Greening the economy: Nordic experiences and challenges

John Magne Skjelvik, Annegrete Bruvoll and Karin Ibenholt

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Preface

The Working Group on Environment and Economics (MEG) under the Nordic Council of Ministers commissioned Vista Analyse AS to prepare a synthesis report on the Nordic countries' environmental policy experiences since the 1970s focusing on the use of economic instruments and how this policy has contributed to the integration of environmental concerns into economic growth and development policies.

The analysis has been carried out during the period October 2010 – March 2011. Main sources for the work have been the large number of reports commissioned by the Nordic Council of Ministers over the last years and published through the TemaNord report series, and various OECD reports.

Main authors have been John Magne Skjelvik, Annegrete Bruvoll and Karin Ibenholt. In addition, associate professor Daði Már Kristófersson, Department of Economics, University of Iceland; professor Matti Liski, Helsinki School of Economics and dr. Marianne Zandersen, National Environmental Research Institute (NERI) at Aarhus University have contributed by valuable comments to previous drafts, as have MEG members and members of other Nordic Council of Minister groups.

Our contact person at MEG has been its chairman Øyvind Lone at the Norwegian Ministry of Environment.

We would like to thank all contributors for their inputs. Potential remaining errors and misunderstandings remain Vista Analyse's responsibility.

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John Magne Skjelvik

Project manager

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Executive Summary

Abstract

The Nordic countries have since the 1970s achieved substantial emissions reductions and improved local and regional environmental quality. During this period economic instruments have played an increasing role in the countries' environmental policy, and they have had an economic growth at the average OECD level or above. Growth in emissions to air has been decoupled from the economic growth. Over time, economic instruments could enhance and promote a greener growth through more cost effective emissions reductions and inventions of green technologies than a command and control approach.

Background: financial crisis and green growth

The integration of environmental concerns into economic growth and development policies has been a priority concern of Nordic environmental policies since the 1970s. Sustainable development has been high on the international agenda since the 1992 Rio Earth Summit. Greening the economy through reduced emissions of greenhouse gases (GHGs) and other pollutants, efficient use of natural resources, conservation of nature etc., while at the same time ensuring economic growth and poverty eradication, are key challenges to achieve a long-term sustainable development in the world.

The focus on green growth has been accentuated recently through the global financial crisis starting in 2008 and the abatement efforts by various governments through stimulus packages with "green" elements. These have been support for research and development (R&D) and investments in environmental friendly transport, public water supply and cleaning, energy efficiency measures in buildings, renewable energy, other kinds of environmental technology and "green" employment in general.

Problem statement

The Nordic countries have since the early 1980s been forerunners in promoting green growth and employment through a broad set of policy instruments. After starting out with command and control approaches in the 1970s, economic instruments like taxes, emission trading and deposit refund systems as well as instruments like information, labelling, agreements and green procurement gradually have played a more important role. At the same time the command and control instruments have been applied more flexibly, and still play an important role. Nordic experiences and examples ("best practices") can be useful also for other industrialized countries, middle income and to some extent also developing countries.

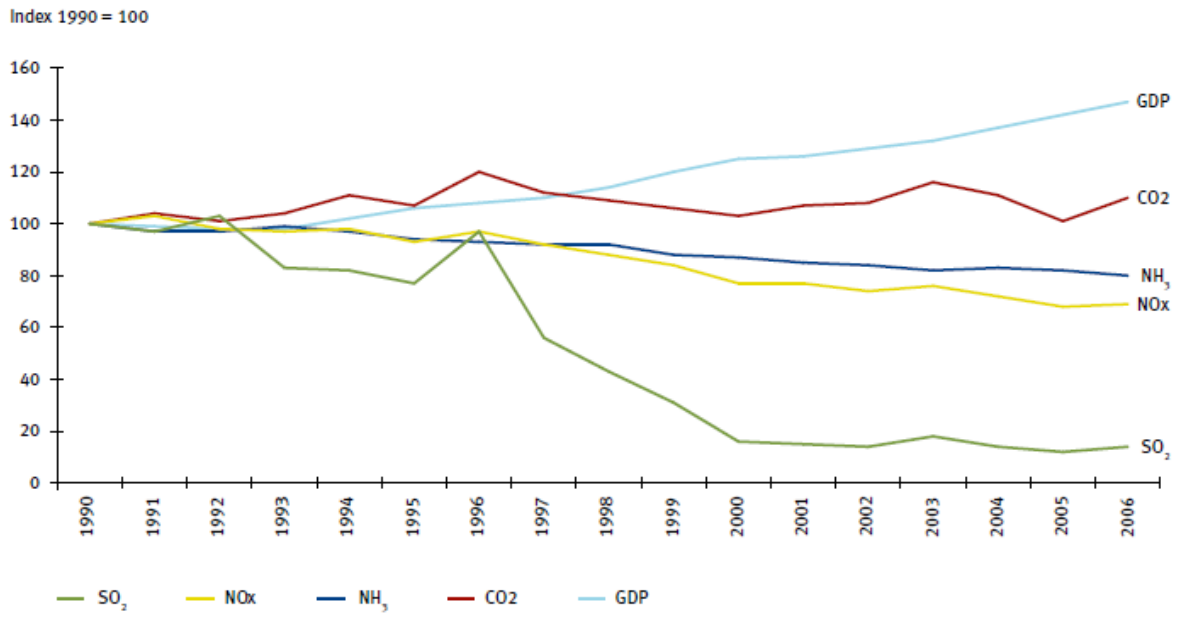
The main goal of this report is to show this through elaborating on the history of the Nordic countries' environmental policies since the 1970s. The discussion aims at developing ideas for a "green growth" strategy to achieve ambitious environmental goals nationally and internationally. Even if the Nordic countries have had considerable success in solving several local, national and regional environmental problems, the large remaining challenges connected to climate change, biodiversity, toxic and other hazardous substances and sustainable production and consumption in general will have to be solved through broad international cooperation. The Nordic experiences may inspire this also, as well as achieving green growth in the Nordic and other industrialized countries.

Some general conclusions and recommendations

Economic growth and growth in emission to air have been decoupled

The Nordic countries have since mid 1980s achieved substantial emissions reductions to air and water and improved local and regional environmental quality. During the same period they have experienced an economic growth at the average OECD level or above. Growth in emissions to air has been decoupled from the economic growth during this period, see Figure 1. Most Nordic countries except Iceland also have achieved decoupling of economic growth and energy use.

Figure 1. Decoupling of Gross Domestic Product (GDP) growth and emissions to air in the Nordic countries.



Source: TemaNord (2009h)

Command and control approaches to curb emissions to air were the main policy instrument from the 1970s. Taxes on products causing emissions and to some extent also taxes directly on emissions have gradually played a more important role since mid 1980s. Since the early 1990s, CO_2 taxes were imposed in all Nordic countries, and CO_2 emissions trading, notably through EU ETS, have played an increasingly important role since the mid 2000s. SO_2 and NOx taxes have been imposed in many countries and taxes on several other pollutants and products are in place. These instruments generally lead to more cost effective emissions reductions than command and control instruments. Furthermore, together with the use of economic instruments economic growth has been at least on par with other industrial countries.

Economic instruments could enhance and promote a greener growth

Environmental policy instruments are meant to contribute to reduced emissions and development of more environmentally benign products and technologies. In this report

we show several examples where new technologies and products have been spurred by various environmental policy instruments. Economic instruments, if properly set up and administered, give polluters continuous incentives to reduce emissions in the cheapest ways. This promotes an overall efficient resource use and could contribute to increase *long term* economic growth compared with the use of command and control instruments. Economic instruments provide incentives to reduce emissions over time, and to look for more efficient ways of curbing emissions through developing new technologies. This would spur green technology development, and lead to growth among existing technology providers and creation of new technology suppliers.

Command and control policy instruments will only spur polluters to reduce emissions up to the required level if regulations are not strengthened over time. It is therefore likely that use of economic instruments will result in lower long term emissions and a larger growth in green technology development than if command and control instruments are used, thus contributing to a greener growth. Through their open, flexible economies promoting innovation and structural industrial changes the Nordic countries have shown that high, green growth is possible also with extensive use of economic instruments.

Pricing pollution should be a key policy element which could yield broader gains

Putting a price on a pollution source or on the over-exploitation of resources through mechanisms like taxes, natural resource charges or tradable allowance systems should be the key element and the first best policy choice in a green growth strategy. This ensures a cost effective emission reduction and compensation for the remaining emissions (the polluter pays principle). Revenues from the use of these instruments can be used to offset more distortive forms of taxation, for instance on labour, to generate broader welfare gains. Given the urgent need to reduce government deficits following the current economic crisis, revenues could also be used for fiscal consolidation. In emerging economies, such revenues could finance other pressing priorities, such as education, health care, climate change adaptation or mitigation and poverty alleviation.

Show the benefits from using economic instruments

There is often considerable resistance against economic instruments. To overcome this it is important that stakeholders are informed about the benefits of reducing pollution in general, and the added benefits in using economic instruments in particular.

An example of such resistance is the opposition against congestion charges during rush hours in cities. It is often claimed that families have few alternatives to car use during rush hours to be able to deliver children in schools and day care and get to work in time. Thus, they will have to pay the charge, since there are no substitution possibilities. But they will also benefit most from the charge as congestion is reduced. Furthermore, resistance might also be reduced if the charge revenue is used for financing improved public transport. It is important to clarify the potential benefits from the charges to reduce the resistance against it, and facilitate the implementation.

Carefully consider the need for supplementary policy instruments

A great advantage of economic instruments over command and control approaches is that when the instrument is targeted as close as possible to the emissions or activities causing the environmental problem, polluters are faced with the true cost of their pollution. It could be left to them to decide whether or to what extent it is profitable to reduce their emissions. Those facing abatement costs lower than the price will reduce their emissions until the unit costs equals the price, and those with higher costs will not take any abatement actions. Thus, no other policy instruments are in general needed. If the authorities decide that further emissions reductions are needed, it is just a matter of increasing the tax.

Additional requirements, for instance by requiring that some special abatement technology should be used, that a particular share of the energy use should be renewable, or that a special kind of waste treatment should be implemented will only add to abatement costs, as it does not secure that these lead to cost effective emission reductions or that the specifications represent the most efficient abatement solutions. Several examples of inefficient policies are presented in this report, where multiple instruments are used towards the same pollution source. Thus, it should be very carefully considered which additional policy instruments are eventually needed. This is especially important when the policy has developed gradually over time, and new instruments have been added on top of existing ones, as in the climate change policy.

Some supplementary instruments could be needed

However, there are also some examples where not all emission sources could be covered by an economic instrument, or that the instrument could not provide the right incentives for all actions. Then a different set of instruments may be justified. A similar situation might occur when economic instruments could be a supplement to existing regulations instead of replacing them, and strengthening the use of other instruments.

When information about environmental costs and possible benefits from e.g. energy saving is missing, approaches like voluntary and information-based instruments such as energy efficiency ratings and eco-labelling can prove important to transfer the relevant information. For example, eco-labels can be effective in strengthening the responsiveness of agents to price signals by raising consumer and producer awareness on the environmental damage caused by specific activities as well as on the availability of cleaner alternatives. Voluntary approaches can also help to reveal information about abatement costs and environmental damages.

The need for subsidies should be critically assessed

Subsidies are mainly used to promote energy efficiency measures and research and development (R&D) in renewable energy, and to some extent also for investments in renewable energy production capacity. Generally, subsidies should be limited to correct for socalled positive externalities. Typical examples of goods with positive external effects are R&D. Subsidies should be used to create incentives to generate an optimal level of externality. Positive externalities are normally present at the R&D phase. This applies to research on new technologies through learning-by-doing (see, for instance, Joskow and Rose, 1985). Other examples are network externalities. For example, electric cars are less attractive unless many utilize the technology to bring along enough charging stations for long distance transport. Subsidies can bring demand beyond a

tipping point where it becomes profitable to establish charging stations at less central locations. Hence, subsidies should generally be used to R&D and eventually the pilot and demonstration phase.

Importantly, the introduction of new technologies and "picking winners" should be left to the market. In practice introduction of new, renewable technologies are subsidized. This creates efficiency losses. Subsidies contribute to reduced energy prices by lowering production costs of some technologies, and thus spur increased energy demand and reduce the incentives to energy efficiency. Then innovation in non-subsidized technologies will be reduced due to lower market prices. Subsidies also potentially imply large budgetary costs and could have distortive effects on competition and trade. Hence, subsidies should only be used to correct for positive externalities. Technology procurement might offer some new ways of spurring technology development and market introduction in some fields that should be looked into. OECD recommends that when subsidies are used, they should be time-bound and closely monitored (OECD, 2010c).

Particularly, so-called environmentally harmful subsidies should be avoided. Worldwide fossil fuel subsidies amounted to well above $400 billion in 2009 (IEA et al. 2010), or 0.7 per cent of world GDP. The support of fossil fuel consumption is most common in developing countries. In developed countries, one should be aware of new, emerging energy subsidies with other environmentally harmful effects, such as subsidies to wind-power and biofuels. The problem of environmentally harmful subsidies is hence two-fold; first to reduce the subsidies to negative externalities, second to reduce the exemptions from environmental taxes, which is another form of environmentally harmful subsidies.

Economic instruments useful also when technology development is not an issue

In this report, focus has been put on showing how economic instruments can spur environmental technology development and new abatement solutions. Perhaps pointing to the obvious, we would like to emphasize that economic instruments also are useful when it is clear that they will not necessary lead to innovations of new technologies, but simply accelerate introduction of existing, more environmental friendly technologies and products. Depending on the sector and niche, small and open countries like the Nordic often have a too small share of the foreign market to influence innovation.

In such situations, economic instruments may mainly enhance the introduction of new technologies. An early example is the introduction of unleaded petrol during the 1980s, when a tax differentiation between leaded and unleaded petrol was introduced. At that time, new cars running on unleaded petrol were available internationally, and refineries had started to produce unleaded petrol. The taxation contributed to speed up the introduction and use of unleaded petrol.

A more recent example is the differentiated car purchase taxation, which in most Nordic countries now is differentiated according to CO_2 emissions and/or energy efficiency. These tax regimes give incentives to buy low emission cars, but the impacts from the tax will depend on the availability of such cars in the market. For instance, differentiating the tax system further to spur the purchase of ultra low emission diesel or petrol cars as is discussed in some countries might have little or no impact in the short term since such

cars are not available in the market today. Such tax differentiations in small countries should not be expected to have any impact on technology development unless many countries implement similar tax changes.

Consider new ways of redistributing or recycling the revenue

Industry will generally oppose to the introduction of new emissions taxes increasing their costs. This has been experienced recently from the introduction of a NOx tax in Norway, where the opposition resulted in a transfer of the tax revenue into a fund financing abatement actions in the affected companies. Other redistribution mechanisms have been used in the Swedish NOx tax regime.

Finding ways of redistributing the revenue to the taxpayers without seriously destroying the incentives to reduce emissions could increase the acceptance for new environmental taxes. While recycling tax revenue might not be in compliance with economic theory, it may offer a second best solution securing cost effective emission reductions. If the revenue is used for abatement purposes this might intensify the impacts of a tax, leading to over-abatement compared to a more optimal tax regime. Nevertheless, such schemes might perform better than direct regulations.

Use economic instruments also to provide ecosystem services and halt biodiversity loss

Payment for ecosystem services (PES) can be combined with existing natural resources regulation, and be used to engage private sector to undertake more environmentally friendly actions than the minimum regulation requires. This can be done by offering landholders compensation for preserving various land areas, reducing nutrient leakage to waterways, produce agricultural landscapes with high amenity values and preserving biodiversity in forests.

There is also significant scope for using PES to promote private sector engagement in biodiversity conservation with opportunities for positive financial returns as well as real biodiversity benefits. Potential areas for this include organic farming, aquaculture, conservation credits or offsets of sustainable forestry or carbon sequestration. Another option is the creation of biodiversity "banks" in both terrestrial and marine/aquatic ecosystems to offset degradation due to land development. Compensation to creating, restoring, enhancing or preserving these resources and services could yield large benefits at low costs.

In the Nordic countries, there is scope to improve the current application of PES through for instance introducing competitive bidding to increase cost-effectiveness or basing compensatory payments on the quality of the output of the activities rather than the activities themselves. There is also scope for expanding the use of PES in Nordic countries outside the EU CAP agri-environmental schemes, in terms of using PES as a 'top-up' measure for instance in forestry.

Special recommendations for the Nordic and other industrialized countries

Below are some special recommendations targeting industrialized countries and emerging economies that have already implemented some energy/environmental taxes, and have developed some tax collection systems.

Global cooperation based on national responsibility crucial to reduce GHG emissions

The most important global remaining environmental challenges are climate change, decreasing biodiversity and spread of toxic, hazardous substances.

In chapter 3 we show that CO2 emission growth is lower than economic growth in the Nordic countries. However, GHG emissions are still growing in absolute terms in most of the countries. Furthermore, because of high income levels and consumption per capita, open economies and high economic growth, the Nordic countries are causing large emissions increases through their imports, thus causing relatively large global consumption related emissions or "carbon footprints"(TemaNord, 2010b, Bruvoll 2006). Thus, continued consumption growth in the Nordic countries should be expected to cause growth in global GHG emissions.

It should be underlined that it is not the economic growth itself that is the problem, but the environmental problems caused by it. For GHG emissions it could be argued that it is the content of the growth that causes emissions, and that changing the growth towards less emission intensive products and services together with new, green production technologies could spur a less emission intensive future growth. Improved resource efficiency and dematerialization could be keywords here.

According to international conventions countries are responsible for the emissions from their own territories. It has been discussed to let countries be responsible for the global emissions their final consumption causes, by correcting the inventories for emissions from export and import, and eventually make some border tax adjustments (BTAs) through taxing imported goods for their implicit emissions. BTAs are increasingly accepted as means to allow countries to develop responsible environmental policies without having to wait for other countries. However, the first best option is that each country takes responsibility for the emissions from their territories, since these are emissions that they can potentially reduce. Border tax adjustments and similar are very difficult to operate, and there is a possibility of creating trade conflicts. But studies on "carbon footprints" could still be useful as background information showing the overall, global picture.

There is no alternative to global cooperation on agreements to reduce the climate change threat. Since most human activities cause some GHG emissions some way or another, using economic instruments should be a crucial part of the approach. Applying taxes or emissions trading would reflect the costs of GHG emissions, and through changing the relative prices of goods and services give producers and consumers information about how their consumption and production cause emissions. Such an approach would ensure cost effective emission reductions through change in consumption patterns, production inputs and energy use, and stimulate development and implementation of new technologies. Other countries could learn from the Nordic experiences and the EU ETS how to implement these instruments to fulfill their emission obligations.

Biodiversity loss should be handled locally

The loss of species is an increasing challenge globally and to an increasing extent also in the Nordic countries. Even though several areas are protected, and the Nordic countries

are sparsely populated compared to many other countries, economic growth and related land use change is a growing challenge to avoid biodiversity loss. The increasing use of areas for new houses and in particular leisure houses and cabins in rural areas, building of roads, railways, wind power sites, power transmission lines, more intensive agricultural and forestry practices (for instance for biofuel supply) etc. are all potential threats to biodiversity if actions are not taken.

The best approach to ensure biodiversity protection and preserve endangered species etc. is to impose various forms of regulation, where Environmental Impact Assessments of larger construction plans could play a crucial role. Also, improving the enforcement of present regulations should also be considered. In addition, payment for ecosystem services (PES) could be implemented as indicated above.

Curbing use of hazardous substances needs international cooperation

The release of hazardous substances has local, regional as well as global dimensions. Many of these substances are transported over long distances, and emissions in Asia can reach as far as the Arctic. Nordic areas have become a sink for transboundary emissions for many of these substances. But local emissions also contribute to increased concentrations of many substances.

Consumption growth in the Nordic and other countries contribute to the use of many new products containing hazardous substances, that will be released through use or when the products end up as waste. These products are to a large extent imported, and the production may cause harmful emissions through the production processes.

To reduce the emissions of hazardous substances require international cooperation to switch from use of hazardous substances towards less harmful ones. Both production and use of products containing hazardous substances would have to be targeted, based on international agreements and cooperation like the EU REACH and similar approaches. Ban of products should be used if the (marginal) environmental damage is intolerably high. For hazardous chemicals this could be the case especially if there are some critical threshold levels that should not be exceeded. This implies that command and control regulations or a mix of quantitative regulations and economic incentives could be the best ways to control chemical use. Deposit refund system for used chemicals also represents a mechanism to consider.

Local car traffic needs special attention

The demand for transportation is expected to grow significantly in the years to come. Increased car traffic might cause local pollution problems and congestion in cities. Some technical improvements reducing emissions of PM and NOx could likely be expected, but local air quality may still continue at unacceptable poor levels in periods of time without policy intervention.

Several alternatives to curb pollution exist. One is to increase fuel taxation if the existing tax rates are lower than the marginal costs of local emissions, noise, road wear and tear, accidents etc. However, these marginal external costs vary considerably between cars, over areas and/or the time of the day, implying that the tax rates would only target these at an average level. Congestion charges as imposed in Stockholm offer a better

approach when it comes to *congestional* concentrations of emissions, but these also cannot target all these external costs sufficiently. However, congestion charges have shown that it is possible to reduce the high emission levels in many cities, and offer a revenue that could be used for local abatement measures, improvement in public transport or similar.

Parking charges is another option to reduce downtown traffic (ECON, 1999). A fixed, not-time dependent parking charge could be imposed on drivers to reflect the external costs that they have caused on their way to the parking lot, and a time-dependent charge to pay for the use of the parking lot itself. Since this approach only covers those actually parking, and not those driving through city centers, this approach is not optimal either. Incentives for biking through construction of bike lanes and improved public transport are other ways of reducing congestion and local pollution.

In the longer run, satellite and land positioning systems may be able to charge actual car use according to driven distances in various areas and times of the day. This could facilitate optimal taxation. However, there are still challenges to overcome if such systems should be implemented.

Make car taxation and costs more transparent to consumers

In the Nordic countries, heavy emphasis is put on taxing the purchase and ownership of private cars for fiscal reasons. These taxes are differentiated using environmental criteria to also reduce emissions, mainly CO_2. Since these approaches do not target actual emissions, a better approach is fuel taxes. However, fuel taxes in the Nordic and many other countries are high already. To the extent that they do not cover marginal costs of all emissions, they could be increased.

Since income and price elasticities for car purchase are relatively high, the high levels of purchase taxes in Denmark and Norway is not a particularly efficient way of raising tax revenue. Thus NOU (2007) recommends that the general tax level for car purchase and ownership is reduced, while the differentiation according to emissions is kept. For those countries with high purchase and/or annual owner taxes, and in need to raise fuel taxes, this offers an opportunity for a tax change that could be easier approved than an isolated fuel tax raise. Reducing the purchase tax could be justified in itself, but this would likely have negative environmental impacts since people would buy larger, less CO_2-efficient cars. Calculations in COWI (2011) indicate this.

COWI (2011) emphasizes that car taxation (including fuel taxation) is complicated and the overall costs of different car types are not fully transparent to consumers. CO_2 emissions may be reduced further by making existing taxation and green transport issues more transparent to consumers, i.e. by informing about costs per kilometre travelled and total costs per year. According to this report one should also critically review all Nordic company car schemes for passenger cars to reduce or abolish tax incentives to buy larger cars and drive more. The Nordic countries should also cooperate on improved energy labelling of cars, particularly to include the overall annual costs, including fuel costs.

Remove tax exemptions

Tax exemptions for fuels and/or users are rather the rule than the exception in most countries. This is a form of environmental harmful subsidy. All exemptions cause inefficiencies in the tax systems, and increase abatement costs. Thus, they should be removed to reduce overall compliance costs for environmental improvements. Potential unwanted impacts for vulnerable groups and industries could be mitigated by other means, and eventually the revenues could be redistributed. This might harm some energy intensive industries, but it should not reduce overall, long term economic growth.

Special recommendations for emerging economies and/or developing countries

Below are some recommendation specially targeted towards developing countries and emerging economies. These countries do to some extent face some special challenges that should be dealt with. Their main concern is abolition of poverty, and this should have first priority. Poverty often leads to degradation of land through deforestation and over-utilization of other resources, implying that reducing poverty should also improve environmental conditions. However, when countries get richer they often face the same challenges of polluted air, water and soil as developed countries. Thus, it is not sure that the experiences from the Nordic countries are very relevant for the developing countries at their present development stage.

Assess the costs of environmental degradation in the country

Developing countries and to some extent emerging economies often have poor statistics and lacking or no overview of the environmental and resource situations. The damages are not always known, and the link between emissions and damages may be poorly understood.

A particular concern in many developing countries (and in many developed countries as well) is the over-exploitation of renewable resources like fish, wildlife, grasslands, water etc., which often leads to degradation and decline in the availability, and also cause environmental damages.

Improving statistics is important to get insight into the environmental situation and the damages caused. This could help the authorities to prioritize between areas where actions should be taken to improve the situation. This overview should also make it easier to get acceptance among the public for the necessary actions.

The World Bank has for several years carried out Country Environmental Assessments (CEAs) in several countries in the third world and emerging economies. These have been assessments of the environmental and resource situation, and the damages have been assessed and to a large extent valuated in monetary terms. The CEAs have shown that the annual damages could be of several percentages of GDP. This has emerged as a powerful tool for the countries in raising awareness about environmental damages and resource degradation. The World Bank would likely be helpful in financing and implementing CEAs in interested countries.

Remove environmental harmful subsidies

Many emerging economies and developing countries subsidize transportation and cooking fuels for social reasons to support poor people. While this may ease the daily life

burden of many families through reduced fuel prices, it also increases the use of these fuels. This increases emissions to air, which deteriorates local air quality and causes damages to human health and other damages.

In many countries environmentally harmful subsidies place great burdens on public budgets, in addition to cause local pollutions and significant health problems. This is particularly true in developing countries with low GDP per capita, where consumption-related fossil-fuel subsidies have exceeded 2 per cent of GDP for many years (examples are Turkmenistan with 15.2 per cent of GDP in 2008; Ecuador, 8.7 per cent; Egypt, 8.4 per cent (Ellis, 2010)). Expenditures relating to the subsidization of fossil fuels may override health and public-education budgets. Among 20 non-OECD countries, subsidies to oil products amount to 2.5 per cent of total GDP (Ellis 2010; Morgan, 2007).

These revenues could alternatively have been spent on investments with long term economic growth effects and improvements in peoples' life quality. Removing the subsidies will increase the strain on households' budgets. Energy subsidies first of all benefit those using most energy. There are many examples of how to alleviate the increasing costs by money transfers to households and support programs targeted directly at the poorest. Examples are cash rebates and expansion of the social safety net following the energy subsidy reform in Malaysia, and the cash transfers following the fossil fuel reform in Mexico and Indonesia (see Vista Analyse (2011), *forthcoming*). Mexico's main anti-poverty program, Oportunidades, targets human capital, i.e. education, health and nutrition of children. The distribution mechanism is cash transfer. Indonesia successfully designed targeted cash transfers that were adopted simultaneously with the fuel price increases in 2005 covering one third of the Indonesian population. The Bolsa Familia program in Brazil represents another example of instruments targeting the income distribution problems directly, and at a low cost. The program provides income support to poor families, subject to their fulfilling of certain human development requirements, such as education participation and health programs.

Consider imposing local resource management and fuel/emission taxation

When local resources like water, grasslands, fish etc. are not sustainably utilized, management of the resources is necessary. Nordic experiences offer several instruments that could be used for this. Tradable fishing quotas could be implemented to manage fish stocks and wildlife management through hunting quotas. Water shortage could be reduced by taxing the use of scarce resources, as could the use of grasslands. However, enforcement is often the most difficult part of resource management in developing countries, implying that the viability of these instruments should be carefully considered. Also, transboundary issues like upstream/downstream water use and general management of larger rivers and waterways might complicate the use of economic instruments.

1. Background: financial crisis and ”Green Growth”

1.1 *Promoting Green Growth*

The integration of environmental concerns into economic growth and development policies has emerged as a priority concern of modern Nordic environmental policies since the 1970s. Sustainable development has been high on the international agenda since the 1992 Rio Earth Summit. Greening the economy through reduced emissions of greenhouse gases (GHGs) and other pollutants, efficient use of natural resources, conservation of nature etc., while at the same time ensuring economic growth and poverty eradication, are key challenges to achieve a long term sustainable development in the world.

The focus on Green growth has been accentuated recently through the global financial crisis from 2008 and the abatement efforts by various governments through stimulus packages with “green” elements. These have been support for research and development (R&D) and investments in environmental friendly transport, public water supply and cleaning, energy efficiency measures in buildings, renewable energy, other kinds of environmental technology and “green” employment in general.

