and costs. Developing some best-practice guidelines on project evaluation that addressed economic considerations in a more rigorous fashion might help.

Air quality, climate change and emissions

19. Sweden's policies on air-borne emissions are governed by two main concerns: acidification and global warming. These two problems are quite distinct in that while acidification affects Sweden directly, climate change affects the planet as a whole, albeit with significantly different regional effects.[7] In each case, the environmental consequences of harmful emissions on Sweden are the same regardless of where and how they originated, so the key social objective ought to be to reduce the relevant emissions in the least-cost way or to maximise the emissions reductions that can be achieved for a given cost. Choosing policies to achieve this may require stepping back from a sectoral approach and instead focusing on economic incentives to encourage those who can reduce emissions most cheaply to do so. Sweden has already achieved some notable successes in using economic instruments as well as regulation to reduce emissions, which have fallen in a number of areas. It should also be noted that since the beginning of the 1990s efforts have been made to achieve cost-efficient reductions in global and regional emissions by directing a major share of development aid to countries in the Baltic region and eastern Europe with large emissions. The emphasis on environment and enlargement as key priorities during Sweden's presidency of the EU is part of the same strategy. Table 3 shows the targets together with the reductions in emissions achieved thus far.

Acidification

20. Acidification of soils and waterways is caused by emissions of sulphur, nitrogen oxide (NO_x), ammonia and volatile organic compounds. It is a particular problem in Sweden because of a combination of abundant precipitation and soil composition. Sweden's low average critical load (*i.e.* where the level of deposition exceeds nature's ability to compensate, and environmental damage to soil and water ensues) has required an extensive programme of liming to offset the damage, at an annual cost of more than SKr 200 million, around 85 per cent of which is publicly funded. The most difficult policy challenge for Sweden in reducing damaging emissions arises from the essentially transboundary nature of the problem. In 1997, for example, more than 123 000 tonnes of sulphur was deposited on Swedish soil, of which only 12 000 tonnes originated in Sweden itself (see Figure 1). Meanwhile, total Swedish emissions amounted to only 34 000 tonnes, one-third of which was deposited at sea. Clearly then, effective action requires international co-operation.

21. Sweden has been working actively since the first UN Environmental and Development Conference in 1972 towards international action to deal with the problem. The Convention on Long-Range Transboundary Air Pollution was agreed 20 years ago, and protocols have contained quantitative reduction targets since 1985 (Ministry of the Environment, 1999). The most recent achievement has been the

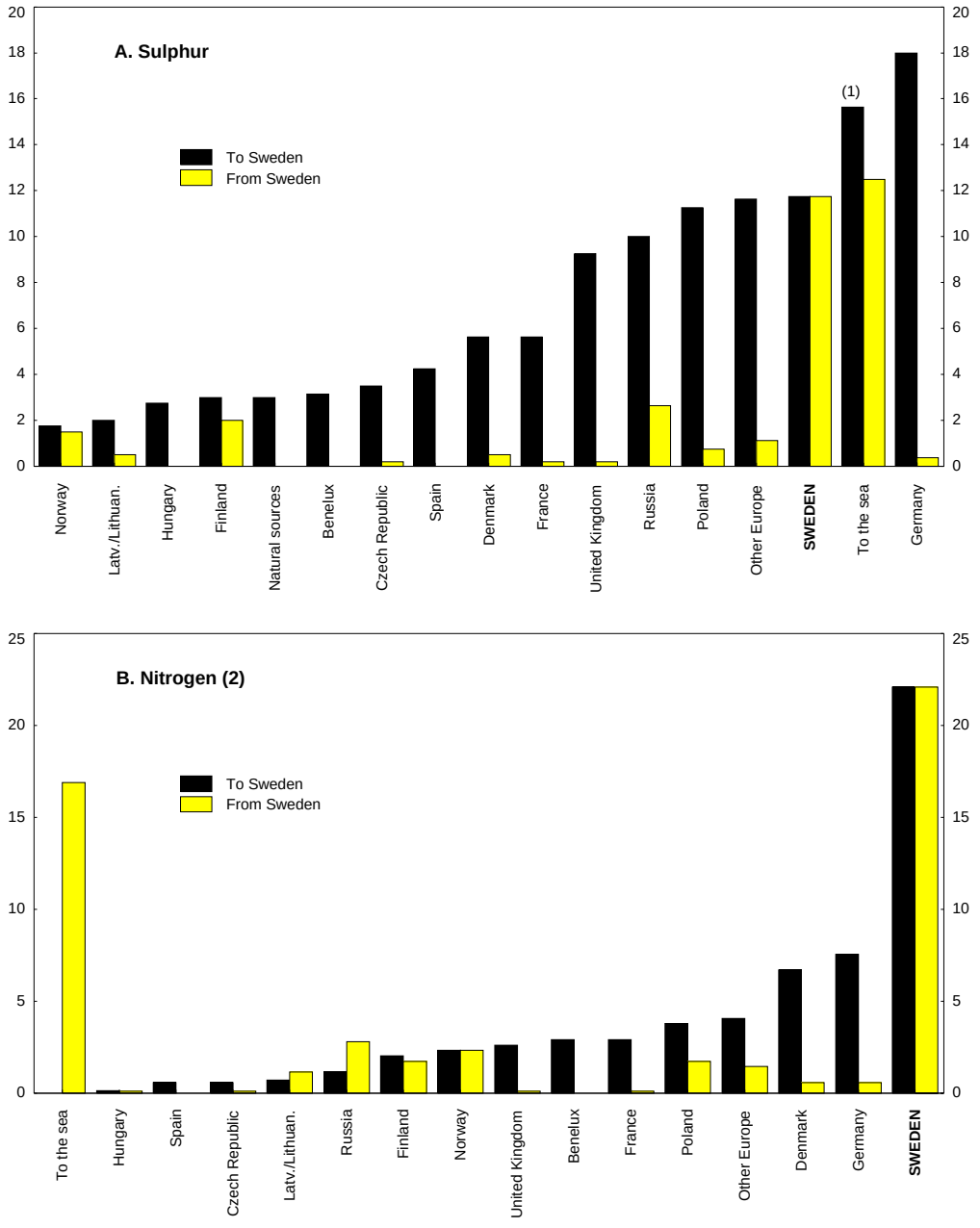
Göteborg Protocol, signed in December 1999, which deals with four types of pollutant and specifies more stringent targets. If the agreed targets for emissions reduction under this agreement are met, only 4 per cent of Sweden's surface area will receive more than the critical load by 2010, compared with 17 per cent in 1990.[8] In principle, the Protocol is designed so that those parties whose emissions have a more severe environmental or health impact and whose emissions are relatively cheap to reduce will have to make the biggest cuts. While it remains up to each country to determine its own set of commitments, parties are encouraged to use economic instruments in order to promote the search for least-cost abatement strategies.

Table 3. **Emissions: achievements and targets**

	1980	1990	1995	Latest	Targets
	(1 000 tonnes)				
Emissions of SO_x	508.0	136.0	94.0	91.0	Previous target
of which:					– Emissions in 2000 equal to only one-fifth of the level prevailing in 1980 (already achieved)
Mobile sources	44.0	37.0	24.0	24.0	
Stationary sources	464.0	99.0	70.0	67.0	Proposed new target
					– By 2010, decreased by at least 25 per cent from 1995 levels, to 72 000 tons
	(1 000 tonnes)				
Emissions of NO_x	448.0	388.0	354.0	337.0	Previous target
of which:					– Emissions in 1995 to be 30 per cent below 1980 levels (achieved in 1997)
Mobile sources	313.0	315.0	286.0	274.0	
Stationary sources	135.0	74.0	63.0	63.0	Proposed new target
					– By 2010, decreased by at least 55 per cent from 1995 levels to 155 000 tons
	(million tonnes)				
Emissions of CO_2	77.1	55.4	58.1	57.0	Previous target
					– Emissions stabilised at 1990 levels by 2000 (not achieved)
Emissions of GHG[1]	-	69.4	68.4	73.8	Kyoto/EU burden-sharing target
					– Emissions for greenhouse gases shall be 4 per cent higher than 1990 levels on average from 2008-12
					Proposed new national target
					– Emissions for greenhouse gases shall be 2 per cent lower than 1990 levels on average from 2008-12

1. Greenhouse gases in CO_2 equivalents.
Source: Swedish authorities.

Figure 1. Exports and imports of air-borne pollutants, 1997
Thousand tonnes



1. Emissions from shipping.
2. Reduced.
Source: Environmental Protection Agency.

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22. Swedish emissions of sulphur have dropped dramatically since 1970, in large part due to the shift away from fossil fuels, and emissions have fallen further since the sulphur tax was introduced in 1991. NO_x emissions have also fallen, but more slowly, and the NO_x charge, imposed since 1992 on large point-sources, seems to have played an important role (Box 1). It should be noted that the variety of sources of emissions makes it impossible to link all emissions to a single stable tax base and thereby design a single economic instrument that in itself will equalise abatement costs (Figure 2). Instead, distinctions must be made between large stationary sources (for whom cap-and-trade systems or taxes can work equally well) and mobile emitters. Indeed, the guidance document on economic instruments associated with the Göteborg Protocol analyses the applicability of different economic instruments to different types of emitters and indicates their current use in various countries (Table 4). In the case of small point-source emitters, no country has yet put in place a workable economic instrument, and regulation may be the only option, although even here it would have to be balanced against compliance costs.

23. The first-best option at this point would be to persuade other countries to do more to reduce the damage they inflict on Sweden. Given the domestic reductions already achieved and the high proportion of imported depositions, the abatement costs for reducing emissions in other countries, especially in Eastern Europe, would almost certainly be lower than domestically. However, although Sweden has continued its efforts at the international level since the Göteborg protocol was signed, the key policy challenges now involve reducing its own emissions in three main areas: Baltic shipping, off-road vehicles and machinery, and farm manure.