According to Dahlin (2010), “Green growth is the means by which the current economy can make the transition to a sustainable economy, to avoid the cost of inaction. Green growth involves promoting growth and development while reducing pollution and greenhouse gas emissions, minimising waste and inefficient use of natural resources, maintaining biodiversity, and strengthening energy security. It requires further “decoupling” of environmental impacts from economic growth, and greening of consumption and production patterns, while reducing poverty and improving health and job prospects. Green growth means making investment in the environment a new source of economic growth”

In the preparation for the UN Conference on Sustainable Development in 2012 (Rio+20) efforts are put on transition towards sustainable development. The current financial crisis represents a special challenge for most OECD countries in this respect. Furthermore, ageing of the population starts to increase expenditure pressures on the public budgets. Assuming that there will be very little room for subsidy schemes on the one hand and caution with respect to the raising of taxes, the need for very effective instruments probably will be stressed even more than today. Likely developments are (1) tax reforms, with ever more stress on taxing consumption of (natural) resources and only limited overall increase of tax rates, (2) abolishment or at least reduction of environmentally harmful subsidies, (3) introduction of other quasi-market incentive structures (tradable emission allowances and certificate systems), (4) radical improvement of market information and (5) combinations of the aforementioned options.

However, increased use of market-based and similar instruments will likely meet some skepticism among many countries. Especially reduction of subsidies will meet opposition from the benefitted groups. Thus, it is crucial to show that specific environmental goals can be reached at the same time as achieving economic growth, that environmental policies can improve welfare, better living conditions and new industries, income and employment, and that use of economic policy instruments like

taxes and reduced harmful subsidies can be implemented and at the same time achieve poverty alleviation.

The Nordic countries have been forerunners in promoting green growth and employment through a broad set of policy instruments. Nordic experiences and examples ("best practices") can be useful also for other industrialized countries, middle income and to some extent also developing countries. The main goal of this report is to show this through elaborating on the history of the Nordic countries' environmental policies since the 1970s. The discussion aims at developing new ideas for a "green growth" strategy to achieve more ambitious environmental goals nationally and internationally. Even if the Nordic countries have had considerable success in solving several local, national and regional environmental problems, the large remaining challenges connected to climate change, biodiversity, toxic and other hazardous substances and sustainable production and consumption in general will have to be solved through broad international cooperation. The Nordic experiences may inspire this also, as well as achieving green growth in the Nordic and other industrialized countries.

1.2 *Categories of environmental policy instruments*

Traditionally, environmental policy instruments have been divided in two main groups, namely direct regulation ("command and control") and economic instruments. But there are also some other policy instruments that do not fit entirely into these categories, see below. Command and control instruments cover the following two approaches (TemaNord, 2009a):

- Technology mandates: a specific requirement regarding the production process (for example to install particular equipment, abatement technology etc), often implemented in the form of uniform technology standards.
- Performance standards: requirement that an output meet certain criteria (e.g. max emission rates per kWh of electricity, energy efficiency standards for buildings or household appliances, fuel economy requirements for new cars etc). This category also includes (non-tradable) emission permits/allowance given to specific large emission sources (e.g. a large factory).

Also, various kinds of legislation for land use (for instance protecting of vulnerable areas), licensing (e.g. of hunting), protecting of endangered species, fishing quotas, bans on the use of various toxic substances etc. belong to these categories.

Economic instruments, or often called incentive-based or market-based instruments, comprise a broad set of various policy tools imposed to change consumers and firms behavior towards reducing emissions. In this report we will use the term for the following instruments:

- Taxes on environmental externalities, i.e. taxes either put directly on emissions or on an input, produced good or service closely associated with pollution (e.g. tax on carbon content in a fuel).
- Taxes on products for other purposes than environmental protection (mostly to generate revenue), but which might also have positive environmental impacts (e.g. car sales tax, electricity consumption tax).

- Deposit-refund schemes where buyers pay a tax upon buying a product and then get a wholly or partly tax refund when delivering the product for treatment when it ends up as waste
- Subsidies for pollution reductions
- Subsidies for renewable energy production, energy efficiency measures etc. that aim to indirectly yield environmental benefits (including socalled green certificates for renewable electricity production)
- Emissions trading, where a cap is set on total emissions and allowances are distributed for free or auctioned among emitters.
- Charges put on sales of products to cover waste collection and treatment costs of products to ensure high collection and proper treatment.

Note that not all economic instruments according to this list are necessarily cost efficient.

Other environmental policy instruments that do not entirely fit into the abovementioned categories are often referred to as "soft instruments", but also sometimes included in the economic instruments category, are the following:

- Information disclosure: Includes labelling (e.g. the Swan label, certification of "green products" etc), public disclosure (e.g. rating of firms by the government, information campaigns to reduce electricity use etc).

- Agreements: Negotiated agreements or similar between industry sectors (typically) and the government to voluntarily reduce pollution to some agreed levels, conditional performance contracting (like payment for ecosystem services (PES)) or agreements on services like waste treatment.

- Other: This is for instrument types that do not fit in the other categories like green procurement.

Subsidies and taxes are also used for other purposes. Subsidies are often used to support specific groups out of income distribution concerns. Fiscal taxes on the sales of products are used to raise revenue for publicly provided goods. According to theory, fiscal taxes should be levied where they are least likely to distort economic activity. Under simplifying assumptions, the fiscal tax rate on a good should then be inversely proportional to the corresponding own price elasticity of demand (Ramsey, 1927), i.e. the tax should be levied on highly demanded goods where a price increase is not likely to reduce demand very much. This will also ensure a stable tax revenue base. This is in contrast to the use of taxes in the environmental policy, where the explicit goal with the tax is to change behaviour by reducing demand for a polluting good, representing a more eroding tax base. Further, fiscal taxes should be levied at the end use, as value added taxes (VAT), implying no taxes on intermediate goods and imports (Diamond and Mirrlees, 1971).

All policy instruments imply administrative or transaction costs. These may vary between the instruments and type of environmental problem. Generally, command and control instruments are assumed to be more administratively burdensome than economic instruments. But general, technical standards require less administration than

individual standards, and may also require less administration than some economic instruments. Environmental taxes imposed on products, like most CO2 taxes, may require relatively little administration once they are established, while taxes imposed directly on emissions could be very costly to administer if emissions monitoring is required. Experiences from the EU ETS show that administration and transaction costs could be quite high in an emissions trading system if allowances are to be allocated for free. Thus, administration and transaction costs should be taken into account when the use of environmental policy instruments is assessed.

1.3 *Report overview*

The report is structured in the following way: in chapter 2 a brief history of the use of policy instruments in the Nordic countries is presented. Chapter 3 gives an assessment of the cost effectiveness and environmental efficiency of the various instruments used, their linkages with each other and impacts on economic growth and on other issues, and is in many ways the main chapter of the report. The properties of the so-called "Nordic model" are discussed in chapter 4, and some potential lessons for other countries to enhance economic growth and the use of economic instruments in the environmental policy are elaborated. Chapter 5 gives a brief overview of what spurs technology change in general and a "green" technology development in particular, and presents some examples of green innovations from the Nordic countries. In chapter 6 some general lessons and recommendations are given, including some special recommendations for industrialized countries, emerging economies and developing countries. A brief overview of the environmental challenges and environmental policy use in each Nordic country is given in an Annex.

2. A brief history of Nordic environmental policy development

2.1 *1970-80s: command and control era*

2.1.1 Regulations of large industrial sources

The policy towards curbing pollution of water, air (including noise) and soil in the Nordic countries really started during the 1970s. During that period most of the Nordic countries established their ministries of environment, and they started focusing on emissions from large industrial sources. This was a natural beginning, since emissions from these sources caused several "hot spots" of local pollution, where the local air, water and/or soil often were heavily polluted. These environmental problems were very visible, and mostly local. Some of these emissions had to some extent also been addressed during the 1950s and 60s, but not as systematically and comprehensively as in the 1970s.

The main policy instrument used towards the large industrial sources was individual emission permits based on an assessment of the environmental situation in the local recipient, the potential measures to curb emissions and their costs. Based on this assessment, the individual plants were given targets for emissions reductions, often also specifying what kind of cleaning technology to use, stack height etc. The latter requirements may seem odd, but was often due to the fact that the authorities at that time knew more about the potential actions to reduce emissions than the companies themselves. The plants were given ample time to implement the necessary actions and integrate them in their ordinary investment cycles. Sometimes they were also seen in a broader industry context. An example of such flexibility from Norway could illustrate this, where the whole pulp and paper industry was restructured as part of the process of regulating and curbing emissions. Small, inefficient and heavy polluting plants were closed down, and replaced by fewer, larger plants with the newest abatement equipment. The industry were given time to make this structural adjustment (DNVI-ECON, 1993b).

The issuing of emission permits were done in several phases. In Norway the first phase was done through the so-called 10-year program for cleaning of older industries from the mid-1970s and lasted till around 1985. Then a second phase started with a renewing of the emission permits from the first phase. The second phase lasted through most of the 1990s. During the 1970s emissions permits for sewage treatment plants were also issued in many of the Nordic countries, requiring them to treat wastewater for various releases to water.

The first permits issued during the 1970s covered relatively few emissions and often only had requirements for emissions per year or per week. This reflected among other things the then limited possibilities for monitoring of the emissions. Later, when monitoring became easier and cheaper, requirements in the permits became more sophisticated. Furthermore, later permits are to a larger extent based on the environmental conditions in the local recipient than the size of the emissions from the sources. There has also been a clear trend in the Nordic countries that national minimum environmental standards replace local standards, partly to fulfill new EU directives (see below). The EU Directive on local air quality is among the first examples

of this, requiring a more comprehensive approach taking all emissions sources into account.

Public participation was ensured through hearings where locals could express their views and present their reactions on proposed emissions reductions. However, these permitting processes were expensive and time consuming, and only captured a small part of all polluting plants. Therefore, in most countries the individual emission permits have been partly replaced by general and/or industry-specific general rules and standards, specifying emission ceilings, production processes or special procedures to employ in order to avoid emissions. These rules comprise all plants in the industry in question. The individual permit system is today mostly still used for local emissions from large plants.

The air, water and soil quality has been substantially improved in the Nordic countries since the 1970s (TemaNord, 2006a).

During the 1970s and 1980s, environmental policies in most industrialized countries were primarily based on various systems of technical regulations (TemaNord, 2006a). However, it became increasingly recognized that traditional regulatory environmental policy, despite some successes, failed to address new environmental pressures and prevent further unacceptable environmental damage. Moreover, these policies imposed potentially high costs to achieve environmental quality objectives. Therefore, economic instruments as opposed to command and control regulations were increasingly recognized for their flexibility and cost effectiveness in achieving environmental objectives (OECD, 2001).

2.1.2 Some few economic instruments were used

Most of the Nordic countries had some economic instruments in use in the 1970s. These were mostly in the form of excise duties with the primary aim of raising revenues, but they could also have some positive environmental impacts. Several countries for many years had already imposed sales taxes for fiscal reasons on gasoline (imposed in Denmark already in 1917), mineral oil and electricity. Also, deposit refund systems on refillable bottles (introduced in Denmark in 1922) were introduced in most countries, prompted by problems of littering in the countryside (TemaNord, 2002). Deposit refund systems for end-of-life vehicles were introduced during these years. Furthermore, charges on water use and sewage were used in all countries. These charges were implemented to cover costs of the services supplied, but also to finance abatement actions in these sectors.

Norway implemented a tax on sulfur content in fuel oil in 1970, which is one of the first attempts in the Nordic countries of a tax primarily imposed for environmental purposes. The tax worked together with regulations on the sulfur content in fuel oil, regulations of fuel quality use in some local areas and sulfur emission permits for large plants. This is one of the first examples of the use of several policy instruments towards an environmental problem.

Sweden imposed several administrative taxes and product charges during the 1980s. A Swedish tax commission (Miljøavgiftsutvalget, 1990, cited in NOU, 1995) concluded that these taxes had little impact on emissions partly because they were too low, and partly

because the way they were designed. They proposed several changes in existing taxes and some new ones.

2.1.3 Fish resources management in Iceland was an early attempt at using economic instruments in resource management

All Nordic countries have for long regulated the amount of fish to be catched to ensure long time sustainable fisheries. The annual total amount of allowed catch has been distributed as individual quotas among fishers mostly according to their historical catch, and fishers have not been allowed to transfer or sell these quotas.

Iceland was one of the first nations in the world to introduce individual transferable quotas (ITQs) in fisheries. The ITQ was first implemented in 1979 for herring and was supported by the fishing industry. In 1984, the ITQ was introduced for other fish species as well. The Icelandic fishery sector was over-capitalized at this time and the stocks were overfished.

The system is described as follows in TemaNord (2009a):

"Central to this policy are the individual transferable quotas given to each fishing boat for each species on the basis of its average catch of that fish over a three-year period. This settles the boat's share of the total allowable catch (TAC) of that fish for the entire country. The size of this total is announced each year on the basis of scientific advice from the independent Marine Research Institute.

Subject to certain conditions, quotas can be traded among boats. If the boat owner has exhausted its quota, the owner must buy one from another boat. 20 percent of a quota may be carried forward a year, and 5 percent of the next year's quota can be claimed in advance. Equipment carried on all vessels send electronic signals to make satellite monitoring possible at all times, and each boat is likely to go to sea with an inspector aboard twice a year. All catches are rigorously recorded as soon as they are landed. The Marine Research Institute knows exactly how much each boat is catching and where. It claims that 95 percent of the total is well reported.

By looking at the Directorate of Fisheries' website fishers can see all landings by date and species and thus work out whether to sell their catch fresh or frozen, and whether to buy, sell or carry forward quotas. All quota changes, catches and landings are posted on the internet, enabling everybody to see what is going on. The idea is to let fishermen be guided by the market.

The owners of a quota are charged a fee per tonne of catch to finance a fund to facilitate rationalization in the fishery sector. The operations of the fund have stopped and the financing is linked to down payment of loans that the fund incurred when it was in operation.

This system was seen as a necessary and temporary remedy to overcome the deep crisis of over-fishing of herring prevailing at the time. There has been some discussion about this quota right, which one may sell, lease out or use oneself like any other possession. Debate has arisen about some of the effect of this management system on fishing practice. Recently, many have made enormous profits by selling fishing quotas which were allocated to them free of charge. Newcomers to the industry find it hard to buy the

licenses and quotas they need to start fishing. As a result, the number of boats is falling. Yet Iceland no longer suffers from overcapacity, and the catch per boat is increasing. Ownership, however, is growing more concentrated.

Also, there has been discussions about that the rights of fishing have been transferred to specific individuals free of charge on a long term basis, thereby excluding others from fishing, which many people still find morally wrong."

2.1.4 Conservation of nature

The Nordic countries were relatively early in protecting valuable landscape and endangered wildlife. The first national park in Europe was established in Sweden in 1909 and the other Nordic countries followed through the 1950s and 1960s and later (the first Danish National Park was opened in 2008). Today considerable areas in the Nordic countries are protected through national parks and other types of protected areas. The Nordic countries have emphasized that the national parks should be characterized by untouched nature. This is in contrast to national parks in most other industrialized and densely populated countries where the areas are more like cultural landscapes crossed by roads and other interventions to ease public access. This again has to do with the fact that free public access to privately owned unpopulated areas are ensured in most Nordic countries (except Denmark), which is rare in other countries (http://www.snl.no/nasjonalparker).

Also, the Nordic countries rather early became aware of the threat towards endangered species. Focus started on the large, rare animals like wolf and bear, which was nearly eradicated in the 1960. The wolf was protected in Scandinavia around 1970, and since then the number of animals has increased. However, there have been considerable local conflicts connected to this protection.

Later, the Nordic countries have ratified various international conventions regarding protection of biodiversity, and have established "red lists" for endangered species. However, there are great challenges in how to protect the various species from eradication.

2.1.5 Spatial planning

Before the 1970s the Nordic countries had mostly in place legislation and systems for spatial planning in and around urban areas to deal with land use. Urban sprawl causes conflict and tension about the use of land, and therefore land use need to be well planned. The plans are usually divided in local plans (covering parts of a local area, for instance part of a town), municipal plans and county plans (OECD, 2007).

Public participation has played a crucial role in the spatial planning processes. Through public hearings and other kinds of activities people have been encouraged to express their views on the various use of the land. Also, when conflicts occur, for instance when larger construction projects are considered and implemented, the most affected people are economically compensated for their loss. If the parties do not agree on compensation these cases are settled in court.

2.1.6 Environmental Impact Assessments

The Nordic countries during the 1970s and 1980s established legislation requiring Environmental Impact Assessments (EIA) for large construction projects. These requirements are usually part of the spatial planning processes. The project developer is required to carry out an EIA to assess all potential positive and negative impacts from the project, including environmental impacts in a broad context. The EIA should also include proposed actions to reduce negative impacts. Stakeholders should be consulted during the process and given the opportunity to comment on a draft EIA. Public meetings and other consultation processes should be used.

Later the concept of Strategic Environmental Assessment (SEA) has also been implemented in the Nordic countries to follow up the EU SEA Directive (2001/42/EC). This concept requires that all new plans, policies and programs should be subject to an assessment of the environmental impacts before implementation. SEA has been a useful tool when designing new policy instruments in the environmental area and in other sector policies, and facilitated the integration of environmental concerns in most of the sector policies.

2.2 *1980s: environmental policies enter new sectors and areas*

The first pollution control measures had a local focus and were mainly directed towards large industry sources. It became soon clear that more sectors had to be approached to solve the environmental problems in a cost effective way. Furthermore, the regional and to some extent also the global properties of many environmental problems raised the need for international cooperation to be able to solve them cost effectively. This resulted in expansions of the environmental policy into several new areas and sectors.

2.2.1 International cooperation becomes important

One of the first attempts to cooperate on emission reductions was the Helsinki protocol from 1985 established under the ECE Convention on Long-Range Transboundary Air Pollution. The protocol requires each country to reduce emissions of sulfur by 30 percent by 1993 compared to their 1980-level. This approach was later criticized for requiring countries to reduce their emissions by an equal percentage share, not taking into account the different patterns by which emissions from the different countries spread and the differences in abatement costs. The follow up sulfur protocol, signed in Oslo in 1994, addresses these shortcomings by differentiating countries' commitments according to nature's limit of tolerance in the receiving countries and the emitting countries' abatement costs. To increase cost effectiveness across countries the Oslo protocol also allows emissions trading among countries or joint implementation of the commitments. This development of international cooperation is a good example of how cost effectiveness gradually has come to play a larger role in international agreements.

Another example of a protocol under the ECE Convention is the first NO_x Protocol signed in Sofia in 1988, in which the parties undertook to stabilize NO_x emissions at the 1987 level by the end of 1994.

Each country was free to choose policy instruments to follow up their requirements under the various protocols, and to some extent sulfur taxes on fuels have been used in the Nordic countries. But most of these emissions have been limited through various regulations on sulfur content in fuel use and direct regulations of emissions from large

industrial sources (including power plants). Also NO_x and other emissions have mostly been curbed by regulations, since applying taxes has been considered administratively costly and complicated. However, an early example of the use of NO_x tax from Sweden and more recently a NO_x charge to finance abatement measures in Norway are presented below.

Later these protocols were replaced by the Gothenburg protocol from 2000 which set individual emission targets for the countries for sulfur dioxide (SO_2), nitrogen oxide (NO_x), volatile organic compounds (VOC) and ammonia (NH3) in 2010 compared by their 1990 level.

In 1974 the Helsinki Convention (HELCOM) was signed, which entered into force in 1980. For the first time ever, all the sources of pollution around an entire sea were made subject to a single convention. The Convention on the Protection of the Marine Environment of the Baltic Sea Area was signed in 1992, and entered into force on 17 January 2000. The Baltic Sea Action Plan (BSAP) covering all countries bordering the Baltic Sea and taking an ecosystem approach to the management of human activities, is a part of this package. The Nordic countries have been the promoters of these comprehensive approaches to improve the water quality of the Baltic Sea.

The North Sea Declarations, starting in 1984, are samples of declarations under the OSPAR Commission where the North Sea countries declare their willingness to reduce releases of nutrients like nitrogen and phosphorous into the North Sea, requiring Denmark, Norway and Sweden to limit these releases from agriculture, sewage and industry. The countries have mostly limited these emissions through the use of direct regulations. Sweden introduced a fertilizer tax on nitrogen and phosphorous as well as a price charge in 1984. Denmark also implemented a tax on fertilizer. These taxes were primarily aimed at reducing leaching to groundwater, but also contributed to reducing release to the North Sea (TemaNord, 2009a). Later the North Sea Declarations were expanded to also cover release of hazardous substances, more on these below.

The Nordic countries were strong encouragers of these agreements and later protocols and treaties. Over the years a broad range of international environmental agreements have been signed by the Nordic countries, which have to an increasing degree become important framework for the countries' environmental policies. Even more important for the choice and design of policy instruments have become the various EU regulations, more about this below.

2.2.2 Waste policy emerges

As mentioned above most Nordic countries had deposit refund schemes for refillable glass bottles in place in the 1960s and 1970s. These schemes were expanded to plastic (PET) bottles (and for some countries also aluminum cans) in the 1980s. Also for products like waste oil (Norway) and ELVs deposit refund systems were imposed.

Apart from the charges on beverage containers from the early 1970s user charges on the collection and treatment of municipal waste were implemented at an early stage, as payment for the services. These are usually flat rate charges, but some municipalities introduced fees depending on the size of the bin or weight-based charges (TemaNord, 2002).

During the 1980s increased emphasis was put on the environmental problems connected to the handling of municipal and industrial waste, i.e. emissions to air from waste incineration and leakages from landfills to soil and water. Thus, emission permits were issued to larger incinerators and landfills in mostly the same way as it had been done earlier for large industry plants. For incinerators limits on emissions of various hazardous substances were imposed, and for landfills several technical requirements for collecting water and releases of methane to air were imposed.

Gradually, a perception also emerged that one should try and reduce the amount of waste generated at source. Various schemes were developed to encourage recycling, reuse or energy use of the waste generated. Denmark and Sweden also imposed taxes on various packaging to reduce the amount of package on products.

Later, several EU Directives have become important for the formation of the waste policy. They have set goals for material and energy recovery, and now landfilling of biodegradable waste is prohibited. The waste policy has over the years gradually been refocused from local environmental problems to contribute to reduced greenhouse gas emissions from waste handling (TemaNord, 2009a).

A system of agreements with various producers and importers on producer responsibility were negotiated with national authorities in all countries during the 1980s. These agreements require producers within selected fields to collect and recycle their products when they are discarded as waste. The objective has been to reduce the volume of waste, increase recycling and encourage environmentally sustainable product development. End-of-life vehicles, tyres, batteries, packaging, newsprint, electrical and electronic products are among the products where agreements on producer responsibility have until recently been negotiated. Producers and importers usually impose a charge on the sales of the products to cover to collection and treatment costs (TemaNord, 2009a).

Waste disposal taxes were later levied on waste supplied to landfills and incinerators in most Nordic countries (TemaNord, 2002). Denmark was the first country to impose charges in 1990, followed by Finland in 1996. Norway and Sweden followed suit in 1999. In Denmark, Norway and Sweden the tax applies to both conventional and industrial waste. These taxes have in some countries been differentiated according to the environmental quality of the landfill, carbon content in the waste and actual emissions from incinerators.

2.2.3 Release of hazardous chemicals from products and other sources were addressed

The Nordic countries were forerunners in international chemicals policy (TemaNord, 2009e). Releases of hazardous substances like heavy metals and other toxic substances from industry were during the 1980s to a large extent regulated through the emission permitting process towards large industry plants. This contributed to large emission reductions.

But there were still considerable emissions left, notably from the use of various products by consumers and in particular when the products end up as waste. Some examples were release of lead from batteries, leaded petrol and use of lead-pellets from shotguns, mercury from thermometers and from dental clinics etc. These emissions caused both

local, regional and to some extent also global damages, and it was recognized that they needed to be reduced.

In general, two basic principles have governed the initiatives towards hazardous chemicals in the Nordic countries: (a) the substitution of safer products for potentially harmful products; and (b) precautionary actions even though the nature and magnitude of risks are not fully known (TemaNord, 2009e). The policies implemented include a variety of regulatory and voluntary tools to reduce hazardous chemical risks, involving education, technical assistance, some taxes and fees as well as bans and phase-outs of many of the substances. The focus has been on the development of long-term goals and action plans for reducing the impacts of broad classes of chemicals, as well as rapid screening processes to prioritize chemicals for reductions. To some extent also special requirements for waste handling targeting particular products and/or releases, for instance collection of lead-containing batteries and mandatory installations of amalgam-collectors at dental clinics, have been imposed.

Nordic policies have also been characterized by the establishment of lists of chemicals of concern to guide business and government decision-making. Government authorities then work with business and procurement agencies to assist them in avoiding these chemicals. Some countries are providing technical support and initiating demonstration projects on alternatives as critical steps in developing safer alternatives. These measures have made the phase-out and ban objectives attainable in practice.

The Nordic countries have also headed several international initiatives to more effectively protect their environment, and to harmonize international standards. These programs have had an important influence in the development of, for instance, the EU chemicals management scheme (REACH).

Few economic instruments were used. Reduced tax on unleaded gasoline is one notable exception, as is some deposit refund systems like for waste oil in Norway introduced in 1988. In 1996 Denmark introduced taxes on the use trichloroethylene, dichloromethane and tetrachlorethylene. Denmark also imposes taxes on PVC and phatalates. Since 2000 Norway taxes trichloroethylene and tetrachlorethylene, and has a refund system when the used substances are delivered for waste handling. Some taxes on pesticides and fertilizers in some Nordic countries have already been mentioned.

2.2.4 Emissions from transportation and agriculture were also addressed

Transportation, i.e. the use of cars, was an early target for excise duties on purchase, ownership and fuel use in most countries. But during the 1970s and 1980s traffic and emissions grew, and it was seen necessary to do something to curb these emissions. Since the Nordic countries hold a small share of the global car market they have little or no influence on the development of the emissions from new cars. Thus, regulating the content of harmful substances in fuel and limiting the amount of driving had to be focused. However, Sweden has invested a lot in the national production of biofuels and spurred a positive development in terms of cars sold that can run on mixed fuels

Addressing lead in gasoline through differentiated taxes has already been mentioned. Sulfur content in gasoline and diesel was also addressed, partly with taxes and regulations. Another measure was introducing emissions standards for NOx from new

private cars. To fulfil the standard some catalytic converters were necessary. It was considered too costly to install these in the existing car park.

Agriculture activities together with emissions from households and some industry contributed to large releases of nutrients like nitrogen and phosphorous to freshwater and sea areas, which caused substantial local and regional damages for instance through growing of poisonous algae. This problem is far from solved, anoxic areas in the Baltic Sea have quadrupled since the 1960s and eutrophication in the Baltic Sea has never been as bad as today. Release of pesticides has also been a challenge. These problems have been addressed by regulating agricultural practice and use of inputs. For the latter, taxes on the use of pesticides and fertilizer were also applied.

2.2.5 Environmental labelling

The Nordic Ecolabelling Scheme, the Swan label, was introduced in 1989 by the Nordic Council of Ministers (TemaNord, 2008a). Norway and Sweden were involved from the beginning, Finland joined the scheme in 1990 and Iceland in 1991. Denmark initially chose to take an observational role while waiting for the introduction of the EU Ecolabelling scheme. Since 1998, Denmark has also been a part of the Nordic Ecolabelling Scheme.

The EU Ecolabelling scheme was established in 1992. One of the ideas behind the scheme was to replace existing national and regional ecolabelling systems in Europe. This did not happen in the years that followed. Alongside the EU Eco-label and the Swan, there are 13 national eco-labels in operation in the European Union (TemaNord, 2008a). The aim of both the ecolabelling schemes is to award an eco-label to products and services with reduced environmental impacts compared to some baseline product. Both the schemes are voluntary. Criteria are established for individual product and service groups. The idea of the schemes is to communicate to consumers that an eco-labelled product has been carefully assessed and has been found to make less of an environmental impact than other similar competing products. In this way, the schemes aim to stimulate environmentally sound product development and to reduce environmental stress.

The Nordic Swan and the EU Eco-label are today very similar systems. The schemes are operated by the same secretariat that serves to co-ordinate the schemes on an operational level. The two ecolabelling schemes have published criteria for 18 overlapping product groups. The labelling criteria have become more similar, even though very few products have exactly the same criteria. The number of product groups with EU Eco-label is still less than half that of the products included in the Nordic Swan (TemaNord, 2008a).