Box 1. **Sweden's NO_x charge: an effective economic instrument**

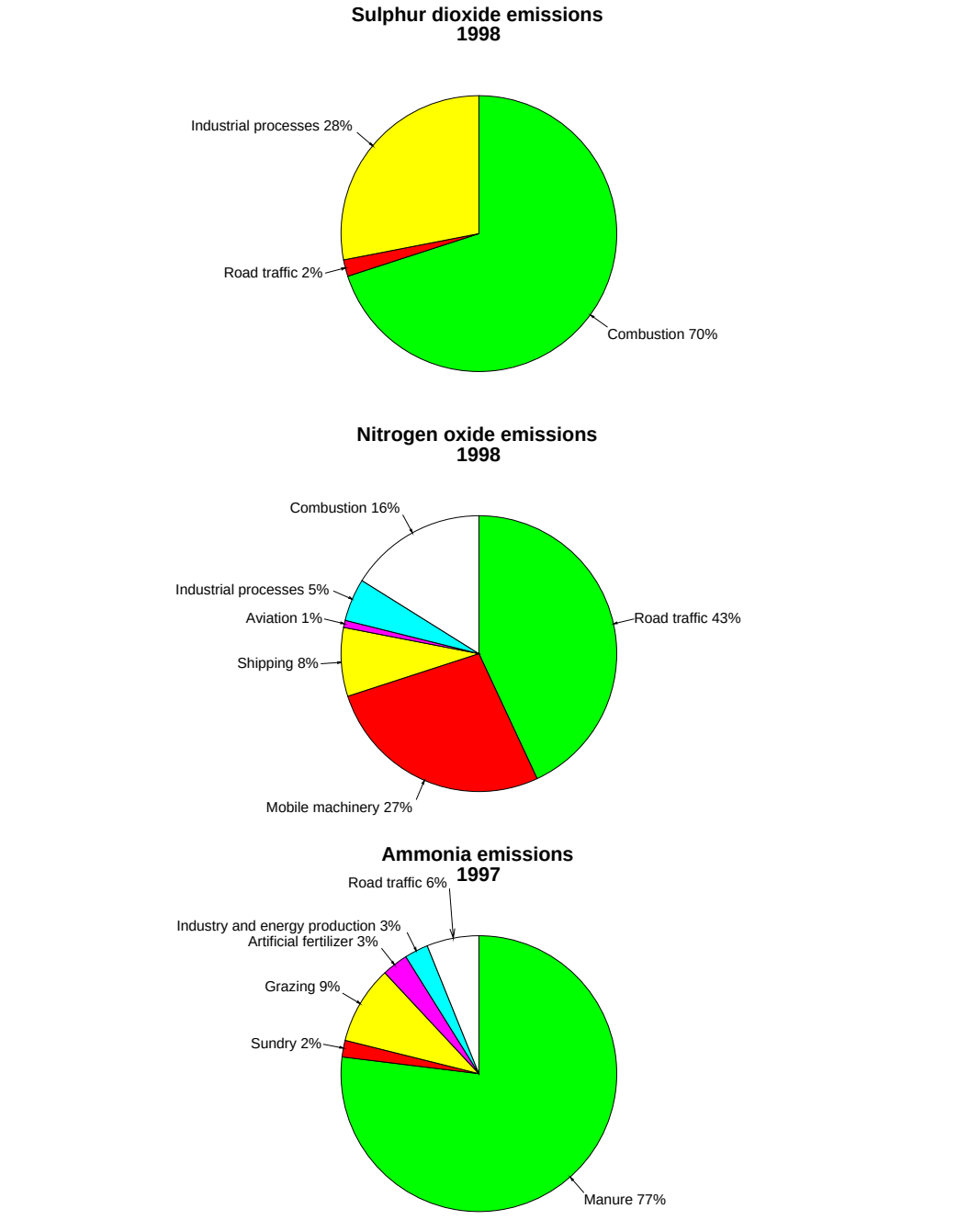
Sweden's NO_x charge on large stationary plants — SKr 40 per kg of NO_x emitted — is an example of an effective economic instrument. Steps to reduce emissions started once the bill was passed by Parliament in June 1990, even though the charges applied only from 1992. Between 1990 and 1995, emissions from plants in the scheme dropped on average by 60 per cent per megajoule of energy generated. Total emissions, however, showed a smaller decline, because the energy generated had increased by 25 per cent over the same period.

In 1996 and 1997 the coverage was expanded to include all installations producing more than 25 GWh of useful energy per year, and many of these newly-covered plants had higher emission rates, which has meant that average emissions have remained stable over more recent years. Currently some 400 units are covered by the charge.

The charge is not a tax, since the total paid is returned to the payers in proportion to their share of the total of useful energy produced. It is administered by the Environmental Protection Agency, whose costs of less than 0.5 per cent of revenue are deducted from the pay-out. The structure of the charge means that any producer with emissions lower than the industry average will receive net benefits, while those with higher emissions face a net cost.

However, there are drawbacks. Measures to reduce NO_x emissions can result in higher emissions of other air pollutants: increased ammonia in the case of flue gas cleaning, and increased emissions of nitrous oxide and carbon monoxide, where improvements are made in the combustion process. An assessment made by the EPA indicated that the cost of reducing one kilogram of NO_x amounted to SKr 19, of which more than half was the cost of damage through increases in other harmful emissions. Nevertheless, the same assessment still valued the gross socio-economic benefit per kilogram at SKr 40, implying a significant net benefit from the measures.

Figure 2. Sources of emissions for sulphur, NOx and ammonia by sector
Per cent



Source: Environment Protection Agency.

Table 4. **Economic instruments for sources of air-borne pollution**

	Tradable permits and quotas	Emission and process taxes/charges[1]	Product taxes and tax differentiation	Subsidies and fiscal inducements
NO_x: (large) point sources	– Emissions trading: United States – "Internal bubbles": Denmark, emissions: France, Italy, Poland, Netherlands	– Incentive charge on emissions: **Sweden** – Financing charges/taxes on emissions: France, Italy, Poland, Slovakia, Switzerland		– Emission related: Netherlands[2] – Energy related: Austria, Canada, Denmark, Germany, Netherlands, Norway, Poland, **Sweden**, United Kingdom – Industry related: Canada, France, Germany, Greece, Netherlands, Poland, Portugal
SO_2: large point sources	– Emissions trading: Poland, United States – "Internal bubbles": Netherlands, United Kingdom	– Financing charges/taxes on emissions: Czech Republic, France, Italy, Poland, Slovakia, Spain	– Taxation of fuels differentiated according to sulphur content: Belgium, Denmark, Finland, France, Norway, Portugal, **Sweden**, Switzerland, United Kingdom	– Energy related: Austria, Canada, Denmark, Germany, Netherlands, Norway, Poland, **Sweden**, United Kingdom – Industry related: Canada, France, Germany, Greece, Netherlands, Poland, Portugal
VOCs: large point sources	– Emissions trading: United States	– Financing charges/taxes on emissions: Czech Republic, France, Poland – Financing charge on processes: Poland	– VAT reduction for low-solvent paint: Czech Republic, Slovakia – Tax on solvents (as from 2000): Switzerland	– Energy related: Austria, Canada, Denmark, Germany, Netherlands, Norway, Poland, **Sweden**, United Kingdom – Industry related: Canada, France, Germany, Greece, Netherlands, Poland, Portugal
Ammonia: large point sources		– Financing charges/taxes: Czech Republic, Poland		– Industry related: Canada, France, Germany, Greece, Netherlands, Poland, Portugal

Table 4. **Economic instruments for sources of air-borne pollution** (*continued*)

	Tradable permits and quotas	Emission and process taxes/charges[1]	Product taxes and tax differentiation	Subsidies and fiscal inducements
NO_x, SO_2, and VOCs: mobile sources	– Only used on the urban scale: Cracow (Poland), Singapore	– Environmentally motivated road pricing: Austria	– Lower taxes on "cleaner" vehicles and/or fuels: Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Slovakia, Spain, **Sweden**, Switzerland, Turkey, United Kingdom, United States	– Investments: Hungary, Poland – Car scrapping schemes: Ireland, **Sweden**, Norway, France, United Kingdom
Ammonia: agriculture	– Emissions trading ("offsets"): Netherlands[3]	– Charge on surplus manure: Belgium, Netherlands	– Charge/tax on N-fertiliser: Austria[2], Finland[2], Norway, **Sweden**, United States	
SO_2 : small point sources	– None	– None	– None	– None
VOCS: small point sources and products	– None	– None	– None	– None

1. Excluding non-compliance fees.
2. Abolished.
3. Sub-national level.

Source: United Nations/ECE (2000).

24. Baltic shipping now contributes more than half of the sulphur depositions in Sweden. The sulphur content of shipping fuel in the region remains around 4.5 per cent, despite the 1997 International Maritime Organisation's agreement to reduce it to 1.5 per cent.[9] Shipping also contributes to high emissions of NO_x. Since these vessels are operating in international waters, achieving reductions can be difficult and require co-operative efforts, and Sweden is actively pursuing the issue with other Baltic states and the EU. It also has instituted a system of differentiated fairway dues (*i.e.* charges imposed to cover the costs of services such as navigational aids and ice-breaking) in order to provide economic incentives for reduced emissions from 1999 (Box 2). A number of Swedish ports also use differentiated harbour fees, although the incentives are somewhat weaker, since ports are required to cover costs and are competing with each other. These economic instruments do seem to be attractive to shipping companies, since within one year of implementation 65 per cent of annual ferry tonnage and 30 per cent of cargo tonnage were using low-sulphur fuel[10] (although some, especially coastal, vessels had already been using low sulphur fuel). The NO_x-related part of the discount has taken longer to produce results, since it requires significant capital investment. But Sweden provides a subsidy to any ships calling at its ports that install NO_x abatement equipment, by reimbursing the fairway dues paid during the first five years after 1 January 1998. Since fairway dues in aggregate are currently set to cover full fairway costs, this reimbursement approach may prove to be costly.

Box 2. **Economic incentives to reduce emissions from shipping**

Shipping produces two types of emissions: sulphur, from burning high-sulphur fuel, and nitrogen oxides, from any form of combustion. Sweden has introduced a system of differentiated fairway dues to provide economic incentives to reduce them.

Sulphur

- Sulphur emissions can be reduced by switching to low-sulphur fuel, without any modification to equipment. However, such fuel is more expensive, and the marginal cost increases as the sulphur content falls. In late 1999, for example, the price of high-sulphur bunker fuel was around $130 per tonne; for 1 per cent sulphur content the price was about $10 higher, and with 0.5 per cent sulphur content an additional $20 was demanded.
- For international shipping, imposing a unilateral tax on sulphur content would lead ships to refuel elsewhere, making it ineffective as an economic instrument. Such an approach would only work if it were imposed on a joint basis, and even then leakage may occur outside the region.
- In a number of northern European countries, including Sweden, Norway, Finland and Denmark, there exist some forms of fairway dues, designed to cover the costs of providing safety-related services such as navigational aids and ice-breaking. However, only Sweden comes close to cost-recovery for the services provided.
- Sweden's fairway dues are based on the ships' gross registered tonnage (GRT) and on the amount of cargo, and the environmental differential applies to the GRT component. Standard fees since the beginning of 1998 have been SKr 5.30 per GRT for oil tankers and SKr 5.00 per GRT for ferries and other ships. Ship-owners who continuously operate ferries on fuels using sulphur content less than 0.5 per cent and other vessels on less than 1.0 per cent receive a discount of SKr 0.90 per GRT.

Nitrogen oxides

- Since nitrogen oxides (NO_x) are a by-product of combustion in ships' engines, the options for reducing emissions are to modify the motor or to treat the exhaust gas. There are a number of technical solutions, all involving some capital investment.
- A discount is also given on fairway dues for low-NO_x emissions, gradually increasing for emissions below 12 grams/kWh to a maximum discount of SKr 1.60 per GRT for emissions of less than 2 grams per kWh.
- To speed investment, the Swedish Maritime Administration is also reimbursing a portion of the fairways dues paid by ships installing the necessary equipment, over the five years to 2002.

Differentiated fairway dues as an economic instrument

- The Swedish system is not perfect, since it operates only on ships that actually call regularly at its ports. Baltic shipping outside of Sweden inflicts considerable amounts of domestic damage, but the present system provides little incentive for ships that call rarely at Swedish ports to modify their behaviour. International co-operation, at least within the Baltic region, where short-sea shipping accounts for almost 90 per cent of all port calls, would clearly be more effective, and Sweden is actively working towards this.
- A further limitation of the Swedish system is that fairway dues are not linked to the distance travelled, although the environmental damage clearly is. However, distance-based charges would make the system much more complicated to administer.
- Given these constraints, the Swedish system does seem to be effective, and it has been successful in encouraging shippers to modify their operations in order to reduce environmental damage.