The Nordic ecolabelling scheme has been evaluated several times, last time in 2008 (TemaNord, 2008a). The general conclusion is that the scheme has performed well, and there is great interest among Nordic producers to use the scheme. It has been a great advantage that the Nordic Swan has maintained a pragmatic approach towards new aspects of sustainable consumption and has included a range of environmental issues like health, quality and some social issues when appropriate. However, users could benefit from more harmonization between the various schemes in use. Denmark strongly favours a more rapid harmonization with the EU system, while the other Nordic countries tend to benefit from the strong market position of the Swan.

In 2001 the Community eco-management and audit scheme (EMAS) was established (Regulation (EC) No 761/2001). EMAS operates as a voluntary eco-management and audit scheme, and helps companies to optimize their production processes, reducing environmental impacts and making more effective use of resources.

2.3 *1990s: climate change policy emerges*

2.3.1 "Think global, act local"

During the late 1980 and early 1990s concerns about potential warming of the globe due to manmade emissions of greenhouse gases (GHG) emerged in many countries. The Nordic countries were early to introduce actions to curb emissions. In the beginning of the 1990s all Nordic countries except Iceland introduced CO_2 taxes on fossil fuels. Finland was the first country in Europe to impose a CO_2 tax in 1990. Norway and Sweden followed in 1991 and Denmark in 1993 after having received EU approval (TemaNord, 2006d). Iceland uses hydro power and geothermal energy for stationary sources, but has now a CO_2 tax on fossil fuels in the transport sector and on stationary fuel use.

These taxes were mostly levied on oil products for domestic and transportation use, and already existing excise taxes were often reduced to avoid increase of the overall tax burden (TemaNord, 2009a). The initial tax rates were low and many exemptions were introduced to avoid undesirable competitiveness effects, as countries outside the Nordic region hesitated in introducing similar measures (TemaNord, 2006d). After a few years Sweden lowered its rather high rate of combined carbon-energy taxation for industries. Denmark started to tax industrial CO_2 emissions cautiously from 1993, phasing in the tax rates gradually up until the year 2000. Norway has exempted taxation of CO_2 from industrial processes since the introduction. However, CO_2 tax rates were gradually increased during the 1990s in the four Nordic countries where the taxation applied. This was supported by the growing recognition of global warming as a pressing issue, and by the steady extension of carbon taxation in several other countries outside the Nordic region (TemaNord, 2006d). The Nordic countries had managed to set an example, and others followed suit. The taxes were and are still not always levied consistently according to the carbon contents in fuels, and some fuels and sources were and still are fully exempted.

2.3.2 Nordic countries also promoters of coordinated actions

The Nordic countries were also among the most eager countries to push for coordinated international actions to curb global emissions. Since it was considered relatively costly to reduce emissions in the Nordic countries, they were early advocates for mechanisms to finance abatement activities in developing countries, and experimenting on how this could be organized and carried out through various joint implementation arrangements were promoted through Nordic Council of Ministers and other bodies.

The UN Climate Convention, adopted in 1992 and entering into force in 1994, established the first important foundation for the international efforts to mitigate human induced climate change. The Kyoto protocol under the convention, adopted in 1997, established a commitment for the reduction of industrialized countries' total greenhouse gas emissions by at least some 5 percent during the period 2008-2012 compared to 1990 level. The protocol contains different commitments for each country,

based to some extent on considerations on projected emissions and abatement cost considerations. For the Nordic EU member countries Denmark, Finland and Sweden the commitments were further differentiated through EU internal negotiations. Iceland and Norway were allowed to increase their emission by 11 and 1 percent respectively compared to their 1990 levels.

In fulfilling these commitments the protocol allows the countries to finance and implement abatement activities in other countries through the Joint Implementation mechanism (in countries with limitation on their total emissions, the socalled Annex I countries) and the Clean Development Mechanism (CDM) in developing countries with no limitations on emissions. This was considered as very important to reduce the overall costs of fulfilling the obligations of the protocol, and the Nordic countries were among the architects behind these mechanisms.

The Kyoto protocol also allows trading of emission allowances among Annex I countries. This was also a mechanism encouraged by the Nordic countries. Denmark was among the first countries in the world to introduce a trading system for CO_2 emissions. During the years 2000-2003 the Danish electricity generating sector was exposed to an emissions trading scheme providing them with fewer and fewer allowances each year (TemaNord, 2006a).

The EU during 2005-2007 established a (trial) emissions trading period prior to the Kyoto protocol's commitment period. This first system of the European Emission Trading System (EU ETS) covered power producers and some energy intensive industry sectors, and the overall goal for these installations was to reduce emissions by 15 percent compared to the "business as usual" projections.

The EU 20–20–20 targets by 2020, i.e. 20 percent GHG emission reductions, 20 percent renewable energy share and 20 percent increase in energy efficiency will be important for the future policy implementation in the Nordic countries. Furthermore, the EU directive on renewable energy (RES-Directive) will give each member country (and Norway and Iceland) targets for the share of renewable energy in their domestic energy supply, which are (partly) justified by their GHG emission reduction abilities (TemaNord, 2009a).

2.3.3 Economic instruments most important GHG policy instrument

The Nordic countries have to a large extent applied economic instruments to reduce GHG emissions to fulfill their Kyoto obligations. Emission trading has been the main instrument through the EU ETS. For those emission sources not covered by the trading system, mainly in the transportation sector and stationary use of fuel oil and other energy products, CO_2 taxes have been the main instrument.

Taxes have also been used for other GHG emissions. In 2001 Denmark introduced a tax on perfluorocarbons (PFCs), sulfur hexafluoride (SF6) and hydrofluorocarbons (HFCs) to curb emissions of these GHGs. These came in addition to the CFC tax which had been in force since 1989 (TemaNord, 2006a). Also Norway from 2003 has had a tax on HFCs and PFCs, also comprising all mixtures of these substances and products containing them. Recovered HFC and PFC are exempted from the tax (TemaNord, 2006a).

Norway has also applied negotiated agreements towards the emissions of PFCs and SF6 from some industry branches. These GHGs were not covered by the EU ETS, and the authorities have not wanted to apply taxes towards them due to competitive reasons. For the same reason they have not applied taxes on CO_2 emissions from power intensive industries like aluminum production, which has not been a part of the EU ETS. Thus, these emissions haven't been subject to any policy instruments. However, from 2013 many of these emission sources will be covered by EU ETS.

The various subsidy schemes for renewable energy production and energy efficiency measures have (partly) been justified by their potentials for CO_2 emission reduction, see more about this below.

2.4 *2000s: new economic instruments come into use*

During the 1980s and into the 1990s with years of experience with the use of various command and control policy instruments, a discussion emerged in many countries on the need for a more environmentally efficient and economically effective pollution control (NOU, 1995). Even if the use of individual emission permits were implemented more flexibly and to some extent replaced by general requirements and standards, a need was felt to improve the regulations. The use of economic instruments was considered as a way to achieve this, but mostly as a supplement to command and control measures. In countries like the UK and US economic instruments were to a somewhat larger extent seen as alternatives to existing regulations.

While the use of economic instruments as we have seen increased during the 1990s, notably towards greenhouse gases, there were still ample room for new instruments and improved use of existing ones. The EU ETS was put in place during the 2000s, and this was really a big achievement not only for the Nordic countries but also for all countries participating in it. As we shall see below, economic instruments also gained ground in other areas.

2.4.1 The Swedish NOx charge

In 1992 Sweden introduced a charge on emissions of nitrogen oxides (NOx) from large stationary combustion plants. The NOx charge is a supplement to emission limits set in operating permits. The main aim of the charge was to combat acidification and reduce emissions beyond the emission limits (TemaNord, 2009a).

From 1997 the charge covers combustion plants generating more than 25 GWh/year. A further criterion for liability to the charge is that the energy produced is used to heat buildings to generate electricity, or in industrial processes. The initial charge introduced in 1992 was SEK 40 per kilo of nitrogen oxides emitted, calculated as nitrogen dioxide. From 2009 this charge was raised to 50 SEK/kg.

All proceeds from the tax are refundable to the collective of regulated plants based on plant output as fraction of total useful energy produced by regulated plants. This means that plants with low emissions compared to the energy production are net receivers of funds, while plants with high emissions in relation to energy production are net payers. According to OECD (2010b) this refunding was established to avoid serious distortions in competitiveness.

The Swedish NOx tax has been widely highlighted globally as an example of an innovative use of environmental taxes to spur emissions reductions and technological innovation.

2.4.2 The Norwegian NOx charge

Norway introduced a tax on NOx emissions in 2007. The purpose of the tax is to contribute to cost effective reductions of NOx emissions and together with other policy measures contribute to fulfill Norway's obligations according to the Gothenburg protocol (TemaNord, 2009a).

The tax comprises:

- Propulsion machinery with total installed engine effect of more than 750 kW
- Engines, boilers and turbines with a total heating effect of more than 10 MW
- Flaring at offshore and onshore installations.

The tax duty arises when NOx is emitted. There is tax exemption for emissions from vessels in direct traffic between Norwegian and foreign harbors, aircrafts in direct routes between Norway and foreign airports, vessels used for fishing and catchment in foreign seas and emission sources comprised by environmental agreement with the government about implementation of NOx reducing interventions in accordance with a fixed goal.

The Ministry of Environment and 14 trade organizations in 2008 entered into an agreement to establish a fund to finance cost effective emission reductions, implying that those installations investing in abatement measures will be relieved from the NOx tax. The tax rate is today around NOK 16/kg NOx, i.e. substantially lower than the Swedish NOx tax rate (see above).

When the tax was introduced it was emphasized that emissions should be reduced without harming the affected industries too much. Therefore, some NOK 400 million was set aside for compensation to the affected installations. When the environmental agreement was signed the need for much of this was reduced, and the compensation has since been substantially reduced.

Both the Swedish and Norwegian approach aim to circumvent the classic argument against environmental taxes, namely that such taxes disrupt competition. By redistributing the proceeds from the tax to those paying them in a way that do not seriously disturb the incentives to reduce emissions, environmental taxes could become acceptable among all stakeholders. This is what appears in both Sweden and Norway. The innovative impacts of the Swedish tax are evaluated later in this report. It is also interesting to note that the Swedish tax is a supplement to direct regulations, while in Norway there are no other policy instruments used towards the emissions covered by the tax.

Denmark also imposed a NOx tax in 2010.

2.4.3 Swedish congestion taxes

Stockholm has introduced congestion taxes intended to reduce congestion on the roads and streets in and around central Stockholm, and to reduce emissions of pollutants that are harmful to health and the environment. Most of the revenues are earmarked for investment in public transport. Trials with the system started in August 2005 and the Government proposed that the system should be permanent in the spring of 2007 after the system was evaluated through a city referendum in 2006 (TemaNord, 2009a).

Different tax rates are levied on different hours of the day. Newly registered environmentally friendly cars are no longer exempt from the tax (as from January 1 2009) while already registered "environmentally friendly" cars are exempted until August 1, 2012. Congestion tax expenses can be deducted in people's declaration for income tax payments, thus potentially reducing some of the impacts of the tax on peoples' driving behavior.

2.4.4 Differentiated car purchase tax

For many years all Nordic countries except Sweden for fiscal reasons have had taxes on purchase or registration of new passenger vehicles. These taxes have recently been modified to give buyers incentives to buy more energy and carbon efficient cars. Norway has been in the front of this change, and to illustrate how fiscal taxes could be designed to improve the environment the changes in the Norwegian tax is discussed below.

In 1982 a gradual change of the value-based purchase tax started towards a combined weight and value based tax, which was fully completed in 1991 (NOU, 2007). In 1996 the purchase tax scheme on motor vehicles was changed again to being entirely based on environmental merits (weight, horsepower and piston displacement). One of the aims of the new tax design was to encourage consumers to buy smaller cars – in terms of weight and power – and hence cars with a lower environmental impact (TemaNord, 2006a).

The registration tax system in 2006 indirectly taxed CO_2 emissions through the weight, displacement and engine effect components. A major change in the tax was made in 2007, when a CO_2 component was introduced, replacing the tax on engine displacement. Today the registration tax consists of vehicle weight, engine effect and CO_2 emissions components. All the elements are progressive. From 2009, the progression has been further developed with a deduction for low emission cars (less than 120 g/km), but total registration tax cannot become negative. Furthermore, high emissions vehicles (more than 250 g/km) have been rather heavy penalized by the tax system.

Electric cars powered from a battery only or through fuel cells pay no registration tax. Also hydrogen fuelled cars are fully exempt from the tax, also if the hydrogen engine is combined with an electric engine. Vehicles run on concentrated ethanol can deduct an amount from the vehicle tax, as will plug-in hybrid cars when they enter the market. The registration taxes for motor cycles and snow scooters have similar, progressive tax systems based on displacement and engine effect as well as a general tax per unit (motorcycles), and on weight, displacement and engine effect (snow scooters).

The purchase tax change from 2007 has led to a considerable increase in the share of diesel vehicles of the total number of new passenger cars sold, and that emissions per

kilometer have been reduced substantially for new cars. The Government has indicated that the tax rates will be further differentiated in the coming years to stimulate purchase of low CO_2 emission cars and increase the costs of cars with high CO_2 emissions. The transformation of the tax system also facilitates a better treatment of for example hybrid and electric vehicles. All cars will have engine effect and weight, but in the future there will be an increased supply of cars without displacement, like electric cars.

For many years, all Nordic countries have for fiscal reasons had annual excise duties levied on the owners of a passenger car. Over the years these duties have also to a varying degree become differentiated according to environmental properties of the cars, like energy efficiency, weight, CO_2 emissions or whether they are diesel or gasoline fuelled, if particle filter is installed etc.

2.4.5 Green Certificates

As the only Nordic country, Sweden has had a green certificate system for electricity production since 2003. The certificate system requires a minimum share of renewable electricity of total electricity consumption. Producers are required to hold certificates corresponding to a share of its total production and sale of electricity that should come from renewable sources. Certificates are handed out to producers based on the amount of electricity produced from renewable sources and can be sold to those electricity producers with no or in short supply of renewable production capacity to fulfill their obligations (TemaNord, 2009a). Norway will join this system from 2012, making it a common Swedish-Norwegian system.

2.4.6 Environmental Information

Information is important to a well functioning market and to ensure that people take the environmental costs of consumption and production into consideration. Various information and communication tools have been used in the Nordic countries over the years. The most important types are product-related communication, public information campaigns and communication via the media (TemaNord, 2006c). Information to consumers and producers on environmentally friendly use and disposal, e.g. how to increase energy saving and promote waste separation and recycling, has been some of the most important areas. Also, information on new rules and legislation, new support schemes etc. has been common. Information is often being used together with other policy instruments like subsidies, legislation etc.

2.4.7 Green Public Procurement (GPP)

Various agencies at state and municipal level are large buyers of goods and services. Using this “purchasing power” to promote environmental benign products and services has developed over the last years. Public procurement constitutes 16 percent of GNP in the Nordic countries and for some product groups the public sector is the most significant purchaser. Among products with a large turnover and a potential significant environmental impact are construction works, IT products, cleaning agents, transport services and vehicles (TemaNord, 2009d). According to TemaNord (2009b) all the Nordic countries have recently issued national action plans on green public procurement or sustainable public procurement. Some legislation has also been adopted. In general, GPP considerations are obligatory for government entities in all Nordic countries (TemaNord, 2009d). Other public organizations, such as local authorities, are not directly obliged to apply GPP practices but are strongly

recommended to do so, and it is part of the national action plans to include all public organizations. The actual level of GPP varies much between the countries, both with regard to implementation of GPP in the administrative units and with regard to product groups included. In all countries it is a complicated and long process to get GPP fully adopted in local authorities.

GPP has also been promoted internationally. The United Nations in 2002 launched a 10–year action programme in which public procurement has an important role in increasing demand for ecologically better products (TemaNord, 2009b). In 2002 the OECD gave a recommendation to improve the environmental performance of public procurement. GPP has also been recognized as one of the most important policy instruments in EU's Integrated Product Policy, and is seen as an integral part of the new Action Plan on Sustainable Consumption and Production and Sustainable Industrial Policy. As part of this, the EU Commission has encouraged all Member States to draw up national action plans describing how they intend to increase the level of environmentally sound procurement (TemaNord, 2009b).

A lot of studies on GPP have also been carried out in the Nordic Council of Ministers (NCM) (Dahlin, 2010). This work has focused on showing benefits from GPP, how to establish practical guidelines and criteria for GPP, and to contribute from Nordic experiences to the related work in the EU and its Member States. Information material on how to carry out GPP has also been produced, and product-specific criteria sets have been developed, see for instance TemaNord (2009c). This work has been able to draw on the work carried out by the Nordic Swan label.

In spite of some efforts to develop common Nordic criteria (see TemaNord 2006c) these have yet to be developed, but a set of criteria has been presented to the EU that can be viewed as examples of Nordic criteria. In 2009 the NCM steering group for GPP proposed that the European Commission should take these criteria sets into account in the further work on the "common GPP criteria" outlined in the "Public procurement for a better environment" communication (Dahlin, 2010). As GPP increases, the criteria used by EU Member States and others should be compatible in order to avoid distortion of the single market and a reduction in EU-wide competition. Having a single set of criteria for each specific product or service would considerably reduce the administrative burden for tendering companies and public administrations implementing GPP (TemaNord, 2009b).

Innovative GPP (IGPP)/Technology procurement is a special part of GPP gaining ground. According to Dahlin (2010) NCM projects on IGPP of construction, IT and transport services and technology procurement have been carried out to examine how GPP can enhance the volume of sales of environmentally innovative products and services. According to TemaNord (2008b) this has been used for a variety of technologies and products such as household and commercial appliances, lighting systems, building components, and office and industrial equipment. Technology procurement has especially been used in Sweden to speed up the market introduction of energy-efficient products. Sweden stands out from the other Nordic countries by having both institutions and regulation with specific focus on technology procurement. In TemaNord (2008b) it is estimated that more than 100 technology procurement projects and processes have been carried out in Sweden.

2.4.8 Payment for ecosystem services (PES)

Conditional, voluntary payment mechanisms to preserve and enhance ecosystem services (ES) were introduced in the Nordic countries from the 1990s. Agri-environmental schemes aiming at increasing biodiversity or reducing nutrient leakage exist in all Nordic countries; biodiversity preservation and groundwater protection schemes exist in forestry in Denmark, Norway, Sweden and Finland; an innovative payment scheme using blue mussels to remove nutrient from coastal waters exists in Sweden and buyout schemes of fishing vessels exist in Denmark and Norway in order to reduce pressure on fishing stocks (TemaNord, 2009i). Finland has used forest procurement auctions for preservation of forests. Also, Finland has used auctions in agriculture where farmers bid land for protective uses against water pollution.

PES is a market-based voluntary approach that is based on conditional performance contracting (TemaNord, 2009i). It functions similarly to targeted subsidies, but with PES at least one of the parties (buyer or seller) can decline and there is ideally firm conditionality based on efficient monitoring and credible sanctioning in case of non-compliance. PES works by having at least one buyer of ES pay at least one provider of ES for securing environmental qualities such as clean water, scenic beauty or carbon sequestration. The maximum payment that should be made is the willingness to pay of beneficiaries for the ES and the minimum payment is the cost that just compensates the land manager for foregoing his legal rights to manage his land in a specific way plus the transaction costs of setting up and running the PES scheme. The price can be subject to negotiation directly between buyers and sellers or it can be set as a fixed payment, which is often found where intermediaries such as governments or NGOs act as the buyer of ES.

3. Assessment of Nordic environmental policy experiences

In this chapter we present an assessment of the overall policy and main policy instruments used in the Nordic countries since the 1970s. The assessment is not complete, but focuses on the most important policy instruments used and also highlights some of the most interesting novel instruments used.

An important part of the assessment is to examine to what extent the use of (economic) policy instruments has enabled a decoupling of the relations between emissions and economic growth, and if the use of these instruments to any extent have had any impact on the growth itself.

During the 1970s and early 1980s various command and control policy instruments were almost the only ones used. These instruments have by and large been in use until today, and as we have seen from chapter 2 more command and control approaches have been applied in new areas. Thus, command and control policy instruments play a crucial role today, and in areas like land use, nature conservation, reduction of biodiversity loss, curbing use of toxic substances, emissions to air and water from large industrial sources et. various command and control approaches are either the only or the main policy instrument applied. But the use of economic instruments has gained ground, and for "new" environmental problems like climate change these instruments play the main role. It seems fair to say that economic instruments have become supplemental to command and control approaches for most traditional environmental problems, and that they play the main role supplemented by command and control approaches towards some other environmental problems.

3.1 *The command and control policy have been fairly (cost) effective*

There are few evaluations of this policy approach, but some evidence from Norway indicates at least that benefits have been larger than the costs. An evaluation from the Grenland area, which had and perhaps still have one of the greatest concentrations of industry in Northern Europe, shows the result of an investigation of the willingness to pay to improve the air quality in the area carried out in 1982 of NOK 1.7 billion (1992 value), see DNVI-ECON (1993a). The same evaluation from 1992 indicated that the costs of reducing the emissions during the period 1982-1992 of NOK 1.2 billion (1992 value).

Could the environmental improvements have been achieved at a lower cost? Since the environmental problems were mostly considered local, it was natural to focus on the largest emission sources, and since they were few (often one for each recipient) it was natural to focus on direct regulations (NOU, 1995). But it has been acknowledged that this approach was perhaps carried out too long, and more emphasis should perhaps have earlier been put on reducing emissions from smaller sources after the emissions from the larger ones had been reduced. In this respect, economic instruments in the form of taxes on emissions or emissions trading could eventually have been used (NOU, 1995). For regional and global environmental problems this would according to this study clearly have been a better approach. Also, supplementing emissions regulations of single plants with a tax on the emission limits could have had some dynamic properties by giving companies incentives to apply for reduced emission limits over time, and thus reveal their true abatement costs. Alternatively, some local or regional emissions trading could have been applied to reduce abatement costs. But costly monitoring and other administration costs could be arguments against this approach.

According to NOU (1995) the use of direct emission regulations do not seem to have caused competitive disadvantages between Norwegian companies in the same branches beyond what could be expected from variations in the environmental conditions in the local recipients. Furthermore, there is no evidence that Norwegian companies have suffered any competitive disadvantages compared with foreign competitors. Even if Norwegian companies faced environmental regulations earlier than many competitors, the latter were also exposed to such regulations. Flexibility in imposing the regulations from the regulator also contributed to this. There are reasons to believe that companies in other Nordic countries have been in a similar situation during this period.

Direct regulations of emissions to air and water are still the preferred policy instruments for industry and similar sources. As seen above, they are used more flexibly and economic considerations are to a larger extent taken into account when target and timetables are set. Furthermore, industries are given more freedom to choose abatement measures.

3.2 *Innovative and increased use of economic instruments*

3.2.1 Economic instruments have become supplemental to command and control

The Nordic countries are regularly seen as forerunners in the application of environmental taxes. As shown above it started as early as in the 1970s and 80s with a modest tax on sulfur content in fuel oil. Before that, deposit-refund systems for bottles were in place in most countries. Finland, Sweden, Denmark and Norway were the first countries to impose CO_2 taxes, but also taxes levied on greenhouse gas emissions other than CO_2 (Norway and Denmark). Furthermore, Nordic countries were early promoters of emissions trading to curb GHG emissions, even though they may not have been the most eager promoters of EU ETS. According to TemaNord (2006a) the environmental policies in the Nordic countries rely on environmental taxes and charges to a greater extent than in the other EU Member States.

Over the years perceptions related to the use of economic instruments have changed. In the past, environmental taxes were seen as substitutes for command and control policy instruments, whereas they are currently observed as complementary instruments. It is more widely accepted that environmental objectives are achieved most effectively within a policy package of regulations and economic instruments (TemaNord, 2006a). We shall see several examples below of how various economic and other policy instruments have come to be useful supplements to various regulations.

From economic theory we know that it takes only one policy instrument to reach one goal. Therefore, adding multiple instruments may just increase the costs of reaching a goal. Only if new goals are to be achieved, additional instrument to the cost effective ones can be justified. We will illustrate this in the assessment of the policy instrument use in the waste sector. Also towards GHG emissions multiple instruments are used. We will discuss this further below.

3.2.2 The transportation sector faces the most comprehensive policy instruments

The most important economic instrument applied in the transport sector is taxes levied on transportation fuels. However, countries also frequently use other transport-related taxes in the form of taxes levied on vehicles, including purchase and registration taxes,

annual circulation taxes, and also charges for the use of infrastructure (i.e. road charging), which are attracting the most attention in the political debate (TemaNord, 2006a).

Regulations are not frequent in this sector. Emission standards for NOx emissions from new vehicles have been applied, and now EU has imposed targets on car producers for CO_2 emissions from their car fleets and requirements for blending biofuels in petrol and diesel. Emissions from mobile sources are hard to regulate directly in other ways than through emission standards for cars and fuels, thus economic instruments have appeared as the most favourable approach. Actions to promote construction of charging stations for electric cars and filling stations for alternative fuels like biofuels and hydrogen are also being promoted.

Purchase taxes, or registration taxes, are of great significance in terms of their revenue generating in Denmark, Finland and Norway, because the tax can more than double the purchase price of a vehicle. Environmental considerations in vehicle taxation schemes were originally of secondary importance, but this has been changing over the last years and the taxes are being differentiated according to environmental criteria. Furthermore, several countries have revised their annual circulation taxes on heavy goods vehicles, replacing the weight-based tax with an annual tax differentiated according to the emission standards of the vehicles.

NOU (2007) underlines that in an optimal, cost effective environmental policy the policy instruments are directed at the source of the emissions, i.e. on the use of the vehicle and not at the purchase or ownership. On the other hand, if there is a goal to change the car stock from larger, emissions intensive cars towards smaller, less polluting ones, a differentiated purchase tax or annual owner tax is a potential instrument.

It has been claimed that a high purchase tax like in Norway and Denmark could imply a low replacement rate and thus an old car stock with less favourable environmental and safety properties. There is no empirical evidence for this from the Nordic countries. According to NOU (2007) the average age of the car stock in Norway and Sweden are 10.2 and 9.6 years respectively, and Sweden has no purchase tax. The average age is lower than this in Denmark, which has the highest purchase taxes of all Nordic countries.

According to NOU (2007), a car purchase tax is in practice progressive, since high income families spend a higher share of their income on purchasing a car than low income families. On the other hand, high price and income elasticities do not make this tax a particularly good way of raising revenue. Thus, NOU (2007) does not see good reasons to keep the purchase tax as high as in Norway, but even if the level is lowered it should still be progressive. Differentiation of annual circulation taxes is according to NOU (2007) a good way of imposing such taxes, and could be a supplement to fuel taxes even if the annual taxes cannot take environmental properties into account in a very precise way.

The EU Commission and The European Conference of Ministers of Transport (ECMT) has considered to overhaul the current scheme of transport taxes and charges with the ultimate aim to charge for the use of transport infrastructure, with charges set at a level close to marginal costs of the local external effects from car use (TemaNord, 2006a). The

instruments for implementing this approach would be distance-related charges which should be differentiated by weight and environmental performance. Furthermore, such charges could be set depending on time and location in relation to infrastructure damage, congestion, environmental and other external marginal costs, using satellite or land based positioning systems. Several Nordic countries are considering such changes.

Changes in the tax systems along this line would lead to a helpful policy tool to address major local problems associated with road traffic. But they would also infringe personal privacy as a consequence of tracking systems, and they are so far only at a discussion stage. An attempt of distance charging is rather common in Nordic countries in the form of road charging for entering city centers like for example the system in Stockholm (and to some extent) in Oslo (TemaNord, 2006a).

Some Nordic countries have imposed CO_2 taxes on jet fuel, and landing fees have been differentiated according to environmental criteria as is the case in Norway (TemaNord, 2009a). Sweden has also introduced a tax on aviation based on the emission level of hydrocarbon and NOx. In addition, taxes on air tickets or seats are either in place or have been imposed. Because of international air traffic agreement and competition distortion issues it has been difficult to impose environmental related taxes on international aviation. But this sector will be included in the EU ETS.

3.2.3 Water pollution mostly regulated through command and control measures

The Nordic countries do not face problems of water scarcity as in other European regions. Water quality issues are of some significance, although traditional point sources are by and large controlled via regulatory measures. Eutrophication of waters, in particular the Baltic Sea, as a consequence of intensive agricultural production methods and the accumulation of nutrient loading from human activities for many years, is still a considerable problem in the Nordic region. The diffuse sources of water pollution are almost impossible to control directly via regulatory measures or by applying effluent taxes. Instead they are regulated through restrictions on farming activities etc. in addition to taxes on some production inputs.

The use of economic instruments for reducing releases to water has not been expanded to the same extent as for air emissions, but some countries have applied taxes on nitrogen in fertilizers and some countries tax pesticides (TemaNord, 2002).

User charges for water supply and wastewater provision are regularly based on the cost recovery principle as stated in Art. 9 in the EU Water Framework Directive (WFD). This principle should also ensure that water pricing policies provide adequate incentives to ensure efficient water use and that this is spread across different water use sectors (TemaNord, 2006a). The WFD also opens up for the possibility of water users paying for the groundwater protective services of forests via their water bill either for the investments in establishing forests and/or the appropriate maintenance and management of existing forest ecosystems, see TemaNord (2009i).

3.2.4 Subsidies are sometimes justified, but have negative side-effects

All countries except Iceland have subsidy schemes to promote renewable energy production capacity, energy efficiency measures and similar (TemaNord, 2009a). The usual argument for these subsidies is to create alternatives to fossil energy, hence to

reduce CO_2 emissions. Thus, they are subsidies for renewable electricity production like wind, biomass, waste etc., installation of various energy efficiency measures in households and industry, aimed at reducing electricity consumption (grants for investment in heating pumps, switching to waterborne solutions based on renewable sources or district heating), but also to switch to renewable heating sources like pellets heating. Similar grants exist for industry companies and public buildings etc. that implement measures to reduce energy consumption or switch to renewable energy sources. The schemes vary somewhat between the countries, but are mostly investment and production subsidies and subsidies for research and development (R&D), tax exemptions, reductions and refunds.

As concluded in TemaNord (2009a) subsidies may be justified to promote energy efficiency at various levels and in various sectors. Industries and households will for many reasons not invest in energy efficiency measures even if the savings far outweigh the costs. For the society it could be cheaper to invest in energy efficiency measures than in new production capacity. But socalled "rebound effects" may reduce most of these benefits, since energy use may increase (see 3.3.1 below).

According to economic theory subsidies and similar support schemes should be used to correct for positive externalities like learning in the development phase for new technologies. In this phase, subsidies should be granted as a support for R&D. But when the technology is developed its implementation and diffusion may be best left to the market to be tested (TemaNord, 2009). One should not use subsidies to pick technology winners too early. Subsidies are only optimal if the use and development of the subsidized technologies have positive external effects themselves, i.e. in terms of learning by doing build-up of know-how.

Also, no energy source is without environmental flaws. Wind and hydro power are emissions free technologies, but may imply environmental conflicts with respect to aesthetics, wildlife, natural scenery etc. Hence, subsidizing any form of energy production implies subsidizing any form of negative externalities.

Subsidies to renewable energy sources would like taxes on polluting technologies increase the use of emissions free technologies, and reduce the use of the more polluting technology. But an important difference compared to taxes is that subsidies will increase total energy consumption, while all taxes tend to reduce energy consumption. The market prices on energy would be reduced, and the lower prices will reduce the profitability of developing new technologies. Thus, subsidies of renewable technologies could yield double negative impacts in relation to environmental friendly goals. Therefore, subsidies tend to increase abatement costs.

Another scheme where subsidies may be justified is through payment for ecosystems (PES), where suppliers of various services are paid for delivering these (see below). It could be discussed if this is a subsidy or not, but these payments through public budgets for a service could hardly be paid for in an ordinary market. Thus, such payment is an example of a so-called "public good" which everyone can enjoy without reducing the benefits for others from enjoying it, and cannot easily be "sold" in a market. Economic theory justifies that this can be financed through public budgets.

3.2.5 Green certificates is a new way of imposing subsidies

A green certificate system is a combination of taxes on energy use and subsidies to new renewable energy production. Given a target of investment in renewable electricity capacity, a certificate market will realize a cost effective capacity expansion, comparable to an auction based subsidy system. The costs of the subsidies are in the Swedish green certificate system passed on to some of the electricity consumers, while the industry is exempted. The producers of new renewable energy harvest a certificate price in the certificate market in addition to the energy price in the energy market, which increases the profitability of producing energy from the defined technologies.

Generally, the green certificate system is inefficient as a means of creating incentives to reduce energy-related CO2 emissions, and to give incentives to long term technology development (see, e.g. Bye 2009, Hagem and Rosendahl 2011). Also, what the real target for the support for renewable energy is, has been questioned, see TemaNord (2009a) for a broader discussion. If the goal is to reduce CO_2 emissions, promoting renewable energy might just add to the overall abatement costs and not contribute to any net GHG emission reductions, especially in the current situation with a cap on overall GHG emissions in the EU ETS covering also emissions from the electricity sector. Therefore, the policies to promote renewable energies should be carefully considered, including EU goals (see below) which underlie the Nordic policies to a large extent.

3.2.6 Many chemicals best curbed through direct regulations, but also economic instruments could have been used more widely

TemaNord (2009e) concludes that the traditional command-and-control approach towards chemicals, which have been extensively used in the Nordic countries, limits the flexibility in using different compliance measures, and that economic incentives could have better track records in these respects. The release of chemicals stems from various non-point sources that are often very difficult and costly to control, not the least if the environmental damages caused by the substances are affected by geographical location and the receiving environment's condition (e.g., pesticides etc.). The harmful chemicals may exist in many products as well as in a wide variety of end use. It may therefore be more efficient to tax the production or the use of chemical compounds upstream in the product chain, given that the damages are independent of the recipient.

According to NOU (1995) the regulatory approaches that were implemented towards harmful chemicals in earlier years were not cost effective. Even though the long term goal was to phase out the use of these substances, and clear signals about this were given, there is a general impression that more use of economic instruments like taxes and deposit refund systems could have ensured a more cost effective reduction of use and emissions. More use of cost benefit analysis to prioritize among various regulations would also have helped in achieving more cost effectiveness.

However, from the theoretical literature we know that the existence of major uncertainties about abatement costs is critical for the choice of environmental policy instruments (TemaNord, 2009e). Emphasis may be put on controlling *quantities* rather than *prices* if the (marginal) environmental damage is intolerably high. For hazardous chemicals this could be the case especially if there are some critical threshold levels that should not be exceeded. If the marginal damage is considered infinite, this corresponds to an infinitely high tax, which is equivalent to a ban on the substance. This implies that

command-and-control regulations or a mix of quantitative regulations and economic incentives could be the best ways to control chemical use.

Moreover, a deposit refund system for used chemicals also represents one mechanism to consider. Handlers or recyclers then pay a deposit when accepting the compound, a deposit that is returned as a refund when the chemical is returned for legal disposal. This raises the costs of illegal disposal, and is principally equal to a tax on inappropriate disposal.

An important condition for a cost effective policy is that the policy instruments are targeted as closely as possible to the damage (balanced to the administrative costs). In many cases, instruments addressing the use and/or production of chemical substances or products may be cost-effective second-best measures. This is typically so if the polluting substance cannot be substituted in the taxed material (another example is the CO_2 content in gasoline). According to TemaNord (2009e) the eventual implementation of economic instruments on chemicals use must be preceded by a detailed account of the likely substitution behaviour, including an environmental assessment of the substitutes. A tax on upstream consumption to decrease use and promote substitution to other compounds could be combined with labelling to inform users about health and environmental impacts and possible actions to mitigate them.

Since many of the products containing harmful chemicals are products sold in an international market, and most of them are imported to the Nordic countries, the sales and use of these products are most effectively curbed through international cooperation like EU REACH and similar.

3.2.7 The Swedish NOx charge is a good example of tax revenue recycling

Economic theory generally states that tax revenues should not be recycled back to polluting industries as this may disturb the effect of economic signals (TemaNord, 2006a). However, some environmental economists make a case for refunding tax revenues, at least under some circumstances. While this may clearly be disputed, we would like to emphasize that refunding revenue could be a good second best solution if this is necessary to get acceptance for the tax.

The Swedish NOx charge is regularly presented as an effective environmental instrument. The NOx charge is levied on large combustion plants, while the revenue is refunded in proportion to their energy production. This offers an incentive to reduce emissions relative to energy output. It also prevents market distortions between large plants subject to the tax, and smaller un-taxed plants. Such distortions might otherwise encourage a backward technology shift toward environmentally less efficient, small combustion units.

OECD (2010b) claims that a strong incentive for emission reduction in the Swedish NOx tax system was attained by setting a high charge level and combining it with mandatory continuous monitoring of emissions, and that high monitoring costs made it economically feasible only to include large combustion plants. According to OECD (2010b), the NOx charge has turned out to be a very effective instrument for reducing NOx emissions per unit of energy produced from stationary combustion plants in Sweden. Emission intensities have been cut by half, which can be considered a

substantial reduction for a pollutant like NOx that is usually technically difficult to reduce.

3.2.8 Payment for ecosystem services could be improved and expanded

Experience from Denmark on paying land owners for creating and maintaining wetlands show a generally positive outcome with 1,704 hectares wetland created in four years and estimated 282 tons of nitrogen leakage avoided (2005 to 2009), although missing the target of 400 tons by the end of 2009. A contributing reason was an insufficient number of participating landowners, which may be linked to the fact that the scheme was based on a fixed-payment that was not spatially targeted and with compensation at a level not attractive enough for landowners with high nitrogen leakage reduction potential (TemaNord, 2009i).

In Finland a program paying forest owners for conserving or managing forest in favour of biodiversity were tested from 2003 to 2007. Experiences from this program have mainly been positive, and the project has now been developed and extended until 2016 (TemaNord, 2009i). Forest owners are generally positive to this kind of voluntary conservation, and the number of sites offered for the project exceeded the amount of funding available. By late 2006, 268 contracts were agreed on, from which 241 are fixed-term contracts and 27 are permanent contracts, and a total of almost 2000 hectares of forest were protected as a result of the project.

Traditionally, PES-like schemes in the Nordic countries are based on fixed-rate payments with no or little spatial targeting or on individually negotiated levels of payments based on e.g. the amount of timber on the plot of land and a fixed level compensation. There is very little experience with using competitive bidding in PES in the Nordic countries, which could improve the schemes. Where opportunity costs are likely to be heterogeneous among landowners, competitive bidding and auctioning may prove more efficient than fixed-rate payments. In addition, finding the right level of compensation in fixed-rate contracts may also profit from auctions, where landowners "reveal" their prices. Several of the PES schemes currently in use internationally may be considered for trial in the Nordic countries.

PES can be combined with existing natural resources regulation, where landholders can obtain compensation for undertaking more environmentally friendly action than the minimum regulation requires. The EU CAP agri-environmental schemes are already such an example. There is also scope for expanding the application of PES into areas where regulation by landholders is traditionally perceived as very negative, and where property rights are very strong. PES could be an option where PES substitutes partly or fully regulation on the grounds that regulation in any case is inefficient. This is the case in forestry.

There is also significant scope for private sector engagement in biodiversity conservation with opportunities for positive financial returns as well as real biodiversity benefits. One avenue is the un-bundling and marketing of biodiversity benefits at landscape-level activities (e.g. organic farming, aquaculture, conservation credits or offsets of sustainable forestry or carbon sequestration). Another option is the creation of biodiversity "banks" in both terrestrial and marine/aquatic ecosystems to offset degradation due to land development. Businesses in the Nordic countries may very well benefit from international experiences in this field. Nordic governments could create the

enabling conditions for such trades to take place and to make sure that they are supplementary and not contradictory or overlapping with other natural resource management regulation.

3.3 *Additional policy instruments are often necessary….*

3.3.1 Energy efficiency could be promoted through different instruments

Industries and households may for many reasons not invest in energy efficiency measures even if analyses estimate that the savings outweigh the monetary costs (TemaNord, 2009a). This may be caused by market failures. But it can also be due to private transaction costs not included in the analyses. In buildings, machines, household equipment etc. the specific energy use is more or less embedded in the equipment when it is produced/bought. A part of this is the so-called landlord-tenant challenge, where the landlord has few or no incentives to invest in measures to reduce energy consumption in buildings since the tenants will carry the energy costs through the building's lifetime. But even when the owner and user is the same person (as is to a large extent the case in the Nordic countries where most households own their homes) investments in profitable energy saving measures may not be made. This is often explained by lack of funding and that people often have a high discount rate for such investments (they would rather use the money today than have some savings over some future years). Also, lack of information about potential actions, their costs and effects could be important hindrances. Different market failures require different instruments, and a set of instruments would be required if several market failures are identified. E.g. information campaign could correct for lack of information of saving possibilities and saving potentials. However, private transaction costs related to seeking information and, changing contracts, and aesthetical costs associated with e.g. heating pumps are not market failures, and should be considered in the overall cost-benefit analysis.

It is important to take into account the socalled "rebound" effect, that may counteract the savings induced. When consumption is reduced, households and to some extent also industries tend to spend much of the money saved on other goods and services that contribute to increase energy use. This can for instance be to increase the room temperature in houses since the energy bill has been lowered, increase holiday travelling etc. that could partly or wholly offset the initial savings, or increase in other environmentally harmful consumption.

For existing buildings and equipment there is often a wide variety of low or no cost actions to take to reduce energy consumption. But when market failures exist such as those mentioned above, households and industries may invest less in such actions than what is optimal.

Technical and performance energy standards, as have been imposed in the Nordic countries, affect the design and construction of new buildings and some equipment, and contribute to reduced energy use. Subsidies for various energy saving measures (including fuel switch) address existing buildings and machinery, and promote energy saving in the existing stock of houses and equipment. The various taxes (including emission permit costs) on electricity and fuel oil give users regularly signals through energy prices of the real costs of energy use, and affect the amount of fuel used (TemaNord, 2009a).

Information activities could impact all these various decisions, in particular information about various energy saving investments in existing buildings and machinery, and how to save energy through daily use. Thus, information activities could contribute to strengthen the impacts of the taxes and subsidies. Also, energy labeling of household appliances and of buildings, as required in the EU Energy Performance in Buildings Directive, might induce a demand for appliances and buildings with lower energy use, and also make builders and owners focus on energy in a life-cycle perspective, and not just in the construction phase (TemaNord, 2009f).

TemaNord (2009a) concludes that the abovementioned combination of policy instruments towards energy efficiency in households and industry supplement each other and could be justified to promote energy efficiency at various levels. To the extent that the instruments correct for market failures, they contribute to increased cost effectiveness in GHG emissions reductions and energy supply. But one should always bear in mind that subsidies also reduce energy prices and thus increase consumption.

3.3.2 Negotiated agreements have contributed to environmental improvements

Negotiated agreements (often also called voluntary agreements) have not been used as widespread in the Nordic countries as compared to for instance the Netherlands and the UK (TemaNord, 2006a).

Agreements have been used mainly in Denmark, Finland and Norway usually related to different categories of waste management where producers and importers have agreed with the authorities to take on responsibility for the waste treatment of their products. This has been accompanied by a charge on the sales of the product to cover waste treatment costs.

In Denmark a system where industry could enter into agreements to implement energy saving measures in return for CO_2 tax reduction has been in place (TemaNord, 2002). Finland also has had a similar system were industry committed themselves to carry out energy audits, and the energy saving investments that were found eligible were supported economically by the government. Norway has had an agreement between energy intensive industries and the government on reducing GHG emissions not covered by taxes or the EU ETS. Also, the current Norwegian NOx charge system described above is based on an agreement between the authorities and industry, as were the agreements to phase out pesticide usage on public areas in Denmark.

In legal terms an agreement that is not voluntary is by definition illegal. Thus, the expression “voluntary” agreement may be misleading. Agreements have mainly been used as an alternative to other policy instruments, notably taxes. Industry has known (or believed) that if they do not enter into an agreement on implementing some measures to reduce an environmental problem, taxes or other less-wanted instruments would be implemented. Such agreements would be efficient if industries have incentives to distribute emissions reductions among sources in a cost effective way, as they have with the Norwegian NOx charge. It is also our impression that the agreements in the waste sector in the Nordic countries have contributed to fulfil their goals, although their abilities to keep overall costs low could be questioned since collection and treatment costs could rather easily be passed on to consumers.

3.3.3 Information could increase the efficiency of policy instruments

Information most often operates together with other policy instruments. Subsidy schemes may be complicated, and information about their existence, how and when to apply for grants etc. are necessary. Also, the impacts of recycling schemes for various waste fractions are higher when people know how to treat the waste and eventually where to deliver it.

In general, information targeted solely at changing the consumers' behaviour stand small chances of success (TemaNord, 2003). According to this report, a majority of researchers claim that there is a great superstition in information as a tool to change how people behave. But under certain conditions, they claim that information can give legitimacy or acceptance for decisions already made or in progress, but then no changes in behavior occur.

Information should be targeted to be efficient (TemaNord, 2006b). This means that one should think through who is the primary subject for the information, for instance the woman in the household, young people etc. Also what distribution (websites, newspapers, folders, outdoor advertising etc.) that should be used is important for the efficiency.

3.3.4 Green Public Procurement (GPP) and eco-labelling could make a difference

GPP and similar schemes are often pronounced as "qualitative regulations". They should inform public buyers on what products to buy or services to use to reduce environmental impacts and at the same time save money. Eco-labelling informs consumers on the environmental properties of products and services, supplementing the information given in the product price through taxes on emissions and other environmental impacts. It then leaves to people to decide what product to buy, eventually buying a more expensive one with better environmental properties.

For GPP, there is the question whether this represents some kind of "double regulation" when procurement officers are required or encouraged to take environmental concerns into account in the procurement process. If all or most environmental problems are regulated close to source, there should be no reason to take special actions to consider the environmental impacts of goods and services in the procurement process. By simply buying the cheapest product at given quality, all costs are embedded in the price. However, it may not be possible to regulate all environmental impacts of a product or service. In TemaNord (2009d) it is claimed that GPP is generally a good alternative where legal and economic instruments are not applied for one reason or another, especially when the total environmental impacts of a product group are relatively large. The report also emphasizes the softer and more dynamic implementation of GPP compared with legal and economic instruments as a major advantage. GPP also offers the potential to take local environmental contexts into consideration in the procurement process. We are not convinced that all these arguments in favor of GPP are justified, especially when taking into account the costs connected to it.

It is also claimed that GPP can be a driver for market development, adding indirect benefits of promoting a greener market on top of direct environmental impact reductions. Also, according to TemaNord (2009d) GPP can be used to promote eco-innovation by closing the "innovative gap". It is well known that industries have an

economic challenge in the move from product development to up-scaling and commercialization of a product. Hence, the public sector could help bringing demand beyond a tipping point where the new technology becomes profitable. Then there is also the question how and to what extent procurement staff should take environmental concerns when this implies increased costs. According to TemaNord (2009d) green purchase criteria often lead to increased costs for the buyer. Thus, there is in our view a challenge to decide whether the increased costs are lower than the benefits from the alleged environmental improvements, that cannot necessary be left to local procurement staff to decide. According to TemaNord (2009d) GPP could be most efficient for products and services with a high public procurement share and with significant environmental impacts, like IT, public transport, cleaning products and construction. Later in the report we will present a case where GPP has played an important role in promoting new technology.

3.4 *…but sometimes they are not*

3.4.1 Various waste taxes and other instruments are used in all countries, and they seem overlapping

Nordic countries are portrayed as forerunners in using economic instruments in waste policy in Europe. The most commonly used charges are user charges for the purpose of financing the management of waste, but there are also instruments introduced to reduce the creation of waste. Most types of bottles made of glass, such as beer, liquor and soft drink bottles are subject to deposit and refund systems. Economic instruments are applied to control certain kinds of toxic waste, such as batteries and lubricating oil. Also, waste taxes on landfill and incineration are in use in parallel with direct regulations of the emissions from these facilities (TemaNord, 2006a).

Over the years there has been established a hierarchy of goals in the waste sector (TemaNord, 2009a). This has resulted in the use of multiple instruments directed towards the waste treatment sector to reduce generation of waste, promote recycling and reuse, and reduce the environmental impacts from waste handling, in particular the reduction of GHG emissions.

The EU ban on putting biodegradable waste on landfills implies that several of the current policy measures directed towards landfills are unnecessary. Technical requirements for existing landfills will still be necessary to avoid future release of methane to air and leakages to water, since these are difficult to monitor and tax. Emissions to air and water will continue for many years also after the landfills are closed. Emissions from incineration plants could be taxed directly according to the emissions, eventually in combination with a tax on the fossil carbon content on the waste as in Norway. Waste containing hazardous substances could eventually still be sorted out and treated separately to avoid releases of these substances to air. Deposit refund systems for bottles and cans could be kept to avoid littering. Information about the negative environmental effects from littering and wrong treatment of hazardous waste should be kept.

The various goals and measures for material and energy recovery should be carefully considered, since they are superfluous for both environmental and optimal resource management. Furthermore, packaging taxes as has been imposed in some countries are

not necessary either from an environmental point of view (TemaNord, 2009a). Since most of the goals in the waste sector are established at the EU level, it could be a very demanding task for the Nordic countries alone to change this.

3.4.2 Renewable energy is supported – but this does not seem necessary for environmental reasons

To promote renewable energy and electricity in particular have been a goal for years in most Nordic countries, and in recent years also backed by EU directives. Therefore, use of various policy instruments to fulfill these goals has been necessary. However, it could be questioned whether renewable energy or power supply is a goal in itself, or is instead primarily related to GHG emissions (TemaNord, 2009a). Energy security is an aim in many countries, and can perhaps explain why domestic energy sources have been promoted.

In the Nordic countries, taxes and emissions trading are the main policy instruments to reduce GHG emissions. For the sources not covered by these instruments, other instruments like direct regulations or voluntary agreements have to some extent been used.

Emissions from power production in the Nordic countries and other countries that are part of the EU ETS are covered by this emissions trading system. This implies that there is a cap on overall emissions for all sources within the trading system, and the allowance trading ensures that emissions are reduced in a cost effective way to fulfill the overall cap. Within this framework, special actions to reduce emissions for instance through promoting renewable power production will not lead to any net emission reduction (TemaNord, 2009a). Such actions would lead to increased compliance costs, since renewable power would displace other, cheaper abatement options within the trading system.

Supporting renewable power production may contribute to lower allowance prices and hence eventually contribute to the tightening of the long term EU ETS emission cap. Support to R&D on renewable technologies offers a better case for long term cost effective emission reductions and spillovers to other countries. Thus, it should be carefully considered if not the renewable power production goals and related policy instruments should be reconsidered in the light of the policy instrument change in the GHG policy. Since some of these goals now to a large extent are related to overall EU goals, coordination with EU would be necessary. The EU is now considering strengthening its GHG emission reduction goals in 2030.

3.5 *EU plays a greater role in policy development over the years*

After Finland and Sweden joined Denmark and became EU members from 1995, and Iceland and Norway continued as members of the European Economic Area (EEA), EU law through directives and other policies have gradually become more important for the Nordic countries' environmental policies and policy instrument design.

In general, EU law in the environmental field as well as in most other areas is based on direct regulations either through emission standards (performance standards) or technical standards specifying what technical equipment or solutions to use in the regulated sectors to reduce emissions or other environmental impacts. EU has a long

history of such rather detailed regulations through various Directives, and this has also largely influenced the EU environmental policy over the years. Cost effectiveness plays a minor role when regulations are decided, and the culture of imposing rather detailed regulations in the EU Commission leaves in our view little scope for considering alternative approaches like for instance taxes.

The EU Treaty is founded on competition and free movements of goods across borders. EU has also since 1975 adopted the Polluter Pays Principle, opening for the use of economic instruments (TemaNord, 2006a). Problems related to competition and free goods movement may arise if policy-makers allow selective exemptions of market-based instruments, so as to allow some polluters either a revenue return or a lower tax rate. Such discretionary treatment by member states may distort competition, both within the member state and vis-a-vis other member states. Therefore, the EU rules on state aid become relevant when considering the use of economic instruments, as for instance reduced tax payment can be regarded as an indirect form of state aid. The same applies for grandfathering of emission allowances and subsidy schemes (TemaNord, 2006a).

To qualify as state aid, measures need to be "selective", there must be "economic advantage" with no return delivery of services as well as a "potential distortion" of competition and trade. Also, the state aid must reach a certain level, above the ceiling of 100.000 Euro over three years prescribed in the "de minimis" rules (TemaNord, 2006a). Guidelines on state aid are established, that address a range of state aid options, including both investment aid and operational aid. Although most of the guidelines address support for renewable energy, the special case of environmentally relevant taxes and exemptions from these are addressed too. This falls under operational aid, for which the most restrictive guidelines apply. Exemptions should not undermine the environmental objectives; this is because integration of environmental objectives in EU competitiveness policy is a priority. The principle of non-discrimination is applicable to the utilization of tax exemptions also here, meaning that selecting certain segments of the business sector and giving them fiscal advantages like tax revenue refund, tax rate reductions and subsidy schemes over other businesses amounts to state aid and is, in the absence of explicit permission, not allowed (TemaNord, 2009e).

In general the implementation of environmental taxes and charges are within the competence of the member states. Still, when a Community-wide legislation is absent, environmental taxes should generally be set and implemented so that rates and methods of tax collection are non-discriminating, i.e., imported goods should be treated as domestically-manufactured goods. In addition, the tax system must also be proportionate to its objectives; the tax must thus signal a proper balance between the instrument chosen and the objectives of the policy. Thus, overall the tax policies must be in compliance with the rules laid down in the EC-treaty (TemaNord, 2009e).

Since the Nordic countries have been pioneers in the use of market-based instruments, their initiatives and experiments have inspired similar approaches in the EU. The Taxation of Energy Products Directive (2003/93/EC) was adopted in 2003, and widened the scope of the pre-existing EU 1992 mineral oils directive by setting minimum excise duty rates also for energy products like coal, coke and natural gas, as well as for electricity which were not previously covered. This had little or no impact on Nordic taxation schemes, since such taxes were mostly already in place and higher than the EU minimum rates. The directive has had some implications for electricity taxation, in

particular in Sweden and Norway, as industrial sectors were previously exempted from electricity tax. Energy tax exemptions and reductions are still possible under the 2003 Energy Products Tax Directive, although these policy measures can distort competition and may therefore be illegal (TemaNord, 2006a).

The launch of the EU Emission Trading Directive (2003/87/EC) (ETS) at the beginning of 2005 was a milestone in EU energy and climate policy. This was also the first trans-national greenhouse gas emissions trading scheme in the world (TemaNord, 2006). It was also perhaps the first attempt of common EU policies on the use of economic instruments that had a significant impact on the Nordic countries' policy design and implementation, even though the scheme was inspired by Nordic and in particular Danish emissions trading at the nation level.

EU directives have in recent years had substantial impact on the Nordic countries in the field of promoting renewable energy. A range of different national policy measures have been implemented in the Nordic countries with the underlying objective of ensuring the achievement of EU, as well as national, renewable energy targets. Support schemes for promoting renewable energy sources are in place in the Nordic countries, but they differ widely since there are no common guidelines on what policy instruments to use to achieve the targets. The new EU 20-20-20 targets by 2020, i.e. 20 percent GHG emission reductions, 20 percent renewable energy share and 20 percent increase in energy efficiency will be important for the future implementation of policy instruments (TemaNord, 2009a).

The EU Commission has over the years expressed a wish for more extensive use of economic instruments in environmental policies. Furthermore, the Council of Ministers has adopted a positive attitude to the instruments. These good intentions have nevertheless been impossible to put into practise when it comes to taxation of environmentally harmful substances in products, for example, because decisions in the fiscal area must be taken by a unanimous Council of Ministers. Tax policies are considered by most countries to be a national concern (TemaNord, 2002). Thus, for instance a European wide CO_2 tax has not been possible to implement due to resistance towards taxation at a European level.

When Community regulations exist member states still have the competence to adopt environmental national provisions (TemaNord, 2009e). However, the competence of member states is in such cases limited and its scope will depend on the content of the provision and of the legal grounds on which the Community provision is based. For instance, in the case of fertilizer control policy, the EC Nitrate Directive (91/676/EEC) is a community-wide regulation for limiting the problems of nitrate leaching. Taxes on fertilizer are neither promoted nor prohibited by the Nitrate Directive. Thus, fertilizer taxes can complement the Directive but cannot replace the regulations prescribed by it. Still, the difficulties of predicting the impact on environmental quality of the tax may constitute an obstacle towards a tax policy. The latter concern did play a critical role in the abandonment of the Dutch fertilizer tax in 2006.

We would like to add another potential example of regulations that might have hampered the use of economic instruments, namely The Integrated Pollution and prevention (IPPC) Directive (1996/61/EC). This directive requires large industry installations to hold a permit containing emission limit values for all major pollutants,

and requires special procedures for the issuing of the permits. The permits must be based on the use of Best Available Technology (BAT) in each installation, leaving no room for flexibility among installations. Though this does not forbid the use of for instance taxes on emissions, it gives little or no potential for achieving cost savings since all installations must apply the same technology in the long run.