Source: Kågeson (1999).

25. Off-road vehicles and machinery (including in agriculture) currently account for around 20 per cent of NO_x emissions. The main approach being taken here is regulatory, particularly through EU directives, in line with the government's objective of further reducing emissions. Further measures could include even stricter exhaust standards, incentives to accelerate the introduction of cleaner equipment and encouraging the installation of abatement equipment, such as catalytic converters. According to one study, these measures would involve lower abatement costs than some of the other measures already in place for emissions reduction (Ågren, 2000). They would help to reduce greenhouse gas emissions as well.

26. Farm manure is the main source of ammonia, with 90 per cent of all ammonia emissions coming from agriculture. Farming techniques play a significant role here. Practices such as turning manure into the ground within four hours can significantly reduce air emissions, but many add to risks of nitrates leaking into aquifers. Application times and corresponding storage capacities are also relevant. These complex relationships may make it difficult to design an effective and reliable economic instrument based on manure volumes or herd numbers. It would also be difficult in practice to measure emissions at the farm level, making an emissions-based instrument impractical. Given these constraints, regulation and education may be the only effective way of changing farmers' behaviour, although realistically, without economic incentives, they are unlikely to voluntarily make more than minor changes to production structures and practices. Regulations on the storage of manure were introduced in 1995 and have contributed to reductions in ammonia emissions. As it happens, Sweden's adoption of the EU Common Agricultural Policy (CAP) in 1995 led to structural changes that have reduced cattle numbers in any case. This has eased this particular source of environmental stress (Swedish Board of Agriculture, 1999), although the overall effect of the CAP on the environment is far more complex and beyond the scope of this *Survey*.

Greenhouse gases and global warming

27. Sweden's emissions of CO_2 are insignificant on a global scale, amounting to just 0.4 per cent of OECD emissions and a mere 0.24 per cent of the world total, while its emissions of methane and nitrous oxide are also minuscule by global standards. On a per capita basis, Sweden releases around 6 tonnes of CO_2 per year, compared with around 9 tonnes for the European Union as a whole and more than 20 tonnes for the United States. It is therefore clear that, acting on its own, Sweden can make very little difference to global outcomes. However, Sweden has been an active leader in seeking collective action to confront and address climate change and strategies to deal with it at an international level, through international agreements on reducing greenhouse gas (GHG) emissions and then sharing the burden of achieving the

targets laid down in them. Under the Kyoto Protocol Sweden, along with all other EU member states, agreed to reduce GHG emissions (expressed as CO_2 equivalents) to 8 per cent below 1990 levels by 2008-12. In the burden-sharing arrangements agreed within the European Union since the Protocol was signed, Sweden negotiated an increase in emissions of 4 per cent above 1990 levels, arguing that it had less scope to reduce these emissions than other EU countries, given the already exceptionally low reliance on fossil fuels for electricity generation, leaving it with a higher proportion of other fossil-fuel uses, such as transport, that are more difficult to cut (Figure 3). The decision to phase out nuclear power plants by 2010 was another factor taken into account.

28. Most OECD countries have found that GHG emissions have continued to grow since 1990, and that, to achieve their targets, significant reductions from present levels will be required. In Sweden's case, CO_2 emissions also fluctuate significantly with the weather, since reserve generating capacity and marginal electricity supply mainly use fossil fuels, while oil is an important fuel for heating. For example, the cold and dry winter in 1996 drove emissions up to 11 per cent above 1990 levels whereas in 1998 they were only 6 per cent higher (Figure 4). Recent high economic growth will have almost certainly spurred an increase in emissions. Two government agencies have recently made projections of emissions in 2010 based on present policies: the National Institute of Economic Research estimates emissions will be 15 per cent higher than 1990 levels, while the National Energy Administration predicts only a 5 per cent rise (Klimatkommittén, 2000).

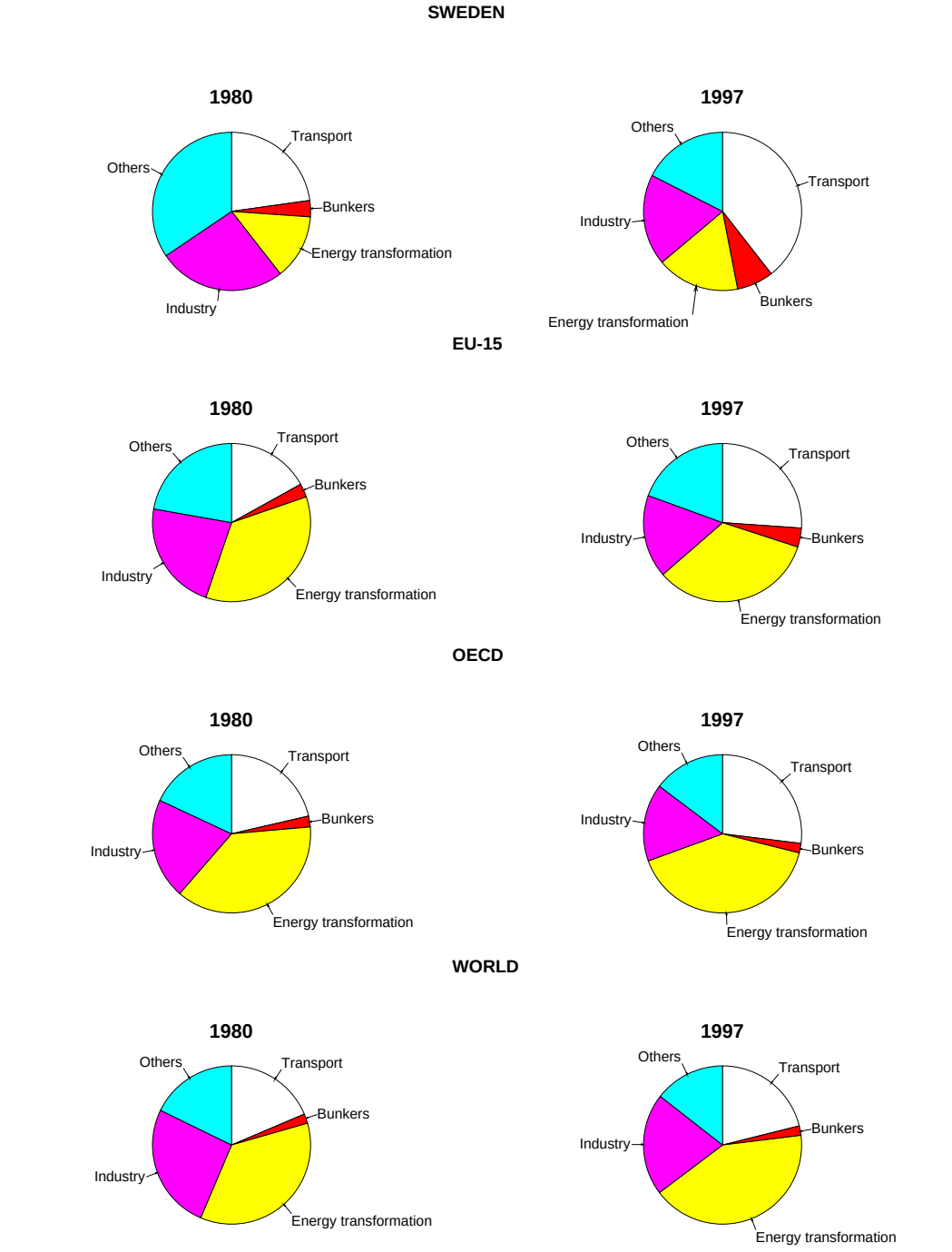
Policies to reduce CO_2 emissions

29. Sweden already has in place a set of policies designed to reduce GHG emissions. The main emphasis is on economic instruments (*i.e.* taxes and subsidies), although Swedish research has also highlighted the influence on motor vehicle emissions of such factors as road characteristics, engine temperature and driving practices. Energy taxes have a long tradition in Sweden. Petrol and alcohol-based motor fuels were first taxed in 1929, and the general energy tax was established in 1957 for purely revenue-raising reasons. It was only in the 1970s that energy-policy objectives became a supplementary justification for the taxes. Sweden first introduced a CO_2 tax in 1991 in conjunction with a reform to energy taxes. Joining the EU necessitated some further changes, and the present tax structure was put in place in 1995.

30. The present tax structure comprises three elements: an energy tax, a CO_2 tax and a sulphur tax (Table 5). The energy tax is levied on fuel oil, coal and natural gas, but electricity generation and industry are exempted. Electricity consumption is also taxed, but again industry is not charged. This tax is also differentiated, with lower rates in North Sweden than in the rest of the country. Specific taxes also apply to nuclear and hydro-electric generation.[11] The CO_2 tax is based on the carbon content of the fuel, and industry and agriculture pay only one-third of the rate paid by other consumers.[12] The sulphur tax is applied to emissions where these are measured, or the sulphur content of oil used. In both cases, the tax is uniform across all users. Together all these taxes generated revenue equivalent to 2.7 per cent of GDP in 1999, half of which from the energy tax.

31. Sweden's tax regime raises three key policy issues: the interaction between energy and emissions-based taxes raises questions about the appropriate level and mix of environmental taxes on energy; the variation in taxes for different users of energy means marginal abatement costs are not equalised across different economic activities, implying that emissions may not be reduced in the most cost-efficient way; and the desire to encourage a particular mix of energy supply, within certain constraints, may render superfluous the signals produced by economic instruments.

Figure 3. CO2 emissions by source



Source: OECD Environmental Data 1999.

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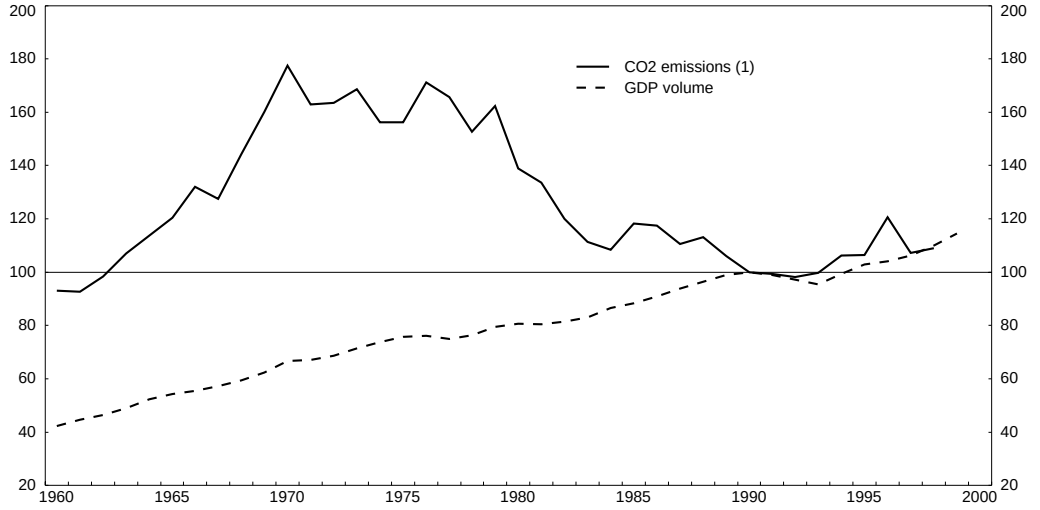
Figure 4. CO2 emissions and GDP growth
1990 = 100



1. CO2 emissions from combustion of total fossil fuels.
Source: Environmental Protection Agency; International Energy Agency (1999); OECD.