To sum up it seems fair to say that EU rules aiming at ensuring competition at a level playing field among countries have ensured more uniform environmental and energy taxation with fewer exemptions, reduced rates etc. for fuels and sources, and thus contributed to a somewhat more cost effective environmental policy in the Nordic countries. Also, the establishment of the EU ETS is a major achievement. But since EU law is to a large degree based on direct, detailed regulations, EU might also have hampered the use of economic instruments. Also the various targets like the 20-20-20 targets in the Renewables Directive is an example of a policy not targeted at the environmental problems, since these are already taken care of in the EU ETS, and thus represents an unnecessary, multiple policy mix.

3.6 *Elements of a green tax reform*

3.6.1 Green tax reforms not likely to give double dividends

So-called "green tax reforms" have been heavily discussed in the Nordic countries and internationally over the years. The hypothesis is that increasing environmental taxes and use the revenue generated to reduce taxes on labour may both improve the environment and increase employment (so-called "double dividend"). Such tax changes have a broad appeal (ECON, 1997a). The traditional view has often been that there is a conflict between high (full) employment and a better environment. Environmental taxes would increase companies' costs, reduce their competitive position and yield lower production and employment. This is the main reason why industries in the Nordic countries and in most other countries have lower environmental tax rates than households.

If the revenue from green taxes is used to reduce for instance the taxes on labour income, the impacts will be different than if the revenue is used to increase public spending. According to ECON (1997a) the industry's overall competitive position will by and large probably be affected little. Labour-intensive companies and technologies will become relatively more profitable than energy- and emissions intensive companies and technologies. Thus, increased use of environmental taxation (or sales of tradable emissions allowances) does not need to cause lower employment. It is even claimed that employment will actually increase as a result of a green tax reform.

Several Nordic studies have investigated this, see for instance Finansministeriet (1994;1996), Ministry of the Environment (1994), NOU (1995), SOU (1996;1997) and Dørs (2009). Generally, there seems to be rather little empirical evidence of a double dividend from a green tax reform. International studies also questions the existence of double dividends, see for instance Bovenberg and Goulder (2002), although some positive impacts may occur. Recycling the revenue from environmental taxes through reduced salary taxes does not have a clear impact on labour supply, it could be both positive and negative. This is because there are two different impacts on the labour supply: reduced salary tax will contribute to increase labour supply, but increased

environmental taxes will increase the general price level in the country and thus reduce real wages, which tend to reduce labour supply. Which of these impacts are strongest is an empirical question. But if the tax system is relatively optimal to start with, it is doubtful whether double dividends exist (Dørs (2009).

However, most studies recommend that economic instruments like environmental taxes and auctioned emission allowances are combined with labour tax releases. This should anyway contribute to reduce at least some of the negative impacts on labour supply from the environmental taxes.

But the tax bases for energy and environmental taxes are relatively small compared to the tax base for labour. Thus, there may be little room for substantial reductions in labour taxes if public tax revenue is to be withheld. Also, taxes on emissions could be an eroding tax base, since emissions and energy use might go down over time if the taxation is effective. Thus, one should expect that green taxes share of total tax revenue are reduced over time, and that other taxes accordingly will play a greater role for the revenue generation.

3.6.2 Green tax reforms in most Nordic countries

All Nordic countries have implemented some environmental tax reform packages, shifting the tax burden from conventional taxes, such as labour, to environmentally damaging activities, such as resource use and pollution, see (ECON (1997a), TemaNord, 2006a).

The general impression from all these green tax reforms is that they have been imposed gradually over the years. However, it can be hard to trace changes in labour taxes and compare them with the changes in the environmental taxes, and even harder to compare the revenue changes these changes have resulted in.

Denmark

As a response to the oil crises in the 1970's an energy tax on fossil fuels was introduced in Denmark 1977 to decrease the energy consumption in order to reduce the balance of payments deficit and to some extent stimulate the use of natural gas. Initially, the tax was only levied on oil-products, but in 1982 the energy tax scheme was expanded so that coal was included in the tax. In 1996 the energy tax scheme was expanded further to include natural gas as well. Today the tax is dependent on the energy content of the fuel. Excise duties on electricity consumption are also levied. Due to the tax freeze imposed in 2001 the energy taxes have remained constant in values since 2002, but have recently increased somewhat (TemaNord, 2009a). Other taxes, mainly on labour have been reduced over the years.

Finland

During the early 1990s a number of economic instruments were introduced for environmental and energy policy purposes in Finland, and since then the emphasis on taxation has gradually shifted from taxation of labour to taxation of polluting activities (TemaNord, 2009a). The most important environmental taxes are today taxes on fossil fuel and electricity use, with the CO_2 tax as the most dominant. Taxes on different kinds of waste and the registration tax on cars are also imposed.

Since the 1990s economic instruments have been a central part of the "green taxation" system. The rates increased somewhat towards 2000, and some few new taxes were introduced (TemaNord, 2009a). Since then most tax rates have only been adjusted annually based on the expected increase in the general price level. Since 1990 labour taxes have also been reduced somewhat. Finland is currently designing a tax reform.

Iceland

In 2010 a carbon tax was introduced on all fossil fuels used in Iceland. It was raised at the beginning of 2011, and is now equivalent to 75 percent of the EU ETS market price. At the beginning of 2010 the tax system of vehicles (registration and annual fees) was changed, and is now entirely dependent upon CO_2 emissions.

Norway

Since the early 1990s, economic instruments notably through taxes on CO_2 emissions and electricity use have been a central part of the "green taxation" system. The rates increased somewhat towards 2000, and some few new taxes were introduced, among others an excise tax on fuel oil was re-introduced in 2000. Since that time most tax rates have only been adjusted from one year to another based on the expected increase in the general price level. Taxes on labour and capital gains were reduced through a tax reform in 1992, and various excise duties and the value added tax have been increased to broaden the tax base.

Sweden

In Sweden a "green tax shift" has taken place since the 1990s, where higher environmental taxes have been shifted against increased personal allowances and lower social security contributions. In this tax shift the government has increased the CO_2 tax introduced in 1991, the electricity tax, the diesel tax, the waste tax, the tax on gravel, the pesticide tax, the road vehicle tax and petrol tax, and introduced a small electricity tax for industry (TemaNord, 2009a).

3.6.3 Denmark applies the highest number of instruments

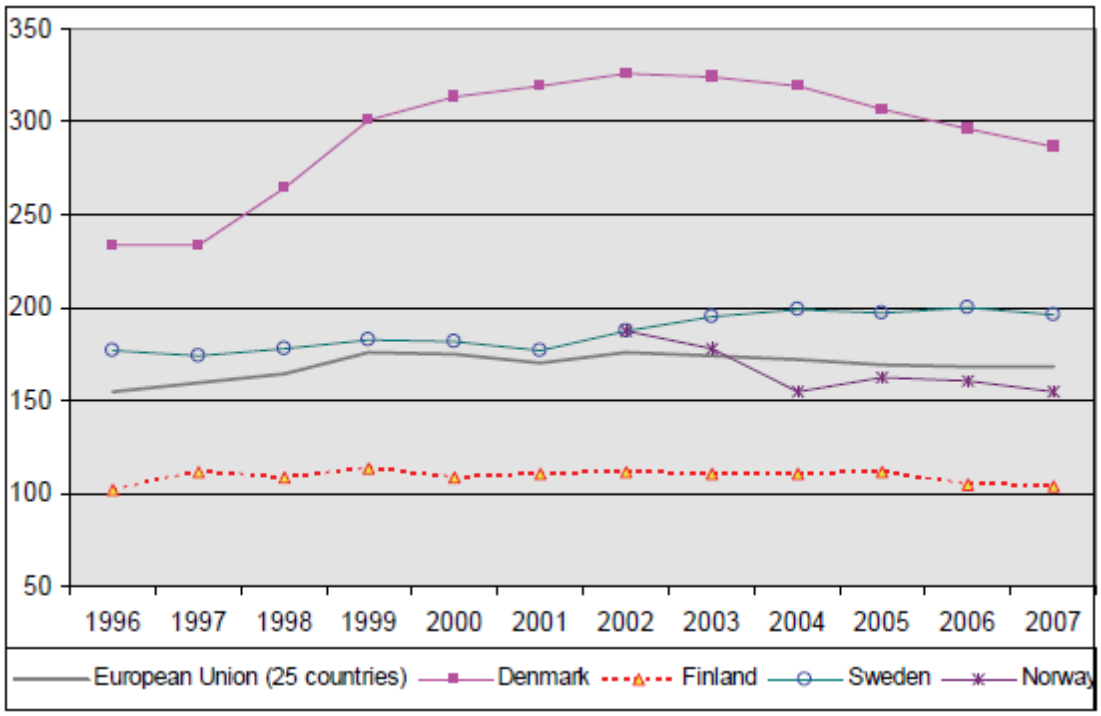
It is hard to compare the use of environmentally related taxes among countries. Statistics are poor, and comparing tax rates among countries are often difficult because of reduced rates and exceptions for sectors and fuels. But when purely considering the number of economic instruments used, Denmark has the highest number of taxes among the Nordic countries (TemaNord, 2009a).

Figure 3.1 below shows the development of gross energy tax revenue as share of final energy consumption during 1996-2007. This clearly shows that Denmark has had high and increasing taxes on energy consumption, and that Sweden also has higher tax levels than Finland and Norway. Finland has the lowest tax level among these countries, and lower than EU average.

There was a freeze in nominal tax rates in Denmark between 2001 and 2008. Possibly due to ongoing savings the taxable base diminished faster than rates went up (see figure 3.2). Also in Sweden energy end-use taxation was tightened somewhat during the period. In Norway energy end-use tax rates were rather stable, and mostly only adjusted

for price level increases. There have been some recent energy tax increases in Finland on households as well as small and medium sized companies. Also Iceland has increased its energy taxes from 2010.

Figure 3.1. Energy tax index (gross energy tax revenue/final energy consumption) in Nordic countries 1996 – 2007. 1996=100.



Source: TemaNord (2010a)

The use of economic instruments has in general been accepted by the population, but not so much by industry (TemaNord, 2006a). Public acceptance of environmental taxation has changed over the years. When environmental taxes were implemented during the 1990s there was a significant degree of public support for the environmental motives for their introduction. This changed as the mistrust of environmental politics developed, with environmental policy often being seen as a means of raising revenues for the national coffer rather than a means to achieve environmental objectives.

Some parts of the population have requested a reduction in energy taxes, in particular those levied on transportation fuels, especially during periods with high oil prices. During winter periods of high electricity prices demand for lower electricity taxes can also be heard, especially in Norway where households to a large degree rely on electricity for space heating.

There is also a tendency to refine existing environmental taxes to reflect better and more accurately the emissions or environmental damages involved so as to improve cost-effectiveness. But as we have seen there is still ample room for such improvement in most countries.

All Nordic countries except Norway will experience a pressure to raise public sector revenue in the coming years and/or reduce expenditures to gradually pay down the increased public debts to more sustainable levels (TemaNord, 2010a).

Revenues from environmental taxation may to some extent increase in the coming years without any policy changes through the auctioning of CO_2 allowances during the third trading period of EU ETS from 2013, which may prove to be a significant source of revenue for the countries' treasuries. As an annual average in the maximum auctioning scenario presented in TemaNord (2009g), Norway is expected to raise 310 million €, Sweden 344 million €, Denmark 552 million € and Finland 692 million € annually for the medium EUA price assumption of 30 €/ton.

The amendments of the EU ETS Directive 2003/87/EC recommends that at least 50 percent of the auctioning revenues are earmarked for activities and measures directed at climate change combat. However, this will not necessarily impose a constraint on spending for the Nordic countries, which already spend considerable amounts on the recommended activities (TemaNord, 2009g). Based on public budgets for the year 2009 the report concludes that the Nordic countries are likely to spend an amount equivalent to more than 50 percent of the auctioning revenues (in the maximum auctioning scenario) on measures related to climate change combat even without the earmarking provision. It is therefore concluded that the earmarking provision is not likely to be binding for the Nordic countries.

3.7 *High economic growth and economic instruments hand in hand*

3.7.1 The Nordic countries have had high GDP growth and large emission reductions

A crucial question is to what extent the use of economic instruments in the environmental and energy policies has affected the economic growth.

The Nordic countries have over the last 25 years since the focus on the environment accelerated and the use of economic instruments increased experienced rather high economic growth (see table 3.1). Finland, Iceland and Sweden had until the financial crisis hit in 2008 real growth rates considerably higher than OECD average, while Norway had a growth at about OECD average and Denmark somewhat below average (see table 3.1). All Nordic countries seem to have been hit harder by the financial crisis than OECD average, Finland and Iceland being the Nordic countries that were hit hardest. All Nordic countries except Iceland are expected to have had positive growth rates in 2010.

According to OECD (2010a) the differences in the drop in GDP growth rates in 2008 and 2009 across Nordic countries can be largely attributed to differences in economic structure, whereas also differences in exchange rate policy play a role.

Table 3.1. Real GDP growth rates. Percentage change from previous year.

	Average 1986-2007	2008	2009	2010*
Denmark	2	-0,9	-4,7	2,2
Finland	3.7	1,0	-8,1	2,7
Iceland	4.5	1,0	-6,8	-3,6
Norway	2.7	0,8	-1,4	0,5
Sweden	3.2	-0,6	-5,1	4,4
Total OECD	2.8	0,3	-3,4	2,8

*Estimate

Source: OECD

As we have seen previously in this report, there has been a rather extensive use of economic and other environmental policy instruments since the 1980s, and great environmental improvements have been achieved. During the same period the annual economic growth in most Nordic countries have either been higher than or at about the same level as the growth for the total OECD area.

3.7.2 Economic instruments could yield a greener economic growth compared to a command and control approach

It is often claimed that since the use of economic instruments increases companies' costs they will in the longer run reduce a country's economic growth, measured as growth in Gross Domestic Product (GDP), compared to if command and control policy instruments are used. GDP is a measure of a country's production of goods and services, and thus an indicator of the people's welfare. However, GDP does not include all issues that are important for people's wellbeing. For instance, pollution and other damages to the environment are not taken into account in GDP. Thus, high GDP growth can imply increased emissions to air and water and thus environmental damage if no actions are taken to protect the environment. Then on the one hand increased access to goods and services increases peoples' welfare, but increased pollution would reduce it. This is important to bear in mind, as there is a tendency to consider GDP growth as a comprehensive welfare measure.

At the macro level, long term economic growth rates are determined by the growth of the labour force and capital, and the productivity of the use of these primary production sources. Education is a key to making the labour force more productive, and R&D is crucial to finding new and more efficient ways of utilizing both labour and capital. The way the whole economy works is also important for the *long term* growth. The ease of doing business and establish new companies, flexibility among other things in labour markets, the creativity of the population, the natural resource base etc. all influence the long term growth rate.

Curbing emissions means increased production costs. If a plant is asked to reduce emissions down to a certain level through a command and control process this will imply increased costs to for instance installing some end-of-pipe cleaning devise. If we assume that the plant is taxed for the same emissions, it would invest in the same cleaning equipment if the tax is high enough to make this profitable. But in addition it will have to pay an annual tax on the remaining emissions, and is thus faced with higher costs than if it only had to make the investment. If labour taxes are reduced to alleviate the introduction of the environmental tax, the cost increase would be somewhat reduced. For energy intensive plants, labour costs would likely mean less than the increased pollution costs. If the company sells its products in an international market, competing with companies with no environmental taxes or even no emission constraints, it may be hard to pass on the increased costs to the buyers. Thus, environmental regulation and even more environmental taxation could curb the *company's* abilities to grow in the long run.

Under a command and control regime companies that are not polluting will be more or less unaffected (depending upon what happens to the production in the regulated firms), but under a green tax shift they would at least in the short and medium term face reduced labour costs. This would stimulate growth in these companies, and hamper growth in the polluting ones. Total emissions would most likely be reduced in a cheaper way using a tax, since only plants with the cheapest abatement options would reduce emissions while under a command and control regime all companies would most likely be required to do so, thus freeing resources in the economy for other activities while obtaining the same total emission reduction target.

Both policy regimes would lead to increased demand for equipment and services to deliver cleaning equipment etc., and thus eventually increased economic growth if there are unemployed labour and other resources. Otherwise, resources would be moved from other sectors, curbing their growth prospects.

Economic instruments could stimulate the production of cleaning equipment and other devises more effectively than other policy instruments, by giving polluters incentives to reduce emissions. Thus, they will constantly be looking for new and cost effective ways to reduce emissions. When a polluter has been given an emissions target there will be no incentives to reduce emissions beyond this, and there will be reduced stimulation to develop new "green" solutions. Brännlund (2007) also recognizes this, stating that economic instruments have good preconditions for long term dynamic efficiency compared to other instruments.

Green taxes could make the economy more efficient and contribute to increased productivity and competitive position compared to a command and control approach. They could also reduce hindrances for economic growth in ways that other policy instruments cannot. For instance, a congestion charge could improve traffic flow and reduce transportation costs for goods and personnel, which could be important for many companies. The charge will in itself increase transportation costs, but also reduce costs through reduced congestion.

According to the Porter hypothesis (see for instance Porter, 1990), increased green taxes could yield innovations, new investments and increased efficiency in emission intensive industries that more than neutralize the increased costs from the taxation. For

instance, the companies may reduce CO_2 emissions through lower energy intensity, which reduces production costs. Furthermore, demand for environmental benign technology will increase internationally, and countries that are in the front with high environmental taxes could develop an industry and a creative industrial environment that could yield large benefits.

The Porter hypothesis has been heavily disputed by many, se e.g. Brännlund (2007) who finds no evidence for it in an analysis of Swedish industry. Traditional economic theory emphasizes that investments in environmental technology will increase from (increased) green taxation. Even if this means reduced energy intensity and increased export of new products, the net impacts on the economy would most likely be negative. If these actions were profitable also without the tax, the companies would have implemented them anyway, and thus companies will be worse off with a tax than without.

However, Porter also emphasizes that innovations and increased energy efficiency can be accelerated, and a pressure towards structural change and innovation is created by increased costs. As we see from some of the evaluations of tax impacts in The Nordic countries in this report, there might be some empirical evidence for this.

The impacts of economic instruments on a country's economic growth will depend on what are the alternatives to the current use of the resources in a country. If some industries are exempted from the economic instruments to avoid disturbing their competitive position and prevent them closing down, the overall costs of achieving the environmental goals will increase, but the production will be maintained. If these industries are taxed and have to close, and the labour force is employed in other (new) activities with at least the same propensities to grow as the industries they are leaving, overall economic growth would not be affected. Experiences from the Nordic countries over the years show that industries closed down have been replaced by new companies in new branches. Even if the work force is unemployed for a while, as in many countries today, efforts to spur creation of new jobs should lead to higher future growth.

If people are led into long term unemployment this might hamper economic growth also in the long run. But then the problems and solutions usually lies in other parts of the economy, like an inflexible labour market, lack of (right) education of the work force, malfunctioning capital markets etc. and not in the environmental policy. By getting the prices on emissions and harmful resources right, clear signals are given to companies to limit emissions and using the resources with the lowest environmental impacts. This should contribute to a long term green growth in all economies.

To sum up, there seems to be some indications that the use of economic instruments in the environmental policy may yield a *greener* growth compared to using command and control instruments. To what extent use of taxes would imply higher or lower economic growth than using other policy instruments in the environmental policy would be an empirical question.

3.8 *Relative energy consumption and intensities not much changed*

3.8.1 Energy consumption per capita fairly constant over time

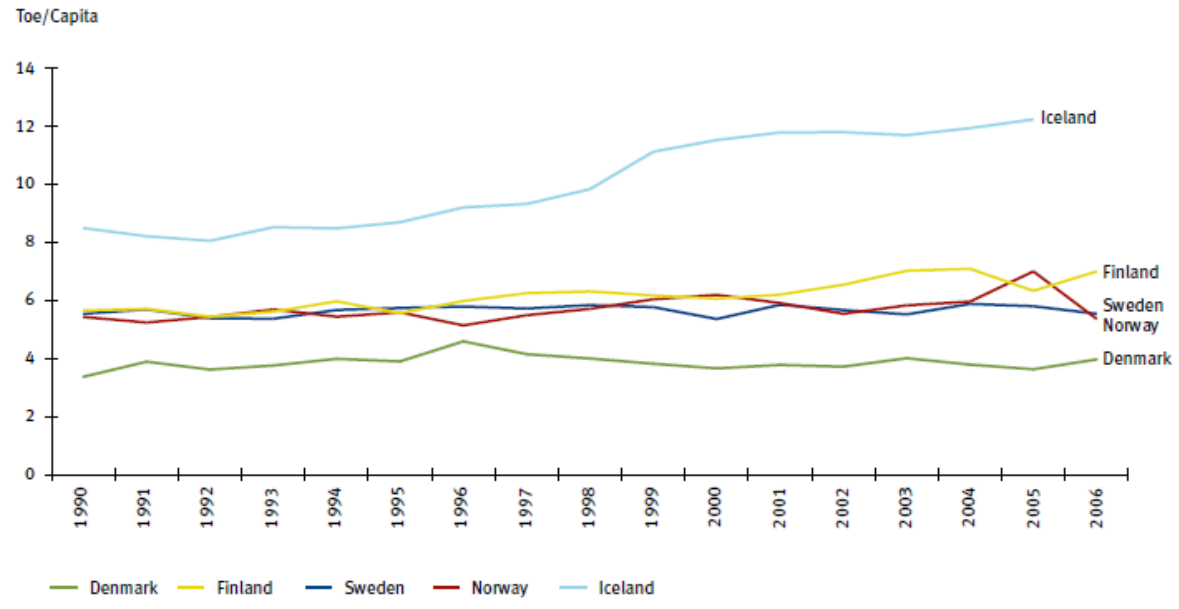
Taxes on energy use in the Nordic countries have over the years been the most important of the taxes we are considering. The Nordic taxes on air pollutants are mostly not levied on emissions, but instead levied on energy products. All Nordic countries have in place tax systems targeting energy consumption. In all countries taxes are levied on fuels, electricity and heat supply for industry and households, as well as on fuels for transportation. Generally, the tax regimes consist of energy taxes (mostly for revenue purposes), CO_2-taxes and sulfur taxes (TemaNord, 2006a).

Energy taxation schemes implemented in the Nordic countries are relatively similar, with the exception of the Icelandic scheme which is not as complex and extensive as in the other Nordic countries. Taxes levied on energy products, either basic energy or CO_2/energy taxes, are by far the biggest revenue generators (TemaNord, 2006a).

Electricity consumption taxes are levied in all Nordic countries. Fuels used in the production of electricity are exempt from taxation in all countries.

The Nordic countries have some of the highest energy taxes within the EU/EEA area. But energy consumption per capita is in general higher than in the rest of the EU, mostly due to temperature and high income levels. Only Denmark has an energy intensity that is close to the EU average (TemaNord, 2007a). The energy consumption as share of GDP (the energy intensity) is also relatively high in the Nordic countries.

Figure 3.2 Gross energy consumption per country 1990-2006. Ton oil equivalents/capita.



Source: TemaNord (2009h)

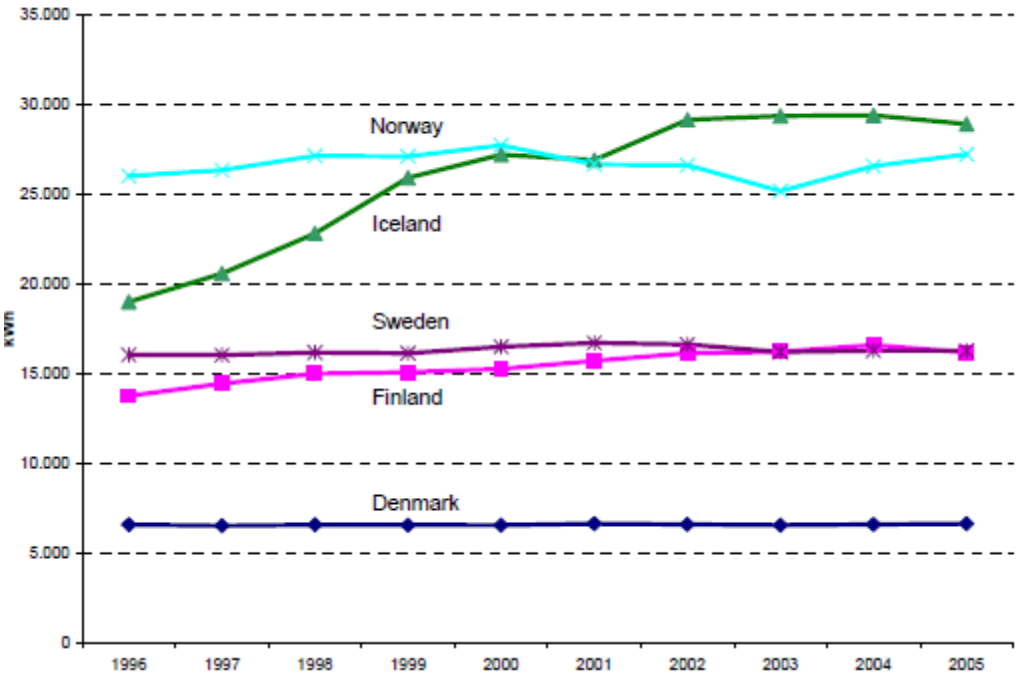
Figure 3.2 displays the differences in energy use per capita between the Nordic countries (including transportation). The differences are mostly explained by

differences in climate and industrial structure (TemaNord, 2009h). The increase in Iceland's energy consumption is due to the country's major investments in the expansion of power-intensive industries using electricity. Iceland in 2010 introduced a tax on all sales of electricity amounting to 0.12 ISK/kWh. At the same time a much lower tax on the sale of geothermal water for heating purposes also was introduced. Despite economic growth, most Nordic countries did not use significantly more gross energy per capita in 2006 than in 1990.

Electricity consumption per capita in the Nordic countries differs a great deal among countries, see figure 3.3. Denmark has had relatively low and constant electricity consumption per capita. In spite of a substantial growth in Danish GDP, electricity consumption has stayed at a constant level. Norway has a relatively high level of electricity consumption per capita, which is mainly due to the use of electric heating of houses and a relatively large power intensive industry. Electricity consumption per capita in Iceland increased a great deal during the 1990s but has remained fairly constant since 2002. The increase in consumption was especially due to a growing power-intensive industry and low electricity prices. Since the electricity production is hydro and geothermal, it generally causes few if any environmental problems.

Differences in the consumer price levels, especially for households, are also an important explanation for the differences in electricity consumption levels. The consumer price is almost three times higher in Denmark than in Norway. The price levels in Finland and Sweden are around 50 percent higher than in Norway. The price differences can to a large degree be explained by differences in the level of energy taxes. Around 60 percent of the consumer price for electricity to households in Denmark is energy taxes and VAT. In Finland only around 25 percent of the consumer price originates from energy taxes and VAT (TemaNord, 2007a).

Figure 3.3 Total electricity consumption per capita in the Nordic countries.



Source: TemaNord (2007a)

Special tax provisions for industries, either in the form of complete tax exemption or reduced tax rates on energy consumption, are more the rule than the exception in the Nordic countries. All these policies have in common that they aim to protect domestic industries to the potential risk of a loss of competitiveness arising from unilaterally imposed high energy taxes. Some of these tax provisions are directly in accordance with EU legislation as, for instance, when energy products are used as raw materials in industrial processes (TemaNord, 2006a).

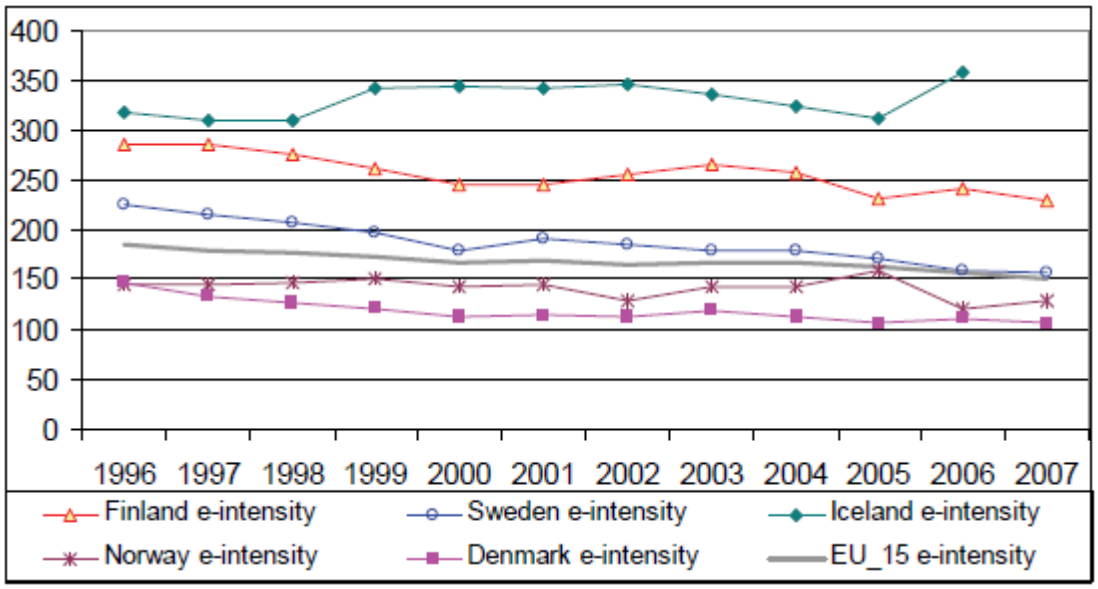
When the purpose of the taxes is fiscal, economic theory prescribes a tax system that to the least extent possible impacts the production of goods and services (NOU, 2007). This implies that fiscal taxes are imposed on end consumption of goods and services rather than on companies' purchase of input goods. But taxes that corrects for external impacts in the production, like taxes on emissions and other environmental taxes, should be imposed. Thus, exemptions from energy taxation that are not related to emissions may be in accordance with economic theory.

Even if the purpose of energy taxation has primarily been fiscal, the taxes have had an impact on the use of energy and hence the CO_2 emissions as well (TemaNord, 2007a).

3.8.2 Some decoupling between energy use and GDP growth

As regards trends and levels of energy use in relation to GDP the Nordic countries can be divided in three groups, Scandinavia, Finland, and Iceland (TemaNord, 2010a).

Figure 3.4 The energy intensity (in relation to GDP) of the Nordic countries and EU-15 (koe/1000 euro).



Source: TemaNord (2010a)

Figure 3.4 shows that Finland and in particular Iceland have much higher energy use levels per GDP value and show less (Finland) or no (Iceland) convergence towards the other Nordic countries. This could partly be due to the fact that end-use prices are in general lower in Iceland and Finland as compared to Sweden and Denmark. In Norway

prices are low as well, but the intensity indicator seems low due to the high level of GDP (TemaNord, 2010a).

From the figure it seems that some degree of decoupling between energy end-use and GDP development has been taking place since the mid-1990s, notably in Sweden and Denmark. In spite of some of the highest energy taxes in the EU, Finland, Iceland and to some extent also Sweden have energy intensities that are higher than EU 15 average. Denmark and Norway have energy intensities lower that the EU 15, with Denmark with the lowest.

3.9 *The policy instruments have had impacts on pollution*

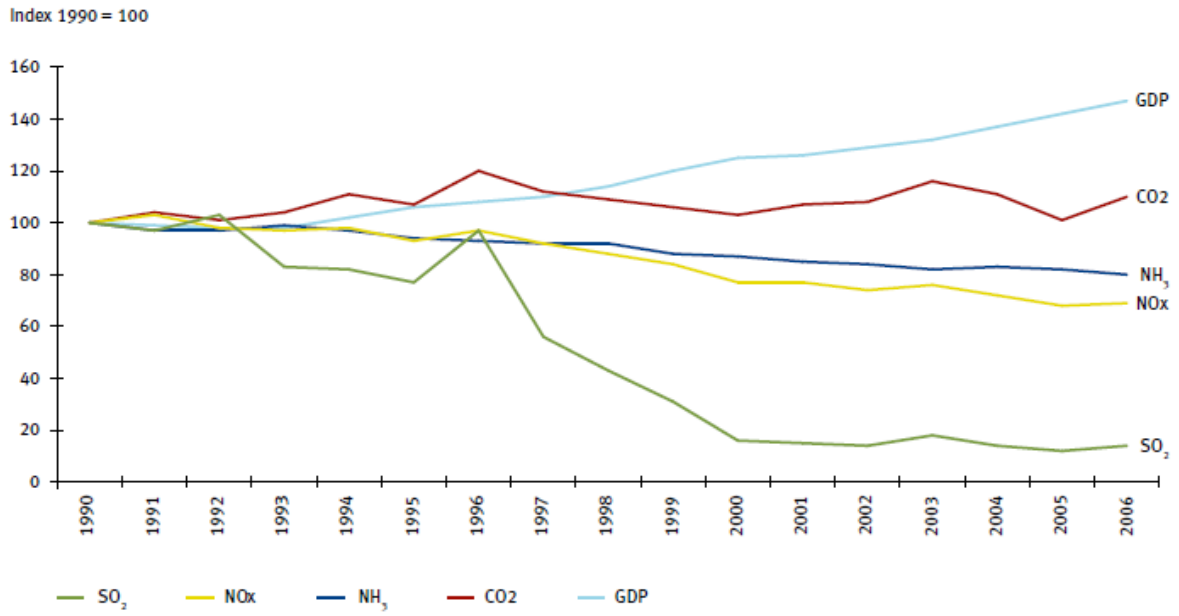
Several evaluations of the ex post impacts of environmental taxes have been carried out in the Nordic countries. Environmental taxes affect relative prices of raw materials, pollution or products, offering price signals to producers and consumers that a certain product or production method involves externalities in the form of environmental damage. This provides incentives for producers or consumers to change behavior towards less pollution-intensive products, implement abatement of emissions, and to reduce environmentally damaging consumption of natural resources. Most of these have focused on energy/ CO_2-related taxes, but a few studies also have assessed effects of waste taxes. Below some of the results from the various studies are presented and discussed.

3.9.1 Economic growth and emissions to air have been decoupled

The existence of the socalled environmental Kuznet's curve has been debated within the environmental economics literature. The Kuznet's curve takes the shape of an inverted U, it implies that emissions in a country first increase with GDP. But after some time a change occurs such that while GDP continues to increase, emissions are "decoupled" and decline.

The mechanism is based on a hypothesis that preferences for more environmental goods, resulting from increased welfare, provide pressures to control emissions. Environmental Kuznet's curves have been identified in several countries for some emissions. Much of the Kuznet's curve debate has focused on the implied relationship between "getting rich" and "getting clean", i.e. whether an increase in GDP is a precondition for environmental improvement (TemaNord, 2006d). This, together with the continuous technological progress could create a decoupling from growth and even a decrease in emissions after certain income levels.

Figure 3.5. Development of gross domestic product (GDP) in relation to some emissions to air in the Nordic countries 1990-2007. 1990=100.



Source: TemaNord (2009h)

Figure 3.5 shows that emissions to air of carbon dioxide (CO_2), ammonia (NH3), nitrogen oxide (NOx) and sulphur dioxides (SO_2) have been decoupled from economic growth in the Nordic countries since early/mid 1990s. The decoupling appears to have been much stronger for the three latter pollutants than for CO_2. Economic growth was very high in the Nordic countries in the period 1994 to 2007. At the same time, the countries cut emissions of the acidifying substances NOx and NH3, but not to the same degree as the cut in SO_2. Figure 3.5 shows that SO_2 emissions were cut substantially in most of the Nordic countries from the early 1980s to the end of the 1990s. Emissions of acidifying compounds stem primarily from the combustion of fossil fuels and emissions from livestock farms (NH3) (TemaNord, 2009h). Much of these emissions can be curbed through technical measures related to fuel, end-of-pipe devises and similar. The incentives to reduce emissions are higher for local pollutants, as there is a more imminent link between abatement costs and benefits.

Figure 3.5 also shows that growth in CO_2-emissions and GDP growth seems to have been decoupled since the late 1990s. For most countries this means that these emissions are growing at a lower rate than GDP, i.e. absolute emissions are still increasing. CO_2 emissions are much more demanding to reduce when the economies grow, since they are related to almost all economic activities and cannot so far be cleaned at reasonable costs. Energy efficiency and switching to fuels with lover or no carbon content have likely been the most important actions to curb CO_2 emissions so far. Coal-fired power plants and the transport sector account for the majority of CO_2 emissions.

3.9.2 Energy/ CO_2-related taxes and subsidies have had impacts on GHG emissions

Review of ex-post evaluations of carbon-energy taxes and subsidies across countries show that carbon taxes have been environmentally effective. Across countries and

sectors, growth-adjusted energy-use and CO_2 emissions have declined since the introduction of carbon tax regimes in the early 1990s (TemaNord, 2006a):

- *Finland*: CO_2 emissions would have been 7 percent higher in 1998 than in 1990 had the CO_2 taxes not been introduced (TemaNord, 2002). They also refer to a study carried out by the Prime Minister's office in 2000 which concluded that CO_2 emissions had been reduced by up to 4 million tonnes because of lower petrol consumption due to the tax.
- *Denmark*: Enevoldsen (2005) found that industrial CO_2 emissions declined by 23 percent during the 1990s, after adjusting for both growth and market-induced industrial restructuring. According to Enevoldsen (2005) an econometric analysis estimated that new Danish CO_2, SO_2 and energy *taxes* reduced total industrial CO_2 emissions by 9–11 percent between 1992 and 2000, compared with a business-as-usual scenario. The effectiveness of the taxation was said to be increased through earmarking the proceeds for subsidies for energy efficiency, estimating the effect of the entire tax/subsidy package at 13–17 percent for the same period. An interview study also showed that CO_2 taxes encouraged investments in energy saving technologies and a move to low-carbon energy sources (Enevoldsen, 2005). TemaNord (2006a) refers to a study from the Danish Environmental Protection Agency that estimates that total CO_2 emissions were reduced by 24 percent between 1990 and 2001 compared with a business-as-usual scenario, as a result of energy-related policies (predominantly taxes and subsidies) introduced during the period. This study estimated the effect of *tax* changes during the 1990s to be a reduction of 1.5 million CO_2 equivalents or 3.5 percent of total energy-related emissions of GHG in 2001, compared with a business-as-usual scenario. Subsidies to private windmills and decentralised CHP reduced emissions by 4.8 million tonnes CO_2-equivalents. Taxes on transport fuel contributed with an additional reduction of 1.2 million tonnes CO_2 equivalents, or about 9.5 percent of actual transport-related emissions in 2001 (TemaNord, 2006a).
- *Norway*: Bruvoll and Larsen (2004) in their general equilibrium simulation estimates that average CO_2 emissions per unit of GDP have been reduced by 12 percent between 1990 and 1999. This reflects a relative decoupling of CO_2 emissions from growth, as CO_2 emissions in absolute terms increased by 19 percent. They estimate that energy taxes in Norway contributed with a 2.3 percent reduction in CO_2 emissions over the period, most of which came in the oil and gas sector. Regarding onshore activities, carbon taxes only accounted for a 1.5 percent decrease in CO_2 emissions. Other studies have reported an 8 percent decline in CO_2 emissions from oil and gas production in 1996 (ECON, 2004), but only 3 of these were attributed to the tax. The energy efficiency per produced unit in this sector improved by 30 percent during this period.
- *Sweden*: Swedish greenhouse gas emissions have oscillated in the 1990–2002 period, mostly determined by variations in temperature, but since 1999 have remained below the 1990 level. Given annual positive growth rates since 1994, this would indicate a growth-adjusted decline in emissions. Model calculations from the Third National Report on Climate Changes estimated that CO_2 emissions were 5 million tonnes lower in 2000 than they would have been without the energy and carbon tax policies passed between 1990 and 2000 (TemaNord, 2006a). TemaNord (2002) also cites Swedish EPA findings that CO_2 emissions fell

> by 19 percent between 1987 and 1994 in the district heating, industry, service and household sectors, but less for total emissions as the transport sector was not included in the study. The Swedish EPA estimated that about 60 percent of emission reductions between 1987 and 1994 were attributable to the energy tax system (TemaNord, 2002). The Swedish EPA also credits the switch to environmentally improved energy sources in the heating sector to the tax.

According to TemaNord (2006a) improved energy efficiency and substitution toward less carbon-intensive fuels account for a large part of the emission reductions. Energy efficiency in Danish industry improved by 26 percent during the 1990s, with this trend accelerating after 1996 when CO_2 taxes were increased and SO_2 taxes introduced (Enevoldsen, 2005). In Norway, average energy intensity was reduced by 11 percent between 1990 and 1999 according to Bruvoll and Larsen (2004).

In all countries the trend has been some substitution away from carbon intensive fuels (Bruvoll and Larsen, 2004; Enevoldsen, 2005 and TemaNord, 2002). For instance, Swedish district heating plants increased their use of bio fuels as a substitute for fossil fuels (Swedish Environmental Protection Agency, 2004). Finland's industry switched from coal and heavy fuel oil toward natural gas and wood (TemaNord, 2002). Danish industry increased its use of CHP and natural gas, but on the other hand fuel taxes resulted in a greater demand for electricity, which in the case of Denmark is rather carbon intensive (Enevoldsen, 2005). This has most likely changed after the introduction of emissions trading in Denmark and later in the EU.

The evaluations suggest that environmental taxes can be credited with some of the emission reductions, but much of the change owes to other factors, including other policies or industrial restructuring. Few studies have been designed to evaluate this precisely. But typically, reductions in CO_2 emissions directly attributable to carbon-energy taxes are in the order of 2–3 percent for the 1990s, although some evaluations ascribe greater effect directly to the taxes (TemaNord, 2006a). The evaluations suggest that carbon-energy taxes could have been more efficient had the taxes been designed optimally, i.e. tax rates have been too low to offer adequate incentives and too many exemptions have excluded large shares of energy consumption from taxation. For example, Bruvoll and Larsen (2004) conclude that differentiations and exemptions within the Norwegian tax regime tend to "impair the composition of sectors and the mix of energy types and intermediates that an optimal tax regime would have created". Due to exemptions of emission-intensive sectors, the carbon taxes then covered only about 64 percent of total CO_2 emissions, while the tax hits sectors with a fairly inelastic energy demand (household transport). They conclude that the sectors where the carbon tax would be most efficient are the same sectors that are exempted. In the highly taxed sectors the substitution possibilities and hence the emission effects are limited. Similar claims have been raised in Finland regarding low tax rates and exemptions for energy-intensive industries (Hiltunen, 2004).

In TemaNord (2006d) the results of an evaluation of the development of some industries CO_2 intensities are presented. Ten industrial sectors, both energy intensive and less energy intensive were investigated, to see whether decoupling between gross value added and carbon emissions occurred during the 1990's and the extent to which any such decoupling can be explained by the incentives provided in terms of carbon-energy taxes in the Nordic countries. For Norway, Denmark and Finland half or more of

the industrial sectors experienced decoupling between economic growth and CO_2 emissions between 1990 and 2001. The predominance of coupling rather than decoupling in Sweden, on the other hand, appears to be related to the economic difficulties of the early 1990s in several industrial sectors. The time-series data suggests that sectors in economic decline have difficulties in adjusting to the incentives from carbon-energy taxation. Successful decoupling seems to require some level of economic growth to allow for renewal within process and energy technologies. According to TemaNord (2006d) this observation is in accordance with recent economic theories on endogenous growth.

The evaluations indicate that taxes may work not only through price signals. First, taxes may focus attention of industries on the cost-effectiveness of environmental abatement and energy savings, regardless of the pre-tax cost-effectiveness of abatement as discovered in the Norwegian offshore petroleum industry (ECON, 2004). Thus, the tax directed the companies' attention on actions that would have been profitable for them to carry out also before the tax was introduced. Other instruments such as subsidies for energy savings may enhance the effect of the carbon-energy taxes, demonstrated in Denmark (Enevoldsen, 2005). That earmarked subsidies may be an effective way to return tax revenue to businesses in order to intensify the effect of the taxation also has some support in economic theory (TemaNord, 2006a). Also, linking tax exemptions to agreements to improve energy efficiency as it has been done in Denmark have accelerated emission reductions (Enevoldsen, 2005).

While the emissions of CO_2 have been steadily increasing in most countries over the last decades, there has been a clear decoupling from economic growth. This is mainly due to the general technological progress; reduced energy intensity and new technologies related to production and transport. For instance in Norway CO_2 emissions from 1980 to 1996 increased by 43 percent of the GDP growth, and over the period 1990-1999 by 53 percent. The main causes for decoupling were reduced energy intensity, changes in energy mixture and other technological changes (Bruvoll and Medin 2000, Bruvoll and Larsen 2004). Carbon taxes played a minor role to the decoupling. Bruvoll and Larsen estimated that the carbon taxes only contributed to some 14 percent of the decoupling over the period from 1990 to 1999[1].

Emission projections show a continuation of the decoupling tendencies. Assuming an income-dependent strengthening of policy (jf the Kutznet hypothesis), Bruvoll, Fæhn and Strøm (2003) estimate that CO_2 emissions will increase by less than half the GDP growth towards 2030.

3.9.3 Acidification is also reduced

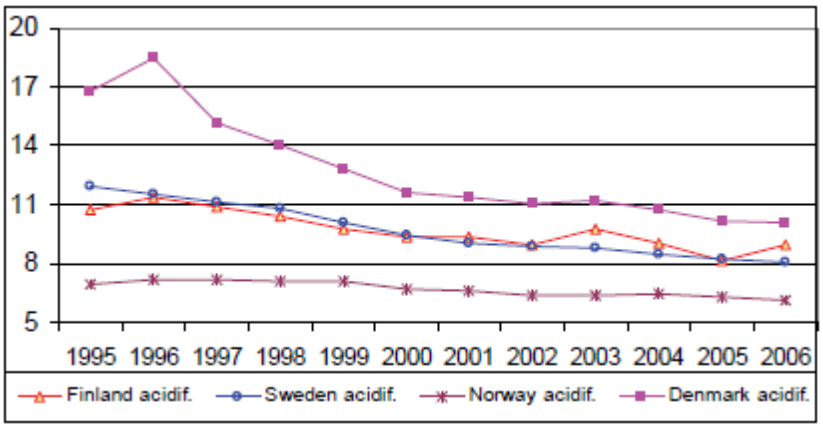
As seen above, emissions of the acidifying substances NOx and NH3 are greatly reduced in the Nordic countries. Acidification can lead to forest dieback and harm to animals and vegetation in water areas (TemaNord, 2009h). The presence of lime may reduce or neutralize the impact of acidification. There is a great presence of lime in soil and in water in Denmark, which neutralizes the effect of acidification. The critical load is not

[1] GDP increased by 35,4 percent and CO_2 emissions by 18,7 percent. The effect f the carbon taxes was estimated to be 2,3 percent (14 percent of the difference between the GDP growth and the emission growth))

exceeded anywhere in Iceland. Sweden and Norway are lime-deficient and are more vulnerable to the acidification of soil, lakes and watercourses. Much of the acidification in the Nordic countries is caused by transboundary emissions from countries outside the region.

Figure 3.6 provides an overview of a compound indicator for acidifying emissions in the Nordic countries except Iceland since 1995. For all countries steady decreases dominate with a few years with small annual increases in Finland in 2003 and 2006, which are related to a significant upswing in coal use in power stations (TemaNord, 2010a). Relative to land area, Denmark has by far the highest emissions of acidifying substances.

Figure 3.6 Acidifying emissions in the Nordic countries except Iceland. 1000 tons of acidifying equivalents based on SO_2, NOx and NH3 emissions.



Source: TemaNord (2010a)

A further review of data by country shows that for these emissions a decoupling from the development of GDP is by and large realized as showed in previous figure. However, absolute emissions may still have increased. NH3 emissions seem to have been reduced in most countries, albeit to varying extent. On the other hand emissions of NOx and SO_2 show fluctuations, but are according to TemaNord (2010a) usually barely lower in recent years as compared to 1990. In Denmark these emissions show even a rising trend, notably after the year 2000. This is probably the result of a common Nordic electricity market, EU ETS and other domestic energy policy decisions leading to an alternating level of attractiveness to use coal.

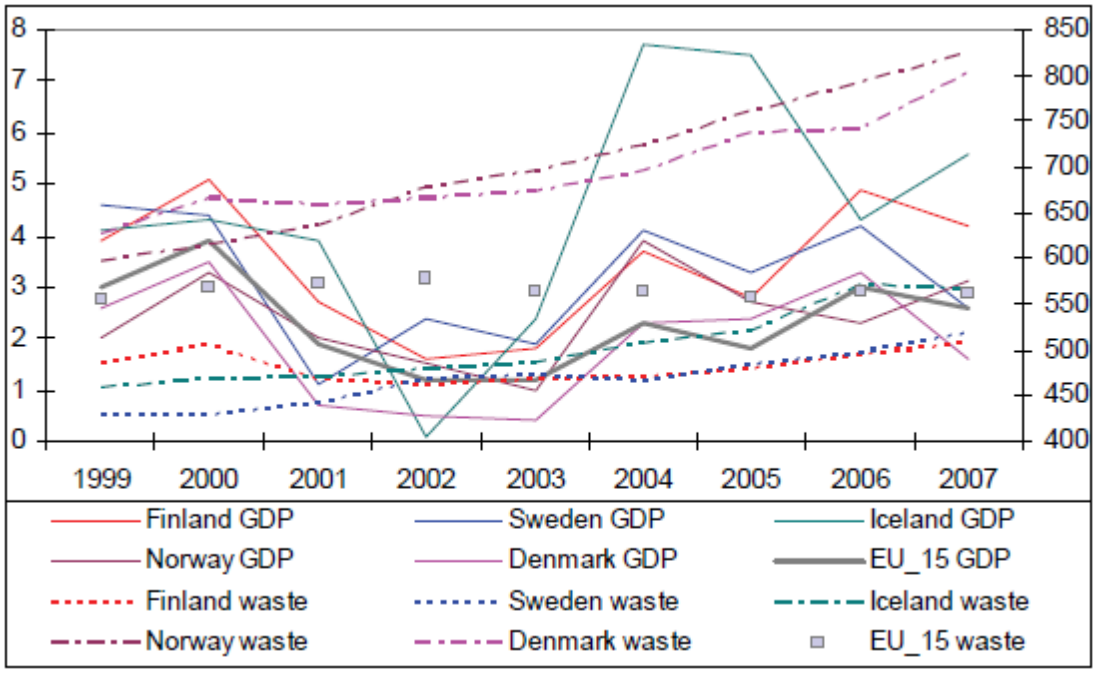
3.9.4 Waste taxation has reduced waste growth

Nordic countries have had quite different levels of urban waste per capita even though their purchasing power differences are not that big. Denmark and Norway have very much higher waste levels per capita compared to the other countries. Furthermore, there does not seem to be any decoupling between GDP and urban waste growth. In terms of a multi-year moving average both show an upward trend, see figure 3.7.

Economic instruments in the Nordic waste sectors consist of *user charges* related to waste treatment, which are generally designed to recover the direct cost of waste handling, *waste taxes* aimed to reduce waste generation or offering incentives for different forms of waste treatment and emission taxes on incineration. Some countries

also tax hazardous waste. Additionally, there are specific charges levied on certain items such as packaging, batteries etc. (TemaNord 2006a).

Figure 3.7. Development of urban waste per capita (in kg; right hand y-axis) and of GDP growth (in percent per year; left hand axis) in the Nordic countries and the EU-15 area.



Source: TemaNord (2010a)

Some evaluations of these systems have been carried out in the Nordic countries:

- *Denmark*: evaluations of the Danish weight-based waste tax presented in TemaNord (2006a) found that delivered amount of waste to municipal sites was reduced by 26 percent, while net waste delivered to smaller sites and private landfills was reduced by 39 percent between 1990 and 1996. Since the tax was weight-based, reductions primarily involved the heavier components of household waste (16 percent) as well as construction waste and mixed waste (63 percent). Moreover, recycling increased, particularly of heavier waste factions such as concrete and compost.
- *Finland*: Finland's solid waste amounts have been reduced by around 15 percent compared with the business-as-usual prediction, thanks to the impetus of the national waste tax. Several studies presented in TemaNord (2006a) indicate reduced amounts of waste delivered to municipal landfills in response to the waste tax. Hiltunen (2004) also reports increased recovery of municipal waste. The largest change has occurred in construction and demolition waste and in commercial waste, as the tax has improved the competitive position of treatments plants for these waste factions.
- *Sweden*: the Swedish waste disposal tax for households was evaluated in 2001, within a year of its introduction (TemaNord, 2006a). The evaluation concludes that a price increase would lead to a reduction in waste disposal among Swedish households of the order of 20–30 kg per person annually, given a tax-induced price increase of 90 SEK. Waste generation is closely related to development in

household incomes; thus it is estimated that an increase of 1 percent in annual income increases household waste volume by 2 percent.

To sum up, waste taxes seem to reduce waste amounts when the price signal is clear and targets relevant groups in a straightforward manner (TemaNord, 2006a). Hence, weight-based systems appear more effective for heavy waste fractions, such as construction waste, according to studies in Finland and Denmark. Industry, in general, has been less responsive to taxes because price signals have been relatively weak. This tendency is even more pronounced for household waste due to the structure of the waste taxes, which means that the price signal is not transformed directly into user fees. Taxes on packaging in Denmark and Finland also seem to have had impact on packaging use and recycling rates (TemaNord, 2006a).

Even though the various waste-related taxes have reduced the growth in total amount of waste generated, the waste amounts have been increasing over the years. If the target is to reduce the amounts of waste, direct price signals are necessary. This implies weight-based rates. Flat rates or discrete options (such as choices of the size of the garbage cans) do not stimulate waste reduction. The question whether policy targets of waste reduction or specific treatment methods represents an efficient environmental policy has been discussed above. If the target is to reduce the environmental damages from waste treatment, emission taxes on incineration, landsfills and recycling emissions are most efficient, and further waste policy only increase policy costs (Bruvoll and Hasane 2010).

3.10 *No significant negative impacts on income distribution*

There have over the years been some concerns about the distributional implications of energy and environmental taxes. However, distributional implications do not play a major role in environmental policy in the Nordic countries. Electricity and transport fuel-related taxes have caused attention mainly in periods with high electricity and oil prices, when there have been some pressure towards lowering the tax rates. Also, some have proposed that the tax rates should vary inversely with the electricity and fuel prices to mitigate periodical price hikes on these commodities.

Energy and environmental taxes have been proclaimed as regressive, i.e. placing a larger relative burden on poor households than on rich ones. While this may be the first order impacts of a tax, evaluations of their total impacts should also take into account to what extent the tax will be fully passed on to consumers via higher prices for energy and products. Also other, indirect impacts, including changes in other taxes like income tax rates, personal tax allowances (i.e. standard deductions) or social security contributions should be considered, since energy and environmental taxes often have been introduced as part of a greater tax reform where recycling measures may be deliberately chosen to counteract the regressive character of energy/CO_2 taxes. Finally, the distribution of benefits from improved environmental quality as a consequence of the implementation of the taxes can affect households in different ways, and should ideally be included in the assessment (TemaNord, 2006a).

Some few special measures addressing distributional implications of economic instruments in environmental policy are in place in Nordic countries. Perhaps the most important of such mitigation measures are the particular form of electricity tax

differentiation in Norway and Sweden, where the northern parts of the countries are either exempted from the tax or pay reduced rates (TemaNord, 2009a). However, these tax differentiations are also valid for the industrial sector in addition to households. Such special tax provisions are widespread in the industrial sector and are implemented with the aim of mitigating potential loss of international competitiveness (see next section).

Evaluations of distributional impacts of energy and environmental taxes from Sweden, Norway and Denmark have taken into account most of these direct and indirect effects of taxes. The findings show that rural areas are most burdened by environmental taxes. Another main result is that while energy taxes tend to be distributionally regressive, taxes on transport fuels and pollution are, respectively, progressive and neutral. Lower income households tend to spend a larger share of their disposable income on heating, electricity and water than high-income households, while the opposite is the case for vehicle and transport consumption. Richer people drive bigger cars, and for longer distances (TemaNord 2006a).

One major finding from the evaluations is that the geographical location of households is of great significance, as households living in rural areas face a higher tax burden as a result of CO_2 taxation than households living in urban regions. This is explained by the fact that households from rural areas face higher transportation and energy needs compared with those in urban areas (TemaNord, 2006a).

An evaluation study of the environmental taxes introduced in Sweden made by the Ministry of Finance in 2004 referred to in TemaNord (2006a) concludes that the regressive effects of environmental taxes, regionally as well as between households, have been largely neutralized by the specific redistribution scheme implemented in Sweden, i.e. the raising of the personal income tax allowance. The result of raising the personal allowance (standard deduction) and transferring a portion of the tax revenues from the service sector to consumers was that very minor, if any, redistributive and regional effects arose during the period 2001–2003 because of the shift towards green taxes. This implies that neutralizing the regressive effects of energy taxes, is the result of the deliberately chosen policy approach aiming to counteract these regressive effects. However, the financial situation for individual households can still be negatively affected as the consumption patterns of households differ widely.

A Danish study finds that energy taxes are regressive, but that taxes levied on transport fuels and vehicles are progressive, meaning that the lower income households pay relatively less than higher income households and that pollution taxes are almost neutral. The electricity tax and the tax on tap water are singled out as specific regressive. They also conclude that the distributional effects of the energy tax are similar to that of the VAT, but less pronounced than the effects of the alcohol and tobacco tax in Denmark (Klinge et al., 2005).