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Appropriate level and mix of taxes

32. As noted above, energy taxation was originally introduced to raise government revenue. It gradually acquired "green" credentials for encouraging energy conservation. CO_2 and sulphur taxes are rather more directly oriented towards reducing environmental damage. However, what matters for influencing behaviour are the overall prices for different kinds of energy. Notwithstanding the various taxes applying to electricity, prices are amongst the lowest in the OECD, although motor fuel prices are well above average (Figure 5). But the impact of these prices on the choices that consumers make relative to the environmental externalities involved are quite different. Taxes based on energy content discourage all energy use, relative to other inputs, while the emissions-linked taxes affect the relative prices of different forms of energy, reflecting not only their production cost, but also their relative environmental impact.

33. The effects of energy taxes on overall energy use have been mixed. Significant efficiency gains have been achieved in housing, cars, appliances, and industrial processes, but energy intensity has fallen more slowly in Sweden than elsewhere in Europe (Figure 6), suggesting that some of the improvements are being offset by higher energy consumption. For example, improvements in fuel economy of cars have been offset by longer distances travelled and larger vehicles. Also households have a widening range of appliances. (These results are entirely consistent with the income and substitution effects arising from any improvements in technology. However, the level of energy intensity in different countries will also affect the scope for changes). While higher energy prices have probably spurred the search for greater efficiency, it is hard to identify how much difference it has made, and whether the social benefits (*i.e*. over and above the private benefits that individuals reap from more energy-efficient machines) justify the dead-weight losses associated with the tax. In any event, Sweden is able to generate electricity at low average variable cost and with very low emissions because of the high proportion of hydro-electricity and nuclear energy.[13] In light of this, it is not clear that the energy tax plays a useful role in a climate change strategy, since it serves to make energy in general more expensive, regardless of the environmental damage it generates. In

Table 5. **Energy and CO_2 tax rates**[1]
SKr, 1 January 2000

Product	Energy tax	Carbon dioxide tax		Total tax	
		Industry	Others	Industry	Others
Petrol *per litre*					
Environmental Class 1	3.61	0.86	0.86	4.47	4.47
Environmental Class 2	3.64	0.86	0.86	4.50	4.50
Other	4.27	0.86	0.86	0.59	0.59
Gas oil, kerosene, heavy fuel oil[2] *per* m^3	743	529	1 058	1 272	1 801
Liquefied Petroleum Gas (LPG) *per tonne*	145	556	912	701	1 257
Natural gas and methane *per 1 000* m^3	241	396	792	637	1 033
Coal and petroleum coke *per tonne*	316	460	920	776	1 236
Crude tallolja[3] *per* m^3	1 801	529	-	2 330	1 801
Electricity[4] *per kWh*					
Manufacturing industry and commercial greenhouse cultivation	0	0	-	0	-
Other consumption in certain areas, mainly in northern Sweden	0.106	-	0.0121	-	0.0121
Electricity, gas, heating or water supplies in areas other than above	0.139	-	0.0159	-	0.0159
Other consumption	0.162	-	0.0185	-	0.0185

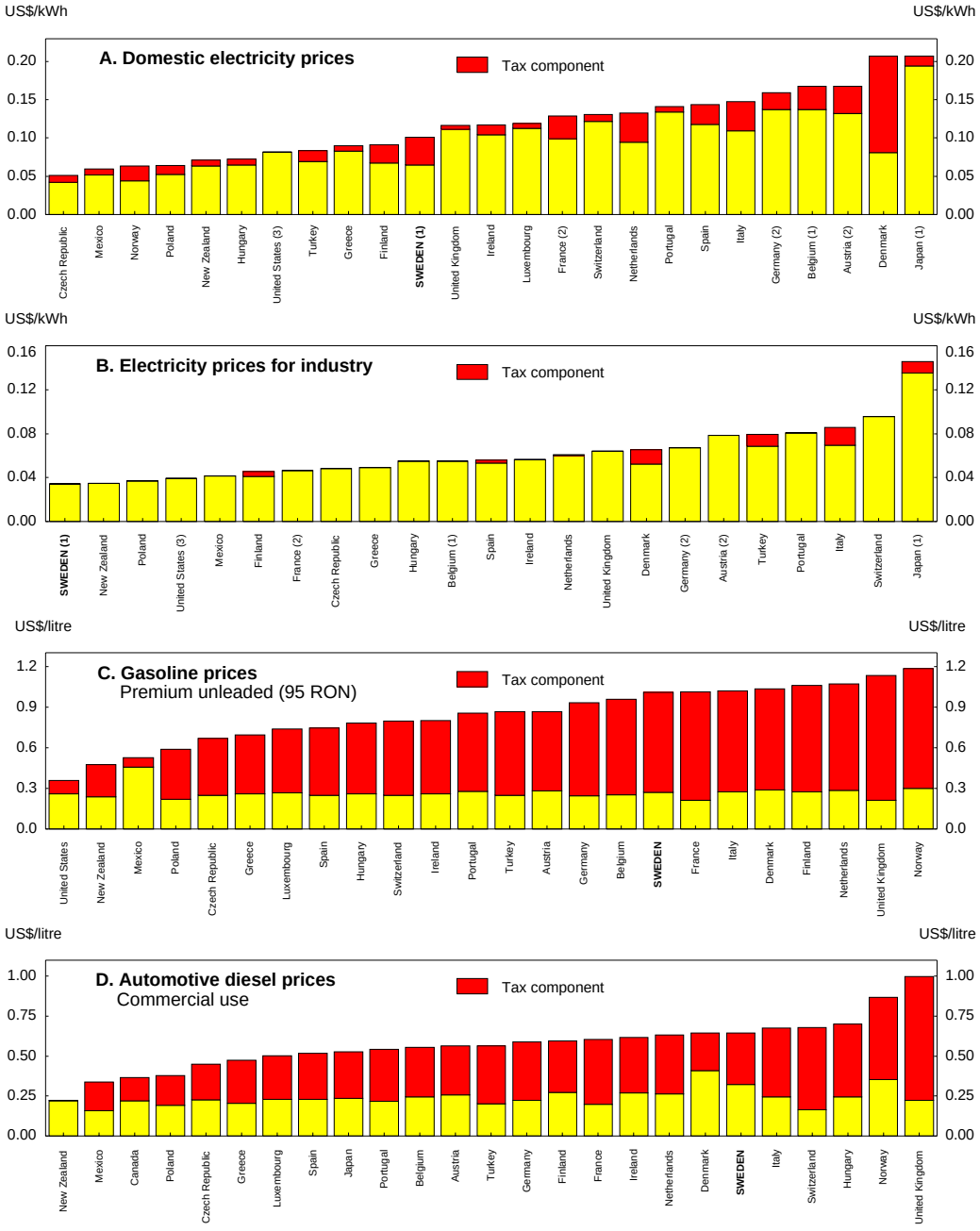
1. Value Added Tax and sulphur tax may also apply.
2. Marked oil. Marked oil is used in stationary motors and ships for heating purposes. Higher rates are paid on consumption of "unmarked" oil used for the propulsion of motor-driven vehicles and boats.
3. Tallolja ("pine oil") is a byproduct from the pulp and paper industry that can be used as a fuel.
4. Electricity consumed in big electrically heated boilers (>2MW) is taxed at higher rates during November-March. Relief from energy tax is granted if the electricity is produced in a certain manner or used for certain specific purposes, *viz.* produced in a wind power station, produced and consumed on board a craft or other means of transportation; used in connection with the production of electricity; produced in a reserve power station; if electricity is produced with other fuels than taxed fuels and the electricity is used by the producer himself for the supplies of electricity, gas, heat or fresh water. Energy and carbon taxes on fuels are exempted when the fuels are used for the production of electricity.

Source: Ministry of Finance.

any case, the energy tax system has evolved over the years into a complicated and uneven set of arrangements and in its 2001 budget, the government announced reforms, clarifying its objectives as being to promote energy efficiency and raise government revenue. In the long run, the energy tax should be simplified and the Government's ambition is to move in the direction of aligning taxes to energy content, including that of biofuels.

34. CO_2 taxes are more tightly focused on environmental damage, and there seems little doubt that Swedish CO_2 taxes have reduced emissions. According to estimates carried out for the Swedish EPA, emissions in 1994 were 5 million tonnes (9 per cent) lower than they would have been in the absence of the tax. The district heating sector underwent the greatest adjustment to the tax. The resulting substantial price differences between heavy oil and biomass fuels[14] produced a significant switch towards biomass, which rose from 25 to 42 per cent of all district heating supplied between 1991 and 1995.

Figure 5. Energy and fuel prices in OECD countries, 1999



1. 1997.
2. 1998.
3. Ex-tax price for the United States.
Source: International Energy Agency.

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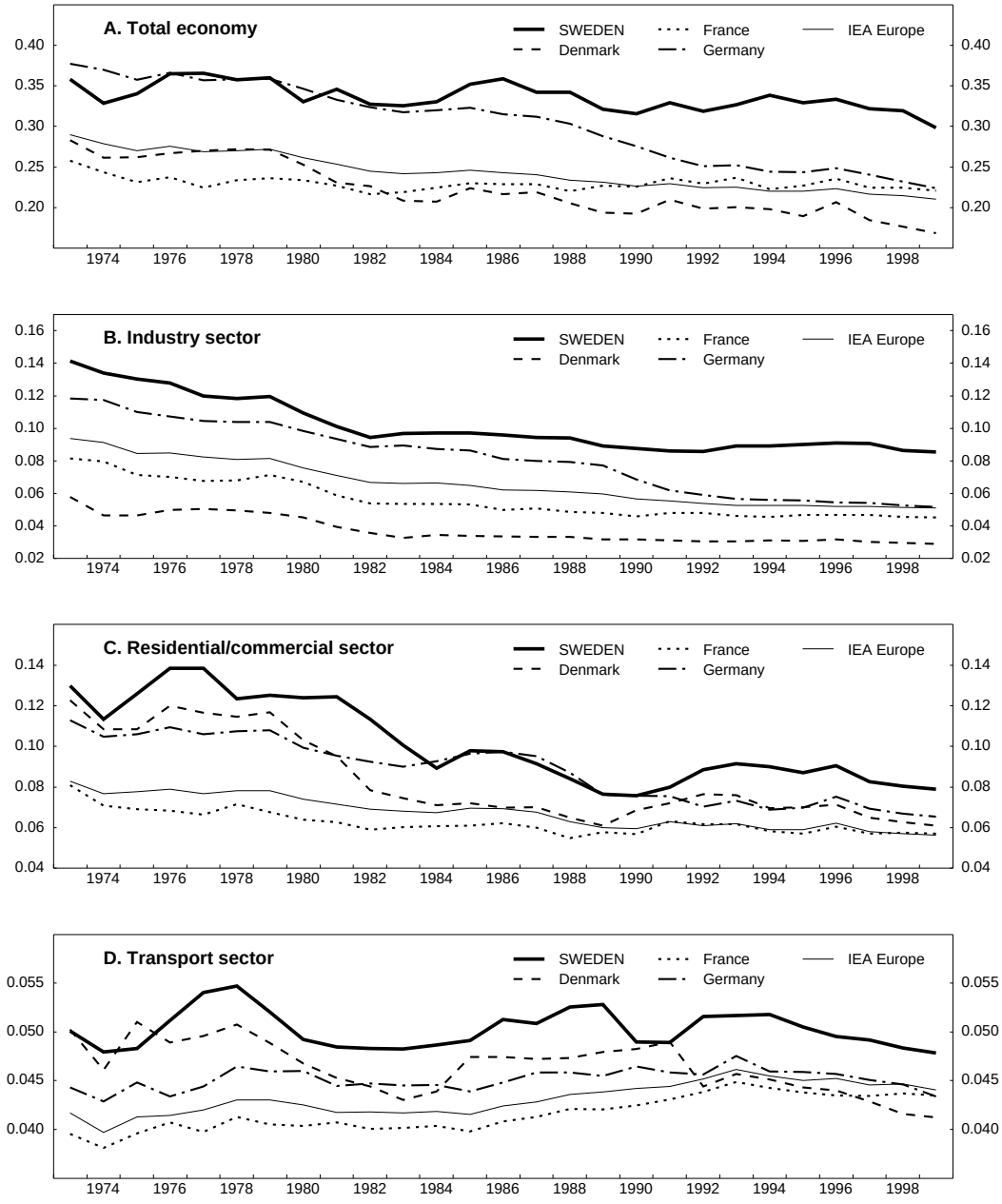
Figure 6. Energy intensity in Sweden and other IEA countries
Toe per thousand US$ at 1990 prices and purchasing power parities



Source: International Energy Agency (2000).

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35. The issue at stake for CO_2 taxes is whether they are set at the right level. The basic principle for any environmental tax is that is it should internalise the negative externalities. But in this context of climate change, there is a great deal of uncertainty about what the "right" global CO_2 tax would be. Nevertheless, Sweden is committed to the Kyoto Protocol, which provides an international framework with agreed quantitative emissions targets: in this context, the appropriate CO_2 tax for Sweden is simply the one that achieves the necessary national reductions (although the Kyoto Protocol does not specifically require domestic reduction). Given the projected evolution for Swedish emissions, it is clear that CO_2 taxes would need to rise from present levels, and simulations suggest that CO_2 taxes would need to be 2½ times higher than 1998 levels (*i.e.* rising to SKr 0.91 per kg CO_2 emitted) in order to lower emissions to the 4 per cent increase agreed under the burden sharing arrangements (Nilsson and Huhtala, 2000): the 2001 budget incorporates a rise in the carbon tax to SKr 0.53 per kilogram of CO_2 gas emitted. However, how high taxes will need to rise in order to meet Kyoto commitments will depend on the extent to which "joint implementation" and emissions trading are to take place within the Kyoto framework. OECD modelling work suggests that if international emissions trading succeeded in equalising marginal abatement costs across the Annex B countries[15] it would reduce the economic costs of meeting the targets by one-third (OECD, 1999*a*). It should be noted, however, that reducing CO_2 emissions may not be as cost-effective for Sweden as reducing other GHG emissions or increasing forests as sinks. It is important, therefore, that the strategy on climate change takes all these into account. A clear and positive outcome of the negotiations within the Conference of the Parties to the UN Framework Convention on Climate Change, and full ratification of the Kyoto Protocol would give Sweden a much clearer basis on which to establish the appropriate tax levels or move to domestic, and eventually international, emissions-trading permits. A further complication arises to the extent that an increase in CO_2 taxes leads to a rise in all electricity prices, including those for hydro-electricity and nuclear energy. This would generate an economic rent for these two groups since their supply capacity has been fixed by law. It would be appropriate to apply a resource tax to such economic rents.

Equalising abatement costs

36. The disparity of tax rates among users is a significant feature of the Swedish taxation regime for both the energy and the CO_2 tax. Energy products used in industry and agriculture are both exempt from energy tax and pay only one-third of the general CO_2 rate. In addition, special rules apply to energy-intensive industries, which play a particularly strong role in the Swedish economy. The pulp and paper industry alone consumes one-third of all electricity used by industry, and energy typically makes up almost 15 per cent of marginal costs in newsprint production from virgin pulp. Altogether, some 60 enterprises, mainly producing iron and steel, chemicals or pulp and paper, are able to benefit from preferential arrangements for energy-intensive operations, which apply if the CO_2 tax paid at the normal industry rate would be greater than 0.8 per cent of sales. The marginal tax burden for these firms is reduced to 12 per cent of the rate paid by industry in general.

37. In Sweden, low electricity prices are a key source of competitive advantage, but the country has chosen to impose higher environmental taxes than most other countries and in advance of concerted international action to address global warming. Thus, the Swedish authorities have chosen the present arrangements to deal with the consequences of acting alone. The concern is that if industry and agriculture faced the full tax rates, they would rendered less competitive against production from less environmentally-conscious countries, even if they would be the most efficient producers in a situation where all countries were making similar efforts to reduce emissions. At the same time, if Swedish production was displaced by other countries, total harmful emissions might even rise, although the extent to which this would occur is an empirical matter.[16] The Swedish authorities argue that if a uniform rate was applied, this competitiveness consideration places a low ceiling on it. However, such a low rate would in turn involve only a weak incentive for other users to reduce emissions. But from an economic perspective, the current differential arrangements effectively provide subsidies to particular users, with the most

intensive energy users benefiting most, which leads to an inefficient allocation of resources. In addition, the emissions reductions that are achieved carry a higher cost than otherwise, because the marginal costs of abatement are not equalised across the economy. While these problems should largely dissipate once the Kyoto Protocol is implemented, in the interim, better arrangements would promote the least cost reduction in emissions while compensating industry for the temporary economic losses that would result. Within a tax-based system, one solution would be to impose the same tax rates on all users, but grant an ongoing tax credit equivalent to, say, the additional environmental taxes paid in the first year that businesses faced the full rates. Under a tradable emissions permits scheme, existing emitters could be allocated permits equivalent to their current emissions, a so-called grandfathering arrangement.

38. A further issue is whether marginal abatement costs are the same for the two main sources of CO_2 emissions in Sweden: energy and transport. Sweden's CO_2 tax per kg of emissions is the same for transport as for elsewhere, except for the reductions and ceilings that apply in industry. Energy tax has long been applied to motor fuels for fiscal reasons and 80 per cent of taxes on motor fuels are energy taxes. It could be argued that these are more closely related to CO_2 emissions than energy taxes elsewhere, and on those grounds the *de facto* carbon taxes could be considered as higher on transport. But the analysis is complicated by the other externalities associated with transport, including congestion, local pollution and accidents, and the degree of spillover between policies to address each of these issues. A comprehensive cost-benefit approach taking into account all the externalities associated with transport might justify higher abatement costs in this sector than would be rational on the grounds of global warming alone, because of those ancillary benefits (OECD, 2000*a*). Indeed, a comparison of the energy taxes on petrol and diesel with external costs, excluding CO_2 emissions, showed that the energy tax was significantly higher than externalities for petrol cars but neutral or lower for diesel, depending on traffic (Swedish Green Tax Commission, 1997). Fuel taxes might not be the ideal way of internalising some of these costs; the roles played by other related policies such as the shift to unleaded petrol, catalytic converters and car-scrapping schemes are important. However, the role of these taxes as instruments for raising revenue also needs to be taken into account. The government has recently announced a major review of the total effects of all traffic-related taxes on the environment as a whole as well as their role in raising revenue to cover the economic costs of the road network, which should bring all these elements together in a coherent framework. Taxes related to these ancillary benefits will be separated from energy taxes on fuel.

Energy supply

39. A major feature of Sweden environment policy is the strategy concerning energy supply. A state-owned enterprise, Vattenfall AB, owns half of the country's electricity-generating capacity, while municipalities own almost a quarter. As part of its environmental objectives Sweden has renounced further hydroelectric development and has also committed itself to phasing out nuclear energy, despite the potentially high costs associated with this decision.[17] All methods for electricity generation have advantages and disadvantages from an environmental point of view. In terms of low operating costs and GHG emissions, both existing hydro-electricity and nuclear energy have clear advantages.

40. Official policy is that nuclear energy can be replaced by greater use of renewable energy sources together with gains in energy efficiency that translate into reductions in energy intensity. Given the weight of nuclear energy in current electricity production, this seems rather optimistic, especially if such a switch is to be realised over a relatively short period of time. In fact, Sweden's nuclear policy has evolved significantly since the original referendum in 1980, which led to the sequence of decisions culminating in the 1997 change in legislation that led to the closure of one reactor (Barsebäck 1 in November 1999). The Swedish parliament has now agreed on stringent conditions to be met before future closures are accepted, including that of Barsebäck 2, which was due for closure on 1 July 2001. In essence, the requirements to be met before Barsebäck 2 can be closed are that it must be possible to compensate the loss of electricity production from the reactor by an increase in electricity supply from other energy sources, and a reduction

in electricity use. As a result, it seems unlikely that this plant will close in the immediate future. The government has announced that, after the closure of both Barsebäck reactors, the developments in, *inter alia*, electricity prices, investments, environmental impact, employment, functioning of the electricity market and R&D, are to be followed up. The conclusions should then act as a guide to future changes.

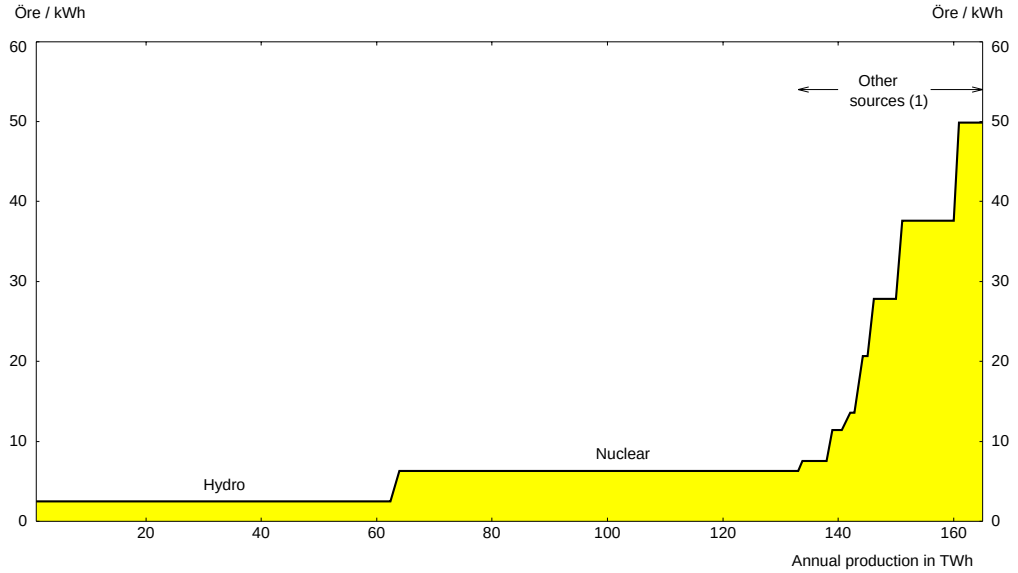
41. The Swedish authorities have placed a lot of emphasis on renewable sources of energy, especially biofuels, wind power and solar energy. A government-funded energy research, development and demonstration programme to promote an ecologically-sustainable energy system was established at the beginning of 1998 with funding of SKr 5 billion over seven years. Biofuels (*i.e.* wood and forest-product wastes) already provide around 15 per cent of Sweden's total primary energy supply, but most of it is used within the forestry sector. However, its use in district heating has been vigorously promoted by the government, and combined heat and power plants (CHPs) using biofuels have benefited from government-funded research programmes and investment subsidies. But although district heating has the advantage of reaping economies of scale, its promotion may have regulatory implications, by establishing *de facto* local monopolies (IEA, 2000). Biomass is also being developed as an alternative source of motor fuel, through production of ethanol, biogas-based methane, dimethyl ether and additives for petrol and diesel oil. Total government funding into research in these areas amounts to around SKr 250 million spread over several years.