A study from Norway analyzing the distributional as well as environmental effects of taxes levied on various transportation modes assess the distributional impacts by distinguishing between six types of transportation modes, categorizing them as inexpensive (bus, moped and bicycle) and expensive (air flight, automobile and taxi). Revenue recycling measures are not considered. They conclude that “higher taxes on air flights, taxis and automobiles together with lower taxes on bus rides, bicycles and

mopeds have both favourable environmental effects and reduce inequality" (Aasness and Larsen, 2002). These findings demonstrate that "differentiating the indirect tax system to account for the environmental effects will at the same time reduce inequality. Gasoline is the exception, in which environmental and distributional effects of the tax system oppose each other" (Aasness and Larsen, 2002).

To conclude, instead of reducing tax rates for specific sectors or geographical regions one should consider compensation measures in the form of *ex post* modification of policy instruments explicitly directed at distributional effects. Examples could be higher financial transfers, for instance through standard deductions in the income tax, to offset higher energy tax bills. Also, increasing economic support to households facing high expenses in periods with high electricity prices as is considered in Norway would be an option. These approaches are preferable to tax cuts as they do not affect the marginal incentive of a tax, i.e. they will not impair the effectiveness of environmental taxes.

3.11 *No evidence of pollution havens*

If relatively clean Nordic industries migrate to so-called pollution havens, the risk of emissions growth at the global level is real. According to Copeland & Taylor (2004) there is little empirical evidence suggesting that more stringent regulation in the North has raised costs to the point of pushing pollution intensive industries to pollution havens. Also a recent study by Kearsley and Riddel (2009) indicates that there is no clear evidence of out-spoken shifts of production. However, it is complicated to find empirical evidence on this.

It could be said that carbon leakage or emission leakage is a part of the globalization process. As costs of producing energy intensive products (including environmental costs) increase in industrialized countries it becomes more profitable for producers to move production to countries with lower input costs. It is therefore not surprising that no proof of the pollution haven hypothesis in its pure form is found. Strict environmental policies in some richer countries may accelerate structural change and international reallocation of production, but there is no evidence that this has been the main reason for such changes (TemaNord, 2010a).

3.12 *No large impacts on competitive positions either*

Concerns over the impacts on competitiveness of the use of economic instruments have been raised in all the Nordic countries as these instruments have been introduced. The arguments for competitiveness concerns refer to the assumed economic implications from increased tax burdens for individual firms or whole industries, often export-oriented, energy-intensive and located in rural areas. Thus, tax rebates and exemptions for energy and air pollution related taxes have been frequently applied towards those sectors most exposed to the taxes. This type of policy can also be found in other environmental areas. For example, industry is exempt from the Danish tap water tax and large farms are exempt from the pesticides tax in Denmark.

A study carried out by the National Statistical Offices of the Nordic countries concludes that "The households pay by far the most in energy taxes and the manufacturing industries are exempted or the taxes are refunded, due to competitive reasons as the OECD countries in general exempt these activities. The service sector pays relatively more than the manufacturing industries but less than the households" (Eurostat, 2003).

Rather than the short-term impact on individual companies, it is the overall impact on a country's competitiveness which should be of concern to the policy-maker (TemaNord 2006a). There are various factors which may ease the impact of the environmental taxes. For example, more efficient use of the taxed resource, the stimulus of the tax to innovation in production, or the imposition of environmental policy instruments in other countries. However, all these factors have in common that they mitigate the impacts on competitiveness in the future, while the taxes impose costs in the present.

Such rebates and exemptions reduce the efficiency of the environmental taxation. "To reach the same environmental goal, the cost to the whole economy will be higher than if the rebate or exemption had not been granted, as other sectors of the economy are required to face a larger burden in order for the predefined environmental goal to be achieved. For example, due to these tax provisions, industry would not need to utilize the potential for exploiting cheap emission abatement. Instead, more costly options for emission abatement would have to be utilized in the household sector. It can be argued that such extra costs are justified if such tax provisions ease the pressure on the economy and avoid any economic disruption and dislocation of economic sectors" (TemaNord, 2006a).

Revenues generated by environmental and energy taxes have been used to reduce other distortionary taxes affecting the cost structure of industry in two ways. On the one hand, the energy cost burden increases, but on the other hand the costs associated with labour input have been reduced somewhat as a consequence of a reduction in labour related taxes, with the result that the overall cost structure can remain stable. Thus, the effect of environmental tax reform is likely to be broadly neutral, or even positive compared with the effects of adopting alternative policy for achieving these environmental goals. However, these impacts are generally valid only at the national level and it cannot be denied that negative effects can emerge at the sectoral and company level since energy and emission costs are far more important than labour costs for the energy intensive industries.

The discussion earlier in this report shows that exempting some industries or plants from environmental taxes could imply a less "green" economic growth, and even also imply reduced economic growth. Thus, efforts should be directed at creating new activities in local areas where plants are eventually closed or scaled down because of the use of economic instruments, instead of exempting them from these instruments. But GHG taxes and auctioned allowances in emissions trading that could yield socalled "carbon leakage" is a special case which is considered below.

3.13 *Carbon leakage a concern, but can be dealt with*

The Nordic countries have exempted several industry sectors partly or wholly from CO_2 taxes to avoid socalled carbon leakage. This is also a major concern in other OECD countries. Also grandfathering, i.e. distributing CO_2 emission allowances free of charge, are applied for the same reason towards many industries in the EU ETS. Carbon leakage could occur if emissions reductions in the Nordic countries are partly or wholly replaced by increased emissions in other countries.

Several studies have tried to analyze the level of carbon leakage under different competitive assumptions, and it has been estimated that the energy price increase in some carbon intensive industries will lead to carbon leakage between 5–34 percent

(TemaNord, 2006a). However, analysis by OECD and others suggest that these concerns may be exaggerated (OECD, 2010c). Unless only a few countries take action against climate change, carbon leakage rates are according to these analyses almost negligible. For example, OECD found that in a scenario (OECD, 2010c) where EU act alone to reduce GHG emissions by 50 percent in 2050, about 12 percent of their emission reductions would be offset by emission increases in other countries. However, if all industrialized (Annex I) countries took action, this leakage rate would be reduced to below 2 percent.

If the countries where emissions are increased also have a cap on their total emissions, carbon leakage is not so much to care about. However, several of the competitors of the Nordic energy-intensive industries are located in countries with no emission caps or no policy instruments used towards their GHG emissions. Should then Nordic companies subject to such competition have lower or no taxes, or have most of their emission allowances for free? If one narrowly considers the policy instruments as means to achieve national emission goals they should not, because this would contribute to raise overall abatement costs. OECD (2010c) shows that if energy intensive industries in all countries are exempted from a CO_2 tax, costs to achieve a global target could increase as much as 50 percent.

If global emission reductions matter, the answer is not so obvious, and it can be argued that some actions to reduce leakages could be justified. Many of the main competitors of the energy-intensive industries in the Nordic countries are in countries with no GHG policy. Moving production to these countries could increase total emissions at worst. This is a difficult issue, as all emission sources should have some incentives on the margin to reduce emissions. This could be achieved through letting these industries have at least some of their emission allowances for free, or have the tax revenue redistributed or earmarked for emission abatement purposes like the NOx taxes in Norway and Sweden. Recycling of revenue should be done in ways that would not undermine the marginal incentive to reduce emissions.

The third phase of EU ETS, starting from 2013, intends to allocate allowances for free to industries according to their assumed risk of carbon leakage (TemaNord, 2009g). In contrast to the first two trading periods where almost all allowances were handed out for free, the main portion of the allowances will be auctioned in the third period. The share of allowance auctioning will be at least 50 percent from 2013. The share of auctioning is however different from sector to sector. For electricity generation the general rule will be full auctioning, with some exemptions. For industry sectors, the general rule is that the share of auctioning is set to rise every year, reaching 70 percent in 2020 and 100 percent in 2027. Industry sectors who are classified as being exposed to a significant risk of carbon leakage may continue to receive up to 100 percent allowances for free.

Alternatively, other types of compensation may be given in a transition phase. For many industries it is assumed that the most important impacts from EU ETS on their costs will be through increased power prices stemming from increased costs for power plants from buying emission allowances, i.e. more important than the costs for purchasing allowances for the industries' own emissions. Thus, the EU Commission opens for a special financial compensation for this for industries where power costs have a high share of production costs (Centre for European Economic Research, 2010).

4. The Nordic model

In this chapter we discuss to what extent the socalled ”Nordic model” have contributed to the relatively high focus on a clean environment and comprehensive use of economic instruments in the environmental policy. Is there anything other countries can learn from this model when considering reforms in their environmental policies, or are the Nordic countries' history, experiences and context too special to be of any use?

The Nordic countries have to some extent different historical experiences and are different when it comes to access to natural resources etc. There are also differences in the ways the societies are organized. Thus, “The Nordic model” is a concept that might be defined somewhat differently, depending on in which of the countries you stand. Nevertheless, there are some distinct similarities in the way these countries are organized and run that distinguish them from other industrialized countries.

The “Nordic model” of social development has long been considered a concept, not only at home, but also among politically interested people outside the Nordic countries. During recent years it has also met with interest in financial circles. The fact that all the Nordic countries come out near the top of international rankings of competitiveness, ease of doing business, living standards etc. has made an impression. For instance, the Nordic model was discussed at the 2011 World Economic Forum in Davos. There seems to have become a perception that the Nordic countries offer some kind of middle road development between “hard core” capitalism and a socialistic planning economy.

4.1.1 Mutual trust and link between labour market and welfare benefits characterize the Nordic model

The Nordic countries have very high GDP per capita, achieved through high economic growth for many years. This wealth is more evenly distributed among the population than in most other countries. The Nordic countries have had high employment, and public finances are in a better shape than in most other industrialized countries. Also, the Nordic countries are characterized by rather generous welfare systems with universal coverage of decentralized, high-quality services provided by the public sector and financed through taxation (Mandag Morgen, 2007). These comprise education at all levels, kindergardens, public social and health insurance, unemployment benefits etc. Also, high level of public participation at all levels of the societies is a key characteristic.

Furthermore, strong labour unions negotiating with trade unions about comprehensive labour work and salary agreements are also some of the important characteristics of the Nordic model. Government interaction in the labour market through legislation and also direct involvement in the negotiations at times is a part of this. The results are relatively small wage differences, high workplace standards, well educated and highly motivated work force and high employment rates with high female participation in the work force. The Nordic countries have more flexibility in their labor markets than many other European countries.

The Nordic Council of Ministers asked the magazine *Mandag Morgen* (Monday Morning) to describe what the Nordic countries have in common. More specifically they wanted to find out what has made the Nordic region into “a global winner region”, as measured by economic statistics. *Mandag Morgen* approached this through interviews with nine

Nordic businesspeople, nine scientists and nine cultural personalities. Eight main points emerged from their answers:

- Equality – we take care of each other
- Trust
- Short distances to those in power – both within enterprises and in society in general there is a low degree of hierarchy
- Social inclusion - we want all to participate
- Flexibility
- Respect for nature
- Aesthetics – we like simplicity and harmony
- Protestant work ethics

It is easy to recognise the connections between the four or five first points on the list and commonly cited external attributes of the Nordic model, such as strong welfare states and strong democracies with diffusion of power. But the report also states that these eight attributes stimulate competitiveness. Where there is a high degree of economic equality, the consequences of failure are bearable, so people dare to be innovative. Where there is trust, transaction costs are small. Where there is a short distance to those in power "subordinate" employees will show initiative and take responsibility instead of waiting for orders. In societies with fewer of these attributes, it is easier to postulate a conflict between competitiveness and generous welfare provisions.

Being small, open economies the Nordic countries have always been exposed to global competition and ups and downs in the international economy. Thus, globalization is not new to these countries as compared to other, larger economies with less reliance on international markets. The Nordic countries are used to recessions and large changes in prices and demands for exported commodities, and therefore more clearly see the necessities of flexibility, easy hiring and firing of people, restructuring and innovation in the economy to be able to compete in an international market. This has been a strength and likely a competitive advantage in a more globalized world where many countries are struggling to meet new challenges from low cost countries.

Many of the properties characterising the Nordic model described above are not unique to these countries. Most industrialized countries have welfare systems, many of them even more generous than the Nordic ones. Also, several other characteristics can be found in the Nordic countries. To the extent that there is a genuine Nordic welfare model we think this lies in the connection between the welfare systems and the labour market. The Nordic countries put large emphasis on participation in the work force, and to ensure the incentives to work instead of receiving welfare benefits. There is an "unwritten contract" or trust between labour unions, trade unions and governments that the wage settlements take into account the competitiveness of the industry to avoid a growth in salaries too high to threaten overall industrial competitiveness.

Employees also accept that it is relatively easy to be fired, and employers have a rather high flexibility in hiring and firing people compared to many other industrialized countries. In return employees get rather generous unemployment benefits, and an active labour market policy and support for further training ensures that employees also enjoy a reasonably high level of income security and are relatively easy provided with

new jobs. Because of this, employers are more willing to take on new staff, and employees will become more mobile and more willing to take jobs that are risky and more future-oriented. Thus, employees do not take to the streets protesting when they are laid off and companies are closed, but focus instead on skills and education and how to get a new job. It is sometimes observed that trade unions are in the front in promoting efficiency measures through restructuring of industries and laying off people, realizing that improving efficiency is crucial to ensure future competitiveness and income growth.

A part of this is the consultations between stakeholders representing employers, employees, local and central authorities when important decisions are made, to reach a consensus on restructuring in industries and other necessary changes and how to mitigate negative impacts of these actions for employers and local societies.

4.1.2 The Nordic model is an asset for the Nordic countries

Many outsiders have been surprised at how well the Nordic countries have fared in the face of increasing global competition. After all, high taxes, high public spending, flat organization structures, strong trade unions and high wage levels are hardly the standard formula for strong economic performance in traditional economic textbooks and in influential financial circles. But as globalization has gathered momentum and the pace of change has accelerated in trade and industry worldwide, the Nordic countries have not only managed to keep pace with the rest of the world but to be in front. Against all odds, small Nordic companies have held their positions in the international premier league, and the Nordic countries come out on top of several economic rankings, including level of innovation and international competitiveness. For instance, the Institute for Management Development's World Competitiveness Scorecard places Norway, Sweden, Finland and Denmark in the top 11 performers in 2009. Also, in employee surveys these countries get top score in how the job involves learning and how employees are able to apply their own ideas at work (Source**:** Fourth European Working Conditions Survey).

Sachs (2006) reviewed the economic and political performance of the Nordic countries compared to the English-speaking OECD countries and the continental western EU countries in view of their vastly different systems of social protection. He finds that despite the high rates of taxation, the Nordic countries have generally performed better than the other countries when it comes to economic growth, income per person and incentives to work. He largely attributes this to the acceptance for industrial change, active labour market policies, public sector commitments to higher education, retraining and R&D etc. Furthermore, he points to the fact that the details of those policies have evolved over time, sometimes in the face of financial difficulties, high unemployment or institutional failures. In other words, Nordic governance has generally been active and alert to the need for change. According to Sachs, the Nordic model should thus be an asset in meeting future challenges from globalization. But immigration might challenge the sustainability of the model.

4.1.3 The Nordic model has likely affected the environmental policy

It is hard to say if at all or to what extent the Nordic model has affected the environmental policies in these countries. One might say that the Nordic population's respect and affection for nature might have spurred the relatively early attempts at

imposing environmental regulations in the 1960s and 1970s, even though several other European and other countries also started focusing on the environment at that time. The Nordic countries were likely not so polluted as many other industrialized countries, since they had relatively few industrial "hot spots". Furthermore, the Nordic countries are relatively sparsely populated, and have had large non-polluted areas. Thus, high environmental standards have been the rule, which might have spurred the early attempts at reducing the few hot spots that were visible. There were broad public agreements behind these standards, which most likely was facilitated by the consensus-shaping properties of the Nordic decision model.

The Nordic model might have been more important for the use of economic instruments in the environmental policy. The Nordic population is in general perhaps not so negative towards taxes than others, since they are generally aware of the fact that high taxes yield high public services. Since the increase in environmental taxes have been followed by reduced taxes on labour, acceptance has perhaps been easier than if they had led to a general tax increase. Furthermore, the environmental taxes have by no means threatened the competitive positions of the industry, including the energy intensive industry. But the energy intensive industries have to a large extent been exempted from these taxes.

An important feature for success from using environmental taxation and emissions trading lies in the innovative and flexible nature of the Nordic economies. The larger the ability to switch from "dirty" activities to "cleaner" activities, the larger impacts will these instruments have in greening the economies and at the same time provide high employment and income. It might be that the Nordic countries in the past have been superior to other industrialized countries in this respect. It remains to be seen if this eventually will prevail also in the future. The current financial crisis might force other countries to become more innovative, increase the use of economic instruments more efficiently and contribute to a green economy in the long run.

On the background of this creativity and flexibility one might ask if Nordic governments have been too cautious when exempting several industries partly or wholly from the environmental taxation; haven't they had enough confidence in their economies' ability to innovate and develop new, greener industries instead of the old ones? This remains an open question that we will come back to in the recommendations for future policies.

4.1.4 Some lessons from the Nordic model could be learned

The Nordic model is hard to replicate for other countries. For instance, the rather few attempts at selling the Nordic model to the eastern European countries after the breakdown of the communist regimes were not any success. The main reason for this seems to have been lack of popular trust in the state, and without such trust no Nordic style welfare state is possible (Witoszek and Midttun, 2011).

But some lessons could be learned. The major one is that together with the implementation of economic instruments one should carry out a policy that promotes industrial restructuring and creation of new economic activities. Thus, policies based on promoting education, R&D and cutting socalled "red tape", i.e. un-necessary regulations of industries that hamper change and growth, should be promoted. Also, identifying weaknesses in other markets (e.g. malfunctioning labour and venture capital markets)

would be crucial. This should enable a green growth based on innovation of new technologies, spurred by environmental taxes.

5. Innovation in green technologies - some cases

In this chapter we look into some more detail on what drives innovation in general and green technology innovation in particular, and present some cases from the Nordic countries on technology development activities spurred by various environmental policy instruments. Since much of these activities are related to energy production and use, we first present some overview and comparison of the energy sector in the Nordic countries. It also shows how political priorities and environmental policies have influenced the development of energy production and use.

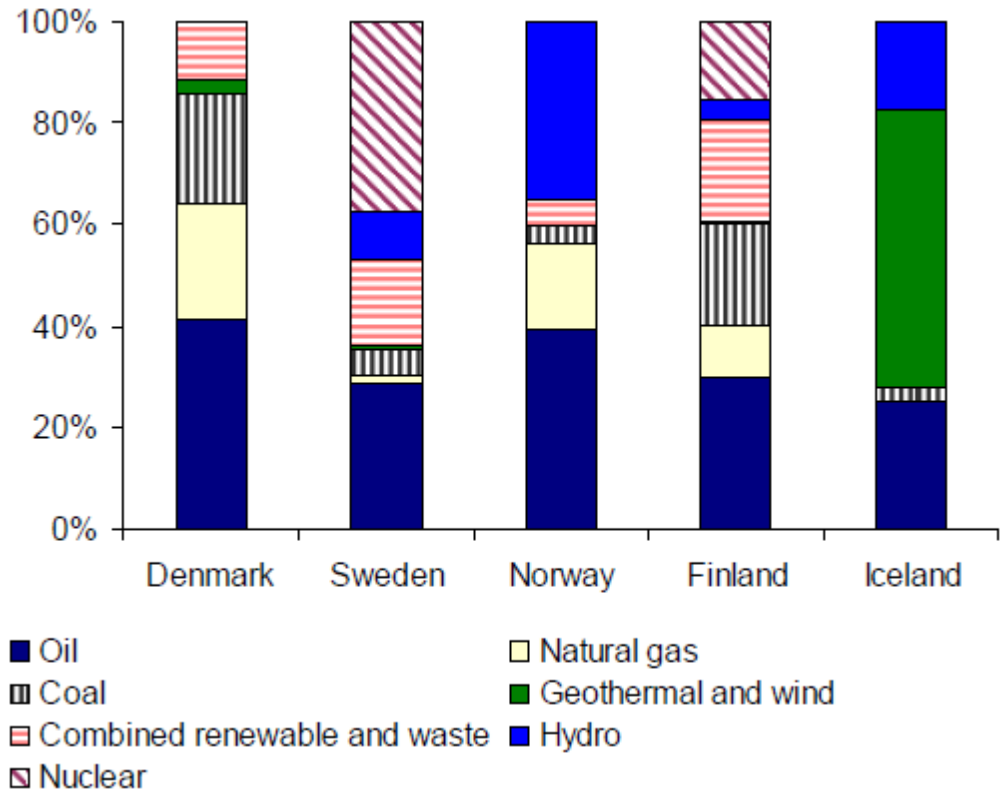
5.1 *Differences in energy production and use are important to understand policies*

Although there are many similarities between the Nordic countries when it comes to economic structure, culture, environmental challenges, environmental and energy policy approach including use of policy instruments, there are also many differences between the countries that can to some extent explain the development in the environmental situation and the choice of policy instruments. Below we discuss some key differences mainly related to the energy and resource mix and industry structure.

The present energy use mix in the Nordic countries is historically determined (TemaNord, 2007a). Natural resources base and political priorities have formed the energy sectors through the last century. Norway and Denmark have large domestic resources of oil and natural gas. Where Denmark uses almost all its natural gas for domestic consumption, less than 1 percent of the final Norwegian energy consumption is based on natural gas. This is about the same magnitude as Sweden uses without having any petroleum resources.

Figure 5.1 shows the relative distribution of primary energy supply in the Nordic countries. It can be seen that oil, mainly for the transportation sector, has a considerable share in all countries. In addition, Denmark has a supply mix of mainly natural gas, coal and renewable/waste. Sweden in addition to oil has a large share of nuclear energy, hydropower and renewable/waste. In Norway oil and hydro are the main energy sources, and natural gas is also used, mainly in electricity production at the continental shelf. Finland uses a mix of oil, gas, coal, renewable/waste, hydro and nuclear, and Iceland get its main energy from geothermal and hydro.

Figure 5.1. Distribution of primary energy supply in the Nordic countries.

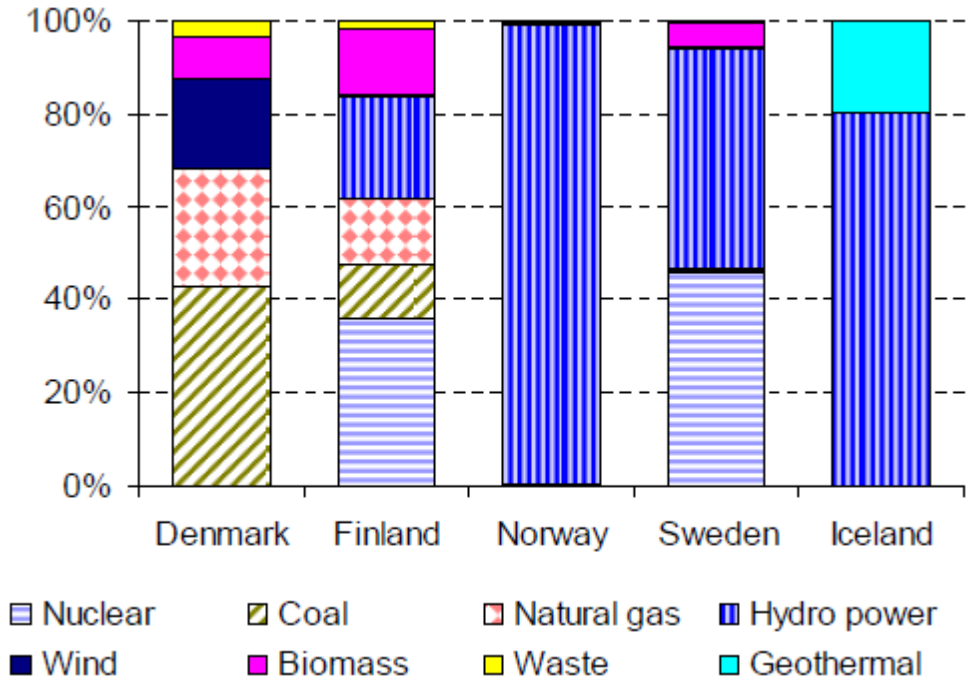


Source: TemaNord (2007a)

The development of the grid-dependent energies, i.e. electricity, district heating and natural gas, have been driven by central planning and heavily influenced by political priorities. Renewable energy has gained large support since the early 1990s. Especially in the electricity sector, small scale renewable have been promoted whereas the supply side of conventional power generation has been liberalized (TemaNord, 2007a).

Electricity constitutes a very large part of the net energy consumption in the Nordic countries. The domestic sources for the power supply differ between the Nordic countries (see figure 5.2). Coal, natural gas and wind are the main resources for power generation in Denmark, and fossil sources accounts for almost 70 percent. Norwegian power generation is almost solely based on hydropower. Swedish power generation is mainly based on nuclear and hydro, and Finnish power generation is based on a mix of different energy resources with nuclear and hydro as the largest. Iceland has a relatively large share of geothermal electricity production in addition to hydropower.

Figure 5.2. Relative fuel mix in the Nordic power generation.



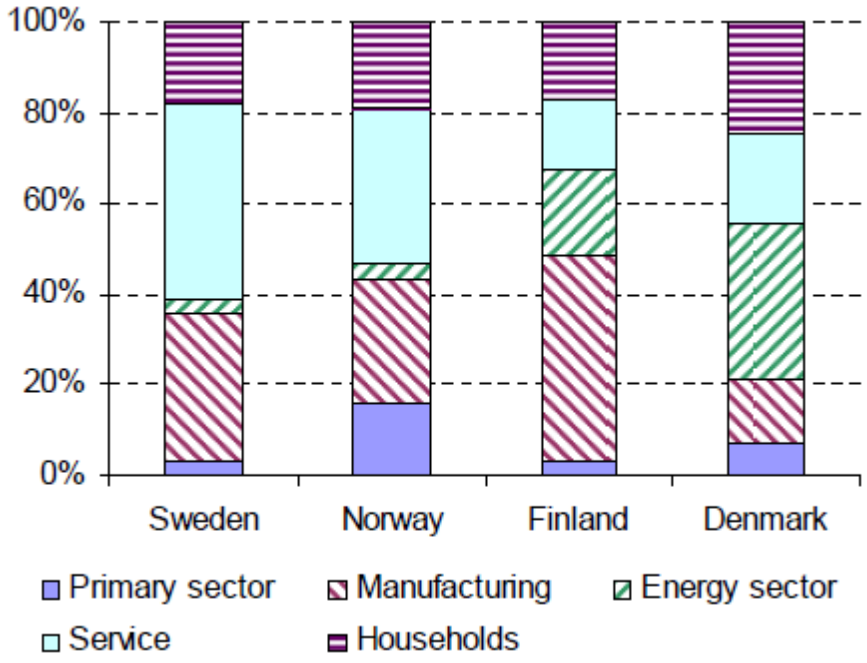
Source: TemaNord (2007a)

Figure 5.2 shows that the largest use of fossil fuels in power generation are in Denmark and to some extent also in Finland, where coal and natural gas are used. This implies that the environmental effects in terms of greenhouse gas emissions and emissions of pollutants to air from electricity supply are much larger in these countries than in the other Nordic countries.

The Nordic countries have some of the highest energy taxes within the EU/EEA area. However, the energy consumption per capita is in general higher in the Nordic countries than in the rest of the EU, and the energy intensity of GDP (energy consumption per unit of GDP) is high. This has much to do with temperatures and industry structure, see below. Only Denmark has an energy intensity that is close to the EU average (TemaNord, 2007a).

Energy consumption in the Nordic countries differs by sector, see Figure 5.3. The consumption of primary industries (called primary sector in the figure) is relatively low in most Nordic countries, with the exception of Norway that has a relatively large power-intensive industry. But Finland has the highest use of energy in industry production, since their pulp and paper industry belongs to the manufacturing sector. The industrial sectors in Norway, Sweden and Finland account for a relatively large part of the energy consumption (37–45 percent of total national consumption) while the same sectors in Denmark consume 20 percent due to a very small energy-intensive industry. These consumption patterns are important to bear in mind when considering the various uses of energy and environmental policy instruments in the Nordic countries.

Figure 5.3. Distribution of gross energy consumption per sector.