42. While wind power has been judged to offer a potential for supplying up to 10tWh, current production is negligible, and it seems unlikely that significant expansion would take place without heavy subsidisation. The Danish experience with promoting the development of wind energy (OECD, 2000*b*) suggests that the cost could be high, even though technological improvements are reducing unit costs. Average production cost on turbines installed in Denmark in 1998 was around SKr 0.36 per kWh compared with a spot price in the Nord Pool electricity market that year of only SKr 0.120/kWh and a hydro generation cost of 0.01kWh (Figure 7). Furthermore, transmission constraints limit the siting of wind farms to within around 150 km of users, unless they are large enough to justify investment in high-voltage transmission capacity (Cassedy, 2000). Although considerable government-funded research has gone into developing Swedish-designed large-scale wind-power technology, as the IEA has noted, it has not yet led to commercial output. Research into solar energy, through photovoltaics and artificial photosynthesis, is at an earlier stage and is not likely to provide any generation capacity within the next 10 years.

Strategy for addressing global warming in the future

43. Notwithstanding all the efforts already made towards reducing global emissions, both through promoting international action and by adopting economic instruments to curb domestic emissions, the parliamentary commission charged with examining the environmental objective of "limited climatic impact" has recently recommended that Sweden should adopt a long-term objective of a 50 per cent reduction in greenhouse gases from 1990 levels by 2050, with further reductions beyond that point. As an intermediate target, it proposed that emissions should on average be 2 per cent lower over the period 2008-12 than in 1990,[18] *i.e.* 6 per cent lower emissions than agreed within the European Union, in order to meet its targets under the Kyoto Protocol. Despite cross-party support within the Parliament, this recommendation has nonetheless drawn criticism from many economists. It should be recognised that this report reflects a laudable desire to do more to reduce global warming. But, by concentrating on reducing Swedish emissions further, it would reduce the global environmental gains that could be achieved for a given domestic economic sacrifice through greater efforts to reduce emissions in other countries where the marginal abatement costs would be lower, either through flexible mechanisms provided in the Kyoto Protocol, or through separate aid and assistance outside that framework.

Figure 7. Electricity generation capacity and variable costs in Sweden



1. Combined heat and power, oil condensing and gas turbine sources.
Source: OECD (1999).

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44. The commission proposed a number of measures. It stressed the importance of economic instruments, CO_2 taxes and/or emissions trading systems, as essential instruments if the targets for 2008-12 are to be met, but argued that given the uncertainties at an international level, it may not be possible to take clear decisions before 2003-04. In light of this, it has drawn up a set of base measures that could be implemented immediately. In fact, however, most of the almost 100 measures, are either statements of intent or reflect a continuation of existing policy rather than specific policy changes. The measures to finance these proposals are perhaps more likely to affect the environment, since the commission proposes to increase the electricity consumption tax, index the CO_2 tax increases to GDP growth, impose differentiated sales tax rates on new cars based on their CO_2 emissions, and increase the vehicle tax. In any case, experience with economic instruments does suggest that using price signals alone might achieve many of the changes that the commission wants to see, in a rather more direct manner and at a lower cost than the myriad of other proposals put forward. Alternatively, a domestic cap-and-trade system for GHG emissions could be instituted immediately, and integrated into international-trading schemes as soon as these become operational. And while in principle cap-and-trade systems or correctly set taxes will produce the same environmental results for the same economic cost, there may be practical advantages to permit trading systems, not least because emissions reductions are fixed and then the appropriate "price" determined, whereas getting taxes right depends on trial and error. International trading of emission permits would in turn make it possible to achieve reductions in emissions at a lower cost than if only national schemes are instituted.

Water quality

45. Sweden has abundant water supply: it has low annual per capita abstractions of around 300 m^3 (compared with the US level of 1 870 m^3) and one of the lowest intensity of abstractions among OECD countries. The main emphasis is therefore on preserving its quality and avoiding pollution of waterways. The problem of acidification has already been discussed above, but eutrophication[19] is also a major concern. Wastewater has progressively been subject to increasingly extensive chemical and biological

treatment to reduce damage from organic material and from phosphorus. Now, the main source of nutrients is nitrogen that comes from artificial fertiliser and farm manure (although air-borne emissions also contribute). These have not only affected Sweden's waterways, they have also added to eutrophication in the Baltic sea. Furthermore, nitrogen has found its way into drinking water, with around 100 000 people now dependent on drinking water which contains higher nitrates than the Swedish health limit, while several municipal waterworks have had to be closed for the same reason.

Policies to reduce nitrogen

46. Agriculture is the main source of excess nutrients, with emissions from crop production and livestock management either through nitrate leaching[20] or through ammonium evaporation. Structural shifts towards larger farms, greater specialisation and more intensive agriculture over the years have exacerbated the environmental problems. Ironically, these trends have been encouraged by agricultural support policies, as the OECD had pointed out to Sweden already in the early 1990s (OECD, 1994) even before Sweden adopted the EU CAP. The significance of artificially high agricultural output prices for environmental outcomes can be seen in modelling work for Denmark, which estimates that a 10 per cent reduction in EU cereal prices would lead to changes in both output and input mix, resulting in a 2.4 per cent fall in nitrogen loading, without any change in environmental programmes or incentives (Wier *et al.*, 1999). A sensible starting point for reform would, therefore, be market-based prices, but although Sweden has strongly advocated CAP reform, it is dependent on progress made at the EU level.

47. In the meantime, policies to address the environmental damage from agriculture have centred on trying to engineer a switch to less damaging farming methods, through legislation, information and subsidies. For example, Sweden has tightened its regulations limiting the proportion of arable land that can be left fallow during autumn and winter, since newly ploughed fields release more nutrients, whereas crops can absorb nitrogen. Organic farming is also actively encouraged, with a sharp increase since 1995 when less than 4 per cent of farm outputs were organic: the goal of cultivating 10 per cent of total acreage organically by 2000 is likely to be met. Funding for this switch is coming from the EU's agri-environmental programme of compensation, which in total costs SKr 2.8 billion per year (half of which comes from the Swedish budget). Organic livestock farming by adapting the animal density to the farm's capacity to produce fodder, was expected to reduce large animal concentrations and thereby lower nutrient leaching. But this amounts to saying that it only works by reducing inter-farm trade. In any case, recent evidence suggests that organic farming has not reduced the nutrient leaching load.

48. Fertiliser taxes have been in place since 1984, but seem to play a relatively small role in the strategy for dealing with nitrogen leaching from agriculture. Current tax rates are SKr 1.80 per kg of nitrogen and SKr 30 per gram of cadmium, for cadmium exceeding 5 grams per tonne of phosphorus. (There is also a charge on pesticides of SKr 20 per kg of active ingredients.) The relationship between fertiliser application and nitrogen leeching is in any case complex and depends both on crop mix and farming methods. The first-best approach, taxing the nitrogen leaching directly, would involve high measurement costs. A "next-best" approach could involve taxing on estimated mineral losses (residual balances) for each farm. Both Denmark and the Netherlands already require farmers to keep detailed records of nitrogen application and absorption, a key requirement for developing such a taxation system. The Dutch authorities have noted that minerals accounting does not involve much extra paperwork for farmers, as the relevant input and output values are already closely monitored for financial reasons. (It does, however, involve significant implementation costs for the government, and monitoring and control costs would rise if the accounts were used as a tax base.) In the Netherlands, however, a standard allowable loss rate per hectare is applied to each farm and a tax applied to any excess loss. From an economic point of view this would not necessarily lead to the most efficient minerals use. Either taxing all nitrogen losses

or allocating loss permits to each farmer and allowing them to trade would be more likely to result in an equalisation of marginal costs of nitrogen reduction.

49. Another approach that has been suggested recently in Sweden and may have some merit would be to shift from the present regulatory and input-oriented system to an incentive system based on farm performance against a set of environmental outcomes. This would provide a means for farmers to optimise their activities with more freedom. An environmental charge system which redistributed income from those with poor environmental performances to above-average ones, as operates with the NO_x charge, bears further investigation, although defining a workable aggregate indicator of environment performance in agriculture may be far from straightforward.

Solid waste management

50. There are basically three types of waste generated in Sweden: production waste, hazardous waste and general waste from households and businesses. Production waste is generally homogenous and produced in Sweden by a few large producers in the mining sector, iron and steel industry, forestry and food production. The waste generated is generally managed at source. In the case of the mining sector, which generates the bulk of this waste, the Swedish Foundation for Strategic Environmental Research (MISTRA) is currently funding a major project to find ways of mitigating the damage associated with mining waste. A large proportion of hazardous waste also results from industrial processes in a relatively small number of enterprises. Some 30 companies have licences for on-site treatment and management. All municipalities are responsible for collecting and handling household hazardous waste, such as batteries and paint cans, while around half of Sweden's municipalities have voluntarily established facilities for handling industrial hazardous waste. Some hazardous waste is transported directly to the national centre for hazardous waste treatment at Kumla in central Sweden, while some hazardous waste is treated in specially dedicated plants. For example, the SAFT recycling plant deals with 97 per cent of the industrial nickel-cadmium batteries disposed of in Sweden, as well as imported batteries for recycling. Costs are covered by a specific charge levied on environmentally hazardous batteries.

51. To facilitate the separation of hazardous waste from general household waste, municipalities often have agreements with petrol stations, pharmacies and paint dealers to provide easy collection points for the public. They also run special campaigns to collect hazardous household waste to help keep it separate from the general selection system. The importance of these measures is reinforced by the leaching of toxic chemicals from landfills, which has occurred in several places, because earlier standards were not stringent enough. However, non-hazardous waste, generated by households and businesses, is the main focus of the efforts to reduce waste, where the strategy involves encouraging recycling through extended producer responsibility and minimising the use of landfill.

Extended producer responsibility

52. Extended Producer Responsibility, which is part of a broader Integrated Product Policy (IPP),[21] is a cornerstone of Swedish environmental policy. Originating with the Agenda 21 Action Plan for Sustainable Development, adopted in 1992, it has been put into place more extensively in Sweden than any other OECD country. Producer responsibility was introduced for packaging, waste paper and tyres in 1994 and for cars in 1997. It will apply to electrical and electronic products from July 2001. Sweden is also actively promoting IPP within the European Union, arguing that this approach is underpinned by the basic principles laid down in the Amsterdam Treaty and would "support an efficient single market that provides effective safeguards for human health and environment" (Government Communication to Parliament, 2000).

53. The key principle underlying producer responsibility is that resources should be conserved and recycled. Regulations oblige each producer to take back their products and recycle a certain proportion of them. They are required to set up collection systems to manage the process and inform and encourage the public to co-operate, although legislation also forces households to separate waste and take it to producers' collection points. For products such as tyres and cars where there are few producers and the items are large and infrequently disposed of, sectoral responsibility could work well as a means of internalising costs. However, for packaging and electrical and electronic products, there are many more producers and diverse products. Given the cost of establishing collection systems, the producer responsibility principle provides a deliberately strong incentive to co-ordinate efforts within the sector, as has happened in Sweden.[22] The costs of collection are then shared among producers on the basis of units of packaging type produced. It should be noted that in the Swedish case importers of products are classed as producers for the purposes of this legislation. In some countries this approach might raise concerns about the wisdom of encouraging firms within a sector to co-operate so closely, in view of the risks to competition more generally. It may also make it more difficult for new firms or importers to enter the market (regardless of their overall environmental credentials). These potential drawbacks do not seem to be considered important in Sweden and would anyway need to be balanced against the economies of scale and density that favour unified collection systems.

54. Another key feature of the Swedish approach is its emphasis on products rather than materials. This approach might seem to suggest that plastics used in packaging, for example, are considered more harmful to the environment than plastic in other items such as toys. In fact, the priority has been to deal first with products where producer responsibility can most easily be instituted, before moving on to deal with those for which it is harder to set up collection systems. In any case, if the concern were about harmful health effects of the products, then it would be more logical to tax the harmful agent, regardless of the products it is embodied in, while concerns about resource depletion would also argue for an explicitly materials-based approach, such as could be provided by environmental taxes. But these have both advantages and drawbacks (see Annex). If instead the intention is to reduce landfill volume *per se*, then an incentive structure designed to address that more directly would make more sense, while encouraging least-cost reductions of waste to be adopted.

55. Of even greater consequence however is the strong assumption underlying this policy that recycling is always worth undertaking, regardless of the economic cost. No cost-benefit analysis was undertaken before these policies were adopted in 1994, and only one assessment has been undertaken since then (Radetzki, 1999). That analysis notes that the producer responsibility strategy has been successful according to its own objectives, namely raising the level of recycling, but judged that it has been achieved at a high cost. For packaging waste, the marginal cost of recycling packaging waste is estimated at SKr 2 220 per ton, which is paid by producers and presumably passed back to consumers via higher prices. This contrasts with SKr 1 500 per ton for incineration and SKr 1 200 for landfill. In addition, there is a significant additional cost to households and firms in sorting, cleaning and transporting packaging waste to the collection point. On the assumption that each household spends an extra half-hour per week, these costs could add up to SKr 1 660 per household over a year, bringing the total costs to society of recycled packaging to an estimated SKr 34 000 per ton and to SKr 6 400 for recycled newsprint. The critical conclusions of this analysis have spurred the Swedish Environmental Protection Agency into carrying out its own economic evaluation, the results of which should be available in 2001.

56. The aforementioned study highlights the degree of complexity embodied in the Swedish approach. In several OECD countries recycling is carried out as part of the municipal rubbish collection system and requires relatively little sorting effort by households. Allowing co-mingling of recyclable materials has also been shown to increase overall recycling rates (Judge and Becker, 1993). Additional sorting and sale of recyclable material takes place centrally, in response to economic signals — *i.e.* the waste handling company can easily assess whether the extra costs of recuperating specific materials can be

justified by their sale. Economic instruments to promote recycling in general or of particular materials could easily be incorporated into this system by shifting relative prices, and recourse to targets and regulations would not be necessary.[23] Another study found that packaging consumed by households fell by only 4 per cent after the introduction of the green dot scheme in Germany (Rousso and Shah, 1994). A further aspect called into question is whether recycling can be taken too far. For Finland, one study showed that the optimal recycling rate was between 30 and 50 per cent, while only cardboard and metal demonstrated net positive social benefits from recycling: glass and paper did not (Huhtala, 1997). Another analysis using US data found an optimal recycling rate of only 7 per cent for solid waste (Palmer and Walls, 1997). While the conclusions of these studies cannot be automatically applied to the situation in Sweden, they do illustrate the importance for policy of a thorough assessment of the producer-responsibility rules already in place. The government has initiated an evaluation of producer responsibility.

Landfill minimisation

57. Sweden's goal is that only a small fraction of waste will be landfilled over the long term and has set itself the intermediate goal that landfilled waste (excluding mining waste) should be 50 per cent lower than 1994 levels by 2005. To help achieve this objective, no combustible waste should be sent to landfill after 2002 and no organic waste after 2005. Sweden is not alone in adopting this waste hierarchy approach, which treats landfill as inherently the least desirable option from the environmental and public health points of view. But, as pointed out by the European Commission (European Commission, 1999) landfill, composting and incineration all have environmental draw-backs, and careful assessments are required to establish which disposal method is optimal and under what local and technological conditions. One US analysis for example, indicates that, with the upgraded federal regulations on landfill since 1976 and modern land-fill management techniques, the external costs can and have been largely internalised, as reflected in a doubling of average disposal costs (Beede and Bloom, 1995). A further complication in setting a policy of incinerating all possible materials is that it requires installing more sophisticated equipment at incineration plants than would need be necessary if certain of them, particularly PVC products, were sent to landfill instead. This significantly increases either the economic cost or the environmental damage of incineration if the equipment is not installed (Brown *et al.*, 2000), although Swedish incineration plants already comply with strict emissions standards. More generally, the relative economic cost of alternative disposal methods does not feature anyway in the waste hierarchy approach, which takes into account only environmental considerations.

58. A more promising development is the consideration of differentiated waste collection rates and treatment charges and a tax on landfilling waste of SKr 250 per tonne, which has now been implemented. These economic instruments would provide an incentive to waste generators to modify their behaviour, while ensuring that those who can cut down on waste for the least cost do so ahead of others, thus achieving an efficient economic outcome. It should be noted that the largest benefit of waste reduction is actually economic, through the savings in resources used in collection and disposal, but this only becomes fully apparent if landfill is subject to a tipping fee that covers full costs (Dewees, 1998).

59. Unit-based pricing for household waste collection has been implemented in a number of OECD countries, either charging on a volume basis (*e.g.* by requiring that pre-paid bags of different sizes be used) or on a subscription basis, where households pre-pay for the right to have a certain volume collected each week, whether or not this volume is generated. Increasingly, albeit more rarely, weight-based charging systems have been implemented by local authorities in Sweden as well as in Australia, Canada, Denmark and the United States. These come closest to marginal cost pricing, but they also involve significantly higher collection costs and are more difficult to adapt to multi-household dwellings. However, various empirical studies in the United States show that demand for solid waste disposal is relatively price

inelastic, so that fee increases have done relatively little to reduce the weight of garbage, though volume-based systems have induced greater home compaction of rubbish (Kinnaman and Fullerton, 1999). It could also be expected that recycling rates would rise, but the empirical evidence is inconclusive. However, studies have shown that illegal dumping and burning have risen where unit pricing schemes have been introduced.

Conclusions and policy recommendations

60. Taken overall, Sweden's approach to environmental policies has a number of obvious strengths, but there are also some notable weaknesses and areas where policies could be improved. Among its strengths are the clarity of its objectives and the degree of discussion and debate that has taken place in establishing them. And there is no doubt that environmental issues play a central role in the policy choices made, unlike in some OECD countries, where environmental policies are not really integrated into the rest of the policy framework. Another feature is the extent to which the authorities have given economic instruments a role to play in achieving environmental outcomes and are willing to consider extending their use. However, there is also a tendency in Swedish policy to emphasise sectoral responses to produce particular results, for example with agriculture, producer responsibility, energy and transport. While the motivation behind this approach is understandable, the wish to steer a sector towards developing in a particular way may actually compromise the search for the best environmental results as well as incurring higher economic costs than necessary.

61. The energy sector provides a case in point. Here, as well as the use of economic instruments such as the energy, CO_2 and sulphur taxes, the authorities are actively promoting renewable energy development and energy efficiency, while banning further expansion of emissions-free capacity in hydroelectricity and reducing nuclear generation. However, the effective deregulation of the Nordic electricity market has reduced electricity prices, making efficiency measures and alternative generation technology relatively less attractive. The economic costs associated with reaping the environmental benefits from these policies has risen, and they have thus become harder to justify. Against this background, policies to address climate change should focus directly on emissions, since they cause the environmental damage. Taxes on electricity generated from emissions-free sources and promotion of energy efficiency do not seem to have an obvious role in a climate-change strategy, especially where capacity constraints are self-imposed. Indeed the environmental damage associated with electricity consumption from low-cost renewable sources is relatively hard to value and local in nature.

62. Sweden is committed to meeting its Kyoto targets, although on current projections of emissions it is clear that significant further efforts will be needed. Essentially the options are much higher CO_2 taxes or shifting to a cap-and-trade system of permits. Without one or other of these, the targets look clearly unattainable, while either of them should provide the right signals to general economic efficiency improvements in the use of fossil fuels and should encourage the development of alternative energy sources. The extent to which Sweden has to reduce its own emissions in order to reach its commitments under the EU burden-sharing arrangements depends on the final form of the ratified Kyoto Protocol. The greater the scope for using international emissions-trading, Joint Implementation and the Clean Development Mechanism in meeting Sweden's targets, the lower the overall costs are likely to be. If Sweden wished to reduce emissions even further than required under Kyoto in the interests of making a greater contribution to reducing global warming, using these same instruments would enable Sweden to make a larger environmental contribution than it could by cutting its domestic emissions even further, as was suggested by the Climate Change Commission.

63. Sweden faces all the challenges of dealing effectively with transboundary pollution in its efforts to deal with acidification and its associated damage: the recently signed Göteborg Protocol represents a

significant milestone in international co-operation. While it is hoped that this agreement will be fulfilled and countries deliver the reductions promised, it will be necessary to monitor progress carefully and maintain the pressure on them to comply with their commitments. In the meantime, Sweden has been doing its best to address those factors where it can directly influence the amount of acid rain that falls on its territory. The recent introduction of economic instruments to reduce emissions from Baltic shipping is already showing good results and would be even more effective if coverage could be widened. However, regulations may be the only option for off-road machinery and farm-based emissions, where the challenge is rather to ensure that these regulations are well designed, efficient and cost-minimising.

64. Dealing with the fall-off in water quality due to eutrophication is a home-grown problem, with nitrogen the main pollutant and farming the culprit. Here, despite the use of an economic instrument, namely the fertiliser tax, the main policy efforts seem to be misplaced. Regulations on farming methods and, more recently, significant subsidies to promote organic farming have been the main tools. These approaches are not only costly, they also overlook the alternative of designing and implementing a more effective economic instrument. Following the example of some other OECD countries, a tax on the nitrogen outflow from farms could provide a much stronger incentive to farmers to tackle and reduce their net nitrogen use. A shift to more organic methods would be one possible outcome, but farmers themselves could judge whether this was the most cost-effective route, given all factors, including the demand for goods qualifying as organically produced. The alternative approach mooted recently of shifting to a more hands-off approach to agriculture with incentives for overall environmental outcomes merits further study.

65. Sweden's policies concerning solid waste management are an area where economic analysis seems to have been rather overlooked and cost-benefit assessments of policies and alternatives have rarely been carried out. Instead, the policies are based on an environmental impact studies and a "waste hierarchy" approach that forms the cornerstone of the Swedish Government's waste policy. Nevertheless, the decision to ban landfill of combustibles and organic waste should be reconsidered, and a full analysis, taking into account the economic cost as well as the environmental damage of different waste management strategies should be carried out. Meanwhile for recycling and extended producer responsibility, the Swedish government has already initiated an evaluation which should include a thorough assessment of the overall costs and benefits, drawing not only on Swedish experience but also comparing it with alternative approaches to recycling used elsewhere, especially those which involve less effort on the part of households. A report is expected by July 2001.

66. Looking across the whole range of policies and specific measures examined in this chapter, the nation would benefit from closer scrutiny of the economic costs associated with achieving its environmental objectives. This would enable policies to be more clearly and constructively assessed, both in relation to the net environmental benefits expected to accrue, and in comparison with alternative policies intended to achieve the same outcome. Specific recommendations for action are presented in Box 3.

Box 3. **Recommendations for further action**

Environmental policy-making

- Ensure that rigorous cost-benefit analysis is systematically used to evaluate environmental policy options.

Acidification

- Reinforce the economic incentive to install NO_x abatement equipment on Baltic shipping by raising fairway dues on those ships operating without the equipment, to cover some of the cost of the subsidy to convert (with the revenue raised used to offset the reimbursement of fairway dues over five years for those ships that invest in abatement technology).
- Ensure that for those areas where regulation is the only practical solution (off-road machinery and vehicles and farming), the approach adopted is subject to rigorous cost-benefit analysis and can demonstrably generate net benefits compared with the absence of regulations.

Climate change

- Restructure energy and carbon taxes so that marginal abatement costs are equalised across the economy while taking appropriate measures to address competitiveness concerns, such as tax credits or grandfathered tradable emission rights.
- Consider the possibility of using a domestic cap-and-trade approach to meeting Kyoto targets, instead of, or as well as, using environmental taxes. Use emissions-trading, Joint Implementation and the Clean Development Mechanism provisions under the Kyoto Protocol to meet targets in the most cost-effective manner.
- If Sweden wishes to make a larger contribution than required under the EU burden-sharing arrangements, then more extensive use of flexible mechanisms (including international trading) should be considered, in order to achieve the most cost-efficient reductions.
- Re-examine energy efficiency promotion to ensure that measures generate net social benefits and do not simply strive to achieve maximum engineering efficiency.
- Examine carefully the policies to promote renewable energy sources to ensure that they do not overstep the mark and become, *de facto*, industrial policy. Allow market signals, adjusted for environmental externalities, to play a greater role in determining the appropriate mix of energy supply. Build sunset clauses into research and development projects.
- Ensure that the competition drawbacks of encouraging a switch from individual to district heating are fully addressed.
- Align energy taxes with energy content and apply uniformly across all energy consumers.

Water quality

- Examine the merits of either adopting a minerals accounting approach and taxing nitrogen losses (*i.e.* residual balances) to provide an economic incentive to reduce the damage from agriculture or shifting to an environmental-outcomes-incentive charge for farmers. Evaluate costs and benefits compared with present arrangements.

Solid waste management

- Ensure that the economic cost is taken properly into consideration as well as the environmental consequences of different waste management strategies.
- Reconsider the emphasis placed on recycling and identify which items are worthwhile recycling on the basis of cost-benefit analysis. Evaluate the relative merits of extended producer responsibility in the light of international experience with alternative approaches to recycling.
- Consider moving to a weight-based general waste collection system to provide a stronger economic incentive to reduce waste.
- Undertake cost-benefit analysis before proceeding with the planned bans on landfill of combustibles and organic waste.

NOTES

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2. See Sustainable Sweden website at www.hallbarasverige.gov.se for further discussion of sustainable development concepts.

3. The global plan of action for sustainable development, agreed at the UN Conference on Environment and Development in 1992 considered the participation of local authorities as a determining factor in achieving successful implementation.

4. Some examples of projects funded are: a campaign promoting energy-efficient windows and investment grants towards purchase; a grant to restore marshland and overgrown pastureland; a grant to a company manufacturing new detergent tabs for washing machines and dishwashers; a package of measures for reducing transport-related CO_2 emissions; a project to strengthen biological diversity in deciduous forests and promote nature tourism; digging new ponds and restoring wetlands; measures to reduce fertiliser run-off and water purification units; and the construction of a district central heating plant that burns bio-fuel and industrial sludge.

5. This represents the immediate and probable future environmental impacts of activity in 1997. An alternative measure would show the environmental damages reflected in the year they impact rather than when they occur (Ministry of Finance, 2000).

6. The value of these damages avoided are estimated to be between SKr 5 to 130 million, using the cost data published by the UN Panel on Climate Change. The model results do not take account of any long-run impacts from innovation, which the oil-shocks experience suggest could be large.

7. Latest estimates suggest that global temperatures would be anywhere between $1.5^{o}$and 6^{o}Celsius higher by 2100, and rises are projected to be higher towards the poles than average (Watson, 2000). Regional effects remain even more uncertain. Sweden's EPA notes that the effects on agriculture and forestry yields would be positive, but biodiversity would suffer and some coastal flooding would occur.

8. However, recent simulations have illustrated that these estimates are subject to a high degree of uncertainty, and the assumed reductions in critical loads implicit in the Protocol may be rather optimistic (Alveteg *et al.*, 2000).

9. This agreement forms part of Annex VI of the International Convention for the Prevention of Pollution from Ships, MARPOL 73/78.

10. However, random spot checks carried out in 1999 by the authorities on 150 vessels that were certified as running on low-sulphur fuel, found that three vessels were in fact cheating, including one large ferry. Their

certificates were withdrawn, and they were required to re-apply, but no fines or other penalties were imposed.

11. Nuclear energy also pays a rent tax, based on generating capacity.

12. Until 1 January 2001, industry and agriculture paid half the standard rate. But their rate was held constant while the standard rate was raised in the 2001 Budget.

13. Furthermore, if desired, hydro capacity could be significantly expanded but such development has been ruled out, in the interests of protecting the natural environment.

14. In 1994, heavy oil for large heating plants cost SKr 22.9/100kWh, while that of biomass fuels was only SKr 10.9/kWh.

15. Annex B countries under the Kyoto Protocol are all OECD countries except Korea, Mexico and Turkey and a number of countries in transition, including Russia.

16. One case study of the effect of revoking the special rules on the Swedish pulp and paper industry shows plausible outcomes ranging from CO_2 emissions falling slightly while those of SO_2 and NO_x rise, to emissions of all three falling significantly (OECD, 1999*b*). Whether emissions would go up or down depends crucially on several key assumptions. *First* is that although the average emissions from electricity generation are low, marginal emissions would be quite high, because they draw on Swedish fossil-fuel reserve capacity or on imported electricity from Nordic neighbours, especially Denmark. *Second*, pulp from virgin wood is significantly more energy-intensive than pulp from recycled paper, so that a shift away from virgin pulp, in which Sweden has a comparative advantage, could imply less energy use for the same world output of paper.

17. Several estimates of the possible costs have been made, (for example, Andersson and Hådén, 1996 and Nordhaus, 1997). But these calculations depend critically on assumptions about the time profile of phase out, the costs of alternative technologies and the degree of competition in the electricity market. The last two factors have evolved significantly in recent years.

18. It should be noted that adopting a new even tougher national target is not without precedent. When the Swedish Parliament ratified the UN Climate Convention, it adopted an interim target that emissions should be stabilised at 1990 levels by the year 2000 and thereafter decrease. This national target has remained, despite the subsequent Kyoto-linked burden-sharing agreement.

19. This is the process whereby excess nutrients in waterways leads to denser vegetation and abundant plankton algae, until waterways become choked with dead flora and fauna.

20. Crop production can also involve denitrification which contributes to global warming and ozone depletion but does not contribute to eutrophication, acidification or contamination of ground water.

21. IPP in Sweden also covers eco-labelling, life-cycle analyses, environmental management systems, etc.

22. Even greater co-ordination has occurred in Germany, where producers and retailers have set up the *Duales System von Deutschland* (DSD), which operates a national recycling system on behalf of all participants, whose products are marked with a green dot.

23. In any case, one empirical analysis of targets and regulations for recycling in the United States shows that they have had little effect on either the amount of recycling or the amount of garbage generated, even in those municipalities where mandatory recycling is reinforced by fines (Duggal *et al.*, 1991).

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ANNEX

EXTENDED PRODUCER RESPONSIBILITY VERSUS ENVIRONMENTAL TAXES

1. Extended producer responsibility (EPR) and environmental taxes are two alternative ways of applying the polluter pays principle to waste products (*e.g.* packaging). There are two objectives to be met: to discourage waste and to pay for its recycling/treatment. It should be noted that implicit in both approaches is the assumption that these particular products do more harm to the environment than general waste.

Extended Producer Responsibility

2. EPR is based on the explicit assumption that producers should be responsible for the environmental damage caused by their products. In addition, at least implicitly, there is an assumption that recycling these products generates more net economic benefit than using other methods of disposal such as incineration or landfill. EPR involves a voluntary agreement by producers within a sector to manage the collection and recycling of their products. Its strengths and weakness are the following:

Strengths

- The aggregate cost is the actual cost of collection and recycling, so that in a direct sense, the polluter pays.

- Fees paid by each producer can be calculated on a per unit basis to provide an incentive to reduce production. In this way the relative prices of the products are shifted to encourage more economic use of the product.

- The scheme is designed by the sector itself, so that a high degree of compliance is to be expected.

- It promotes recycling efforts, in line with agreed targets for total recycling goals by product.

Weaknesses

- It emphasises products rather than the materials; this may compromise the principle of equalising marginal abatement costs across the economy. It also may provide only very indirect encouragement to switching towards producing products that use less harmful materials.

- Producers outside the voluntary agreement can free ride and have no incentive to modify their behaviour. It may also difficult to integrate imports into the system.

- Voluntary agreements may risk encouraging overly co-operative (even collusive) behaviour among firms.

- It may encourage over-recycling, if it may be more cost-effective and environmentally appropriate to use general collection and disposal.

- It promotes multiple waste-collection systems, which may be less efficient than a single integrated system.

Environmental taxes

3. An alternative approach would be to tax the materials in line with the additional disposal costs that they present, over and above the general cost of waste disposal, by landfill or incineration, to internalise the environmental externality they generate. The strengths and weaknesses in this approach are summarised below:

Strengths

- The taxes can be set to cover the costs of environmental damage regardless of who takes care of the disposal and the method chosen. Recycling will only take place if it is cost-effective in economic terms.

- By altering relative prices, they provide an incentive to economise on the use of the taxed material, in whatever way it is used. It also provides a mechanism for equalising abatement costs across the economy.

- It is compulsory and does not rely on industry co-operation.

Weaknesses

- Tax collection costs may be high and a set of materials-based taxes that provide the environmentally correct signals may become extremely complex.

- A great deal of cost-benefit information is required in order to be able to set the taxes at the right level.

- It can be difficult to integrate imports into the tax base.

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