Source: TemaNord (2007a)

5.2 *Environmental policies and technology development*

5.2.1 Innovation takes place in the intersection of many policies

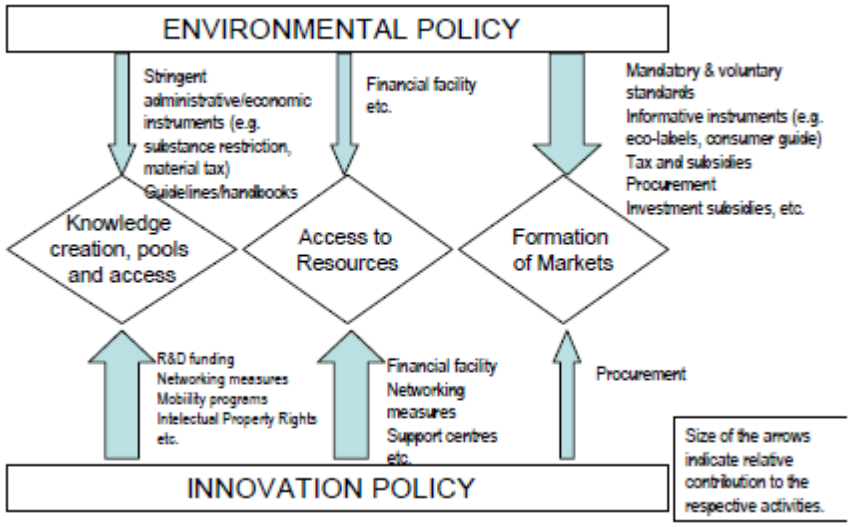
Environmental policy would over the years contribute to an economy which is less harmful to the environment than if no policies directed at the environmental problems had been carried out. Since many of the environmental problems, especially those related to air emissions, are related to production and use of energy, environmental policy would also contribute to a more efficient production and use of energy, including a switch to more environmentally benign energy sources. These policies could not only spur efficiency in existing sectors, but also over time lead to closing down of plant and whole industries that are no longer profitable within the new policy regime. Thus, in the long run one should expect that "dirty" plants and industries are closed down and replaced by "greener" and less polluting and energy intensive industries.

All this creates new and interesting business opportunities for lots of industries. This could be suppliers of new and more efficient equipment and tools in various fields. For instance, industries facing environmental regulations could invent new and more efficient ways of producing their products which is less harmful to the environment, and then create a market through selling this to other plants. But it could also spur technology suppliers to invent new and more efficient production equipment.

Innovations take place in the intersection between many policies and different markets, and are not yet always fully understood. Governments in most Nordic countries have policy instruments to spur innovation, like support for R&D, laws to protect intellectual property rights etc. But also other conditions like capital markets and availability of capital (perhaps especially the efficiency of local venture capital markets), availability of

people with the right education and skills, ease of doing business in general and to form new businesses in particular are among those issues that contribute also to "green" innovations.

Figure 5.4 Linkages between environmental and innovation policy.



Source: TemaNord (2008c)

Figure 5.4 summarizes the dynamics between the environmental and innovation politics when it comes to issues important for green innovation like knowledge creation, access to resources and formation of markets, which are all crucial for the creation of new products and solutions.

Environmental policy and innovation policy have two different goals. While the environmental policy's goal is to spur emission reductions or other actions to improve the environment, the innovation policy's goal is to spur the development of new products or production processes that could either be sold profitably in the market and/or create value added for the country through reduced production costs. As shown in figure 5.4 these policies may interact and influence each other. But ideally the choice of policy instruments under each policy should not take into account the impacts on the other policy areas. The environmental policy should be designed to improve the environment in a cost effective way, regardless of what options there are to develop new abatement solution in the domestic industry. The innovation policy should be designed based on the strengths of the domestic industries to create world class products or technologies, regardless of sector, environmental problems or policies. This distinction could be particularly important in small countries, which would likely have to import most products and technologies to solve their environmental problems, and where domestic industries often will have to focus on world market potentials rather than domestic markets.

But these policies will interfere and may create new commercial products or processes that could both contribute to solving environmental problems and create new, profitable markets for producers. Domestic markets could act as a platform for further international expansions for new environmental benign products and processes.

One of the most common descriptions of the way technologies in general are developed and diffused in society is in terms of 'technology-push/market-pull' (OECD, 2009b). This suggests that technologies are developed through basic and applied research and development (R&D), to demonstration and commercialization and thereby diffused into the society. The first, pre-market phases of the process are often described as 'technology push', because the principal drivers are the business and policy decisions, including government investment in R&D and the activities and interests of scientists and engineers, that cause the technology to be developed.

The commercialization and diffusion processes (often called the innovation phase) are according to OECD (2009b) much more driven by demand in the markets from consumers and industries which have been targeted or into which the technologies will by then have penetrated to some extent. Clearly, both sets of drivers are present to some extent in all phases: even at the earliest phases of technology R&D potential market demand is a major interest, and even during diffusion research-driven technological change may occur. For the process to take place successfully, continuous learning from and feedback between these processes are required.

Innovations in the environmental field have been studied extensively in the literature. By and large, the literature has demonstrated the usefulness of environmental policy towards innovation in specific cases in terms of its ability to contribute to the formation of markets through the provision of incentives (such as procurement) or imperatives (such as emission limits) for action (TemaNord, 2008c). Through the formation or modification of markets environmental policy instruments can create a demand pull in the innovation process, providing incentives for investment in knowledge and attracting new resources to the industry. Furthermore, in cases of stringent regulation, such as bans on hazardous substances, command and control instruments have been shown to contribute to knowledge formation and innovation during the search for new and alternative solutions. But according to TemaNord (2008c) regulations have also been found to inhibit investment and slow down productivity growth. Thus, its effects on innovation have been context specific.

In the aftermath of the financial crisis there has been a lot of focus on how to promote green growth. OECD (2010c) points to that:

"Green growth strategies will require a mix of policy instruments, including market-based approaches, regulations and standards, measures to provide incentives for R&D, and information-based instruments to facilitate consumer choices. Correctly pricing pollution or the exploitation of a scarce resource through taxes, natural resource charges or tradable permit systems should be a central element of the policy mix, most notably to provide a clear market signal. However, market-based instruments alone will not be enough to bring about a shift to greener consumption and production patterns. Regulations will be needed in cases where market failures result in weak responses to price signals or when a complete ban on certain activities is necessary, for example in the production and use of toxic chemicals. Other approaches, such as voluntary instruments and information-based measures such as energy efficiency ratings and well-designed eco-labelling can play an important supporting role in raising consumer and producer awareness on the environmental impact of specific activities as well as on the availability of clean alternatives".

From the discussion above it can be concluded that all environmental policy instruments would contribute to a greener economy. However, we would like to add that since economic instruments like taxes and emissions trading (as long as the allowance price is positive) continuously spur polluters to reduce their emissions, they would often provide stronger, long term incentives to knowledge formation, innovation and technology development than command and control instruments, since the latter give no incentives to reduce emissions beyond the required limits without frequent changes in the emission limits. This also seems to be broadly in line with theoretical and empirical findings referred to in OECD (2009b).

Countries should primarily choose the environmental policy instrument that could most cost-effectively limit the respective environmental problem. To what extent the chosen instrument would spur technological change is another matter that should not interfere with the choice of the optimal environmental policy instrument.

5.2.2 Nordic leadership in green technologies

Nordic countries have strong positions in a broad range of socalled "eco-industries" Eco-industries have been defined as "activities which produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. That includes technologies, products and services that reduce environmental risk and minimize pollution and resources." (TemaNord, 2010a). Denmark has the largest eco-industry in terms of share of GDP, while in Finland this cluster expanded by 54 percent in the period 1999–2004. In 2004, the main Nordic eco-industry export fields were equipment for air and water pollution control, and other environmental equipment.

According to TemaNord (2010a) there are both favourable and less favourable aspects when it comes to future prospects and innovative strength of the Nordic countries. Overall, Nordic countries often rate quite high in terms of input (expenditures, human resources, ICT infrastructure) for R&D and innovation, but show mixed and partly even rather modest ratings when it comes to result and commercialization oriented indicators (coherent and strategic accumulation of knowledge, entrepreneurship and expansion, venture capital etc.).

For many of the mentioned application areas Nordic countries have to compete with industries from other countries, which mean that a continued strong R&D effort will be necessary to keep up with competitors. Furthermore, for many industries successful export of innovations will only abound after some stage of "proven technology" has been achieved domestically (TemaNord, 2010a).

Below we present some examples of "green" innovations in the Nordic countries. A broad specter of innovations and changes are shown, to illustrate the broad set of changes that environmental and/or innovation policies can lead to. We have not assessed the cost effectiveness or environmental effectiveness of these innovations and transformations.

5.3 *Cases: green innovations and transformations*

5.3.1 Energy transformation and development in Denmark through a policy mix

Today Denmark has one of the most energy efficient and emission efficient economies in the OECD area. The Danish economy has grown by some 78 percent since 1980, and during this period total energy consumption has been rather constant (Energistyrelsen, 2010). When the first oil price hike stroke in 1973, more than 90 percent of total energy supply was imported oil. Thus, energy security and costs spurred a transformation of Danish energy use. The policies leading to a transformation of the energy production in Denmark applied typical command and control mechanisms, spatial planning, subsidies and controlled markets.

Developing renewable energy sources and energy efficiency were prioritized. Combined electricity and heat production capacity was built, and district heating networks were built and expanded. In 2007 61 percent of all Danish dwellings were supplied by district heating. The development of district heating networks has enabled the use of excess heat from power plants. But also several decentralized combined power-heat plants and smaller industrial combined units have been built during the 1990s. The share of district heating produced in combined power-heat units increased from 30 percent in 1980 to 80 percent today. The share of electricity produced in such units has increased from 18 percent to 53 percent. This development is one of the main causes behind the decoupling of GDP growth and energy use.

The production of heat and power has to an increasing degree been based on renewable fuels like wood, straw and waste. The share of renewable energy of total energy end-use has been increasing, and today accounts for 19 percent. Renewable sources accounts for some 29 percent of the electricity production, which mostly consists of wind power. A domestic natural gas pipeline system was also built, based on domestic gas production.

The energy efficiency in buildings is considerably improved through stricter energy standards for buildings. A dwelling built in 2008 uses half the amount of energy per square meter as a dwelling built before 1977. All private dwellings put up for sale need an energy certificate showing the energy performance and recommended actions for improvements. New electric appliances are subject to energy-labelling. Public campaigns for energy efficiency in households, agreements on energy efficiency actions are signed between the authorities and industries, and various subsidy schemes for R&D in renewable energy production and for investments in energy efficiency actions have been used. Also, heavy taxes on energy end-use have been applied.

These policy initiatives have also spurred development of new energy technologies that have lead to new industries. The export value of Danish energy technologies was DKK 64 billion in 2008, which is around 11 percent of total Danish export of goods. Denmark has today a leading role in windmill production, and covers 1/3 of the global market. This industry has according to TemaNord (2009d) for decades been supported by subsidies and tax reduction. The industry has gradually reduced construction costs and is now one of the largest industry and export sectors in Denmark with a significant further potential.

Vestas is the largest windmill producer in Denmark. It was founded already in 1898 and until the 1970s it produced steel windows and agricultural equipment

(www.vestas.com). In 1979 Vestas delivered the first wind turbines. The industry experienced a genuine boom at the start of the 1980s, but in 1986 Vestas was forced to suspend payments because the market in the United States was destroyed due to the expiration of a special tax that provided incentives for investment in wind turbines. In 1986 large sections of Vestas were sold off and a new company was founded at the end of the year to concentrate exclusively on wind energy.

From 1987 Vestas has developed from a pioneer in the industry with a staff of around 60 people to become a global hi-tech and market-leading company employing more than 20,000 people worldwide. The company has delivered more than 41,000 turbines in sixty five countries across five continents. Vestas' R&D centre is today the largest in the world, doing real-time monitoring more than 16 thousand turbines to optimize operation. Vestas' wind turbines generate more than 60 million MWh of energy per year, or enough electricity to supply millions of households. Sales in 2010 were some EUR 6,0n00 millions.

5.3.2 Energy efficient mobile phone chargers not spurred by environmental policy

This case is an example showing innovation beyond environmental policies and initiatives and the selling point of the product is not the environmental performance. It is technologically feasible to get a factor 10–15 improvement in mobile phone chargers with limited extra cost. This can achieve huge energy savings globally if all mobile users would switch to this technology. In 1988 the Finnish company Salcomp launched the first mass produced socalled switch-mode chargers for mobile phones. This charger reduced the power use significantly when charging and on stand-by mode. There is to some extent a trade-off between these, and Salcomp has optimized the energy use in stand-by mode. The first mover advantage was beneficial and still today Salcomp is a market leader. Today, both industry and academia in the Nordic countries have excellent competencies within low power switch mode suppliers. Thus, the knowledge to develop mass produced and cheap chargers with much lower energy consumption is present in the Nordic industry. The description below is mainly based on TemaNord (2008d).

Salcomp's production plants are located in Shenzhen in China, in Manaus in Brazil and in Chennai in India. In addition to these locations, Salcomp has operations in Salo in Finland, in Leesburg and Chicago in the USA, in São Paolo in Brazil and in Taipei in Taiwan, as well as in Tokyo in Japan (www.salcomp.com). The operations have gradually been moved from Finland to become global.

The case shows that the main brand holders of mobile phones industry spends limited resources and attention on chargers in general. The brand holder must invest in the better performing charger, while the user benefits from the lower energy costs. However, because the savings realized by the consumer are insignificant, there is not necessarily an incentive for the consumer to want this charger or to pay extra for it. Therefore, this is not an option for differentiation to the brand holders either. Funds for research and knowledge generation on energy efficient chargers have not been sufficient for these chargers to be introduced on mass markets.

The main driver for the technological change has not been environmental or energy reasons, but rather technical and commercial arguments. The primary reasons for choosing switch-mode chargers instead of the more commonly used linear chargers are

the smaller size, the flexible input, and the lower weight, which allows more powerful chargers and still keeping the weight and size down. This provides shorter charge time compared to linear chargers, and the stand-by consumption is lower.

These priorities, except the price, have evolved as the market has become more globalised, phones have become more energy demanding and expectations of consumers in respect to charge times and flexibility has increased. This has lead to a change in technology, but due to the price the linear chargers has until a few years ago been market dominating, while switch-mode chargers were an option for upgrade or came with the high-end phones.

EU has established a Code of Conduct (CoC) on energy consumption of external power suppliers (including chargers) and the US has established Energy Star, and both are requiring chargers to have standby consumption less than 0,3W. Most actors in the industry have adopted either the EU CoC or Energy Star, and an average charger use around 0,2W in standby. However, this is much higher than the energy use of the switch-mode chargers.

As part of EU's Integrated Product Policy (IPP) strategy, some stakeholder initiatives in different product sectors have been initiated – called IPP pilots. One of these was on mobile phones with Nokia appointed to lead a consortium with other brand holders and component suppliers within chips and LCD, as well as network operators, recyclers, government agencies as well as NGO's. The objectives were to identify environmental areas of concern from a lifecycle perspective and find solutions to minimise those. In general, the IPP pilot project focused on voluntary actions and it has not promoted significant technological innovations.

The IPP pilot project can be seen as a governance initiative with all the actors around the same table, and as a way to create a mutual understanding of environmental problems and improvement potentials both in a short and long perspective. On the other side, NGOs and governmental agencies might come to justify an agenda of the industry, in case there is not consensus on ambitious objectives and if they do not have the knowledge about technological potentials in order to ask for more ambitious improvements. The increase of environmental regulations on the sector has been relatively recent, and some EU directives are still in the process of being implemented.

Furthermore, in the mobile phone sector the awareness of environmental impacts and the demand for environmental products from consumers have not been an issue. Therefore, the brand holders do not believe that environmental concerns will be a parameter consumers do consider important when buying a new phone. Experiences from other product groups reveals that consumers mainly act on environmental labels if they are connected to either their own safety or economic gains, such as energy savings. But the potential energy savings are minor from a private economic perspective. Therefore, the use of environmental labeling has not been an issue. Brand holders seem to be reluctant to use labeling even if a standard existed also because of relative high costs for verification and very short time from designing a new model till market introduction.

5.3.3 Energy and environmental innovations in Nordic building sector through various regulations

The Nordic building and property sector accounts for 40-50 percent of total energy use (TemaNord, 2006e). The Nordic countries have insulations standards for new buildings, and some also for specific energy use in the building codes.

In the building sector, lack of customer demand for better buildings has been cited as a market barrier and partly attributed to lack of knowledge regarding the options for and the impacts of various solutions on energy operating costs (TemaNord, 2008c). Similarly, in the building industry, public perceptions of environmental issues or energy consumption are low. While energy performance stipulations concerning buildings are present, for example, in the building code, the sector has only as of late begun to be subject to explicit environmental regulation considerations on a larger scale. In addition to lack of knowledge, segmentation of actors has explicitly been cited as a barrier to commercialization in the building industry.

Technologies such as solar energy, heat-recycling systems, new insulation technologies and environmentally friendly building materials have been developed and applied in Nordic buildings in recent years. Furthermore, technologies for making older buildings more energy-efficient are available (TemaNord, 2006e). Some examples of new, innovative appliances to reduce energy consumption are presented below, based on TemaNord (2006e) and TemaNord (2008c).

Eco-labelling of houses

One way to develop environmentally and energy friendly housing is by labelling houses that fulfill certain standards. The Nordic eco-label "the Swan" in 2008 adopted the first version of criteria for Swan-labelled houses (TemaNord, 2006e). The criteria allow eco-labelling of small standard houses, for instance single-family houses and terraced houses. The Swan eco-label lays down strict requirements for heat loss and consumption of energy during the lifetime of the house. To meet the heat loss requirements the house must be well insulated, and thermal bridges must be minimized. Moreover, to meet the criteria, the house must have an energy saving system, such as heat recycling and/or use energy from solar cells or panels. The Swan criteria applied to houses also mean that a large number of known environmentally hazardous and harmful substances are not allowed in building products for these houses.

Consumers are not always willing to pay much upfront for reduced energy use even if this could be very profitable. One reason can be lack of information of the potential benefits. Swan-labelling may increase information and will spur more energy efficient buildings.

Environmentally friendly housing for everybody

In Denmark, the Municipality of Køge and The Centre for Sustainable Environment "The Green House" of the city of Køge have initiated a project known as "The single-family house of the future", which aims at making low-energy housing available to all. A total of 55 completed single-family houses, 5 two family houses, and 24 terraced houses, all different and built by different building companies, have been built and exhibited. In the future, the houses will be part of the construction companies' catalogue, and will offer a

unique opportunity for launching the Swan label for houses. All the houses must meet the requirements of the Swan eco-label by using less than 75 percent of the energy allowed for new houses built in Denmark today (TemaNord, 2006e). This is an example of spatial planning and public led construction.

Solar energy used for heating in houses

The Norwegian company Catch Solar Energy AS (previously SOLARNOR A/S) has in collaboration with General Electric Plastics developed a flexible technology of heat-producing solar collectors crafted in plastic materials, which can provide up to half of the energy consumed in an average house. The collector is a standard building element that can replace other types of roof or facade coverings. Thanks to their great flexibility, the solar collectors can be used on different scales, from single and multi-family homes, to institutions, hotels, swimming pools and sports centres.

The solar heating system can supply free solar energy for up to half of the annual energy need of an average house. In properly designed solar heating systems each square meter of collector area delivers between 250-700 kWh per year, depending on the solar fraction. In Norway combined systems are optimally designed with a solar fraction of 30-50 percent. Further south in Europe the solar fraction will be higher for a similar system. The collector is the world's first high-temperature polymer collector which heats pure water that flows through a collector manifold into a heat store. The company has completed several projects in the Nordic and other European countries, and the commercial potential of the heating systems is significant. This is an example of private innovation beyond current legislation.

New and older sustainable housing

In the southern part of Sweden 35 apartments were constructed during 2003-2004 by the municipal housing company, AB Landskronahem. Thanks to insulation thickness and triple glazed windows the energy savings are 30-50 percent. The apartments have no conventional heating, i.e. radiators or under-floor heating. The apartments are built with high quality air tightness and moisture prevention. There are other examples of similar technical solutions in Gothenburg, Lund, Malmö and Stockholm.

A number of existing apartment buildings in Sweden have been renovated and turned into sustainable housing. In western Sweden ten multifamily houses from the 1970s comprising 255 flats have been made into low-energy flats in the project "Solar Buildings". After the renovation, consumption of district heating has been reduced by 40 percent and electricity consumption has decreased by approximately 30 percent.

All façades and roofs have been insulated, and windows have been replaced by a low energy type. A system for individual measurement of electricity, heat, hot and cold water for each flat provide greater energy awareness and results in lower consumption. Furthermore, solar technology has been used both to heat water for the flats and for "air based solar heating. This is an example of criteria setting beyond current legislation.

Full scale sustainable housing

In Finland, 1800 residents live in socalled "ecologically sustainable houses" as part of the Viikki environmental housing project, established as a full scale test of energy

efficient solutions. The project, which consists of a mix of housing types, was built between 1999 and 2004 outside Helsinki.

The city of Helsinki set 17 exceptionally strict criteria related to five main issues: emissions, the use of natural resources, health factors, biodiversity, and food production. All the approved construction projects surpassed the minimum environmental standards set for Eco-Viikki, which were much stricter than those usually applied to new buildings.

Many other environmental projects are being run at Eco-Viikki, including schemes using solar energy to provide heat and electricity for homes and electricity collected by solar energy panels. Furthermore, flexible timber construction techniques have been applied at Eco-Viikki, and the residents benefit from a low energy housing design.

The Valkoapila housing scheme, part of Eco-Viikki, employs the entire range of energy efficient solutions and has succeeded in reducing the consumption of purchased energy by 50 percent. The housing is equipped with a mechanical supply/extract ventilation system with heat recovery and solar energy used for under floor heating in bathrooms and lavatories and for producing hot water. This is an example of criteria setting beyond current legislation.

5.3.4 Environmental improvements in pulp and paper industry through regulations and customer pressure

Finland, Norway and Sweden have pulp and paper industries that over the years have caused considerable local environmental problems through emissions to air and water. The sector is also extensive user of energy and timber (TemaNord, 2006e). These emissions were regulated already from the 1970s, and through the 1980s and 1990s new and stricter direct regulations were imposed on the plants. The industries also went through a considerable restructuring in most countries, since small units were closed down and larger units built.

Technological innovation and development has led to increased production capacity and simultaneously reduced the pollutant load significantly. During the past two decades several important technological innovations have been introduced, e.g. chlorine-free bleaching and biological wastewater treatment. Significant advances have been made to improve the resource efficiency and water consumption of the production processes, the latter developing towards closed water systems within a plant. Take the Finnish pulp and paper industry as an example, the per unit water consumption of pulp production has been reduced from 600 m3 per ton, in the 1950s, to close to 10 m3 per ton in the early 2000s (TemaNord, 2006e).

In 2002, over 40 percent of the electricity consumption of the Finnish forest industry was obtained from its own electricity production and 75 percent of the energy used by the forest industry is bio-energy. For heat energy, the industry is completely self-sufficient.

Innovation has been driven by various forces (TemaNord, 2008c). An important driver has of course been the relatively heavy regulations on water discharges, air emissions and recycling that have also provided a potential market for the improved technology. Plants have been able to increase the capacity of the pulp mills at a relatively low

investment cost, and have been further advanced by increasing oil prices and the EU biofuels directive (due to the biomass gasification potential).

The pulp and paper industry has frequently found itself in the public eye with regards to environmental issues, due in part to the (past) significant local impacts of its production activities. Also, customer awareness has played an important role. In many cases it has been the customer awareness and demand that has facilitated the development and diffusion of new process innovations. An important example is the development of non-chlorine pulp bleaching, which was largely drive by customers and public awareness in general (Hildén et al., 2002).

Outside pressure have been important in this sector, since the general level of awareness of production and product impacts has been low (TemaNord, 2008c). Requirements from customers to only use certified timber as input in the production has also resulted in more sustainable forestry.

In some cases in the pulp and paper industry, commercialization of the technologies has proceeded in the absence of direct environmental regulation intervention. In one case from the pulp and paper sector, market drivers have included needs to improve mill efficiency, energy savings, and the desire to produce a new product (TemaNord, 2008c).

In recent years EU regulation on the use of biofuels in transportation has provided new incentives for developing new production processes and products (socalled 2. generation biofuels from timber products), increasing investor interest in developing the bio-refinery technology. Furthermore, renewable fuel tax signals have provided an additional economic driver (TemaNord, 2008c).

At the initiative of the Finnish and Swedish forest industries, a Forest-based Sector Technology Platform (FTP) has been established at European level (TemaNord, 2008c). Its main aims are to meet the multifunctional demands on forest resources and their sustainable management, to promote sustainability and to carry out more efficient R&D. FTP aims to boost European competitiveness by efficient stakeholder co-operation. Among the strategic objectives of the FTP are:

- Meeting the multifunctional demands on forest resources and their sustainable management.
- Enhancing availability and use of forest biomass for products and energy.
- Development of intelligent and efficient manufacturing processes, including reduced energy consumption.
- Development of innovative products for changing markets and customer needs.

The FTP is an industry-driven process, embedded in industry reality, and supporting the sector's strategy. It is organized as a high level group, an advisory committee, a scientific council and management persons. The FTP also has established national support groups in a range of European countries.

5.3.5 Energy management on marine vessels spurred by fuel saving

The Icelandic company Marorka has developed an innovative system of energy management (Maren) which helps to minimize fuel consumption and harmful emissions on marine vessels (TemaNord, 2006e). The underlying technologies included in Maren have been used in both fishing vessels and the commercial fleet, e.g. container vessels (TemaNord, 2006e).

Maren is an energy management system designed to maximize energy efficiency and thereby reduce operating costs through significant fuel savings. The Maren system is built on knowledge and experience gained from advanced research projects carried out during the last 10 years.

The Maren process on board a vessel starts with comprehensive planning by the management teams. Once the planning phase is complete, the energy systems are monitored and measurements and data are fed to a mathematical computer model that optimises the operational parameters.

Maren works continuously, maintaining peak efficiency by monitoring, optimising, analyzing, making recommendations or taking actions during operation when applicable. In other words, a detailed analysis of system performance is carried out to determine the appropriate course of action, which can be implemented automatically or reported to the ships officers.

Fuel savings up to 12 percent have been reported by Marorka customers. Through this reductions in CO_2 and harmful emissions have been achieved.

5.3.6 CO_2 emission reductions in upstream petroleum production through CO_2 taxation

In Norway, upstream petroleum operations have since 1991 been subject to a rather high CO_2 tax. In addition to the tax, the sector has been subject to a portfolio of other measures comprising publicly-funded R&D support schemes, gas flaring permits etc. (TemaNord, 2010a). From 2008 CO_2 emissions from the sector were included in EU ETS, and the installations have to buy all their allowances. At the same time the CO_2 tax was approximately halved to keep the CO_2 price at about the same level as before.

The impacts of the tax was evaluated twice during the 1990s, see ECON (1994;1997b). Through interviews with the industry it revealed that several investments and operational improvements were implemented to reduce emissions. Emphasis has been put on reducing the gas flaring and use of natural gas for electricity production on the platforms. These emissions accounted for some 95 percent of the taxed emissions. It is concluded that the identified actions led to en emission reduction of some 8 percent in 1996 compared to what they would have been without the tax. The tax contributed to some 3 percentage points of these, implying that most of these actions were profitable also without the tax. The interviews revealed that the CO_2 tax led to increased awareness about the emissions, and therefore the tax was important also to the implementation of the already profitable actions.

However, perhaps most important has been the long term impacts of the tax. It has led to planning and design of new installations where emissions per produced unit are

reduced, and technology reducing gas use through heat recovery and combined cycle power production is now standard on new platforms. According to ECON (1997b) CO_2 emissions per produced unit fell by some 30 percent between 1991 and 1996. Christiansen & Skjærseth (2005) found that the specific emissions fell by some 22 percent between 1990 and 2001, see below.

The CO_2 tax was an important factor behind the decision to separate the CO_2 offshore at the Sleipner field and store it in geological formations some 800 m under the sea bottom under the platform. This has led to an annual storage of around 1 million tons CO_2 since 1996. It is assumed that this is a safe storage that could keep the CO_2 forever.

Christiansen and Skjærseth (2005) undertake a comparative analysis of the impacts of climate change policies on the upstream petroleum sectors in Norway and the Netherlands during the 1990s. In the Netherlands, the control of CO_2 emissions from the petroleum sector was addressed through a series of voluntary agreements between the sector and the government. In 1995, the oil and gas industry signed a Declaration of Intent which included quantified targets for improvements in energy efficiency by 20 percent over the period 1989-2000 and reductions in CO_2 emissions by 2000 without any targets. In 2001, a new agreement was signed which committed firms to implementing energy efficiency measures with a positive net present value (NPV) at a 15 percent discount rate or a five year payback period.

Energy efficiency improved by around 35 percent in the Netherlands' petroleum sector between 1990 and 2001, compared to 22 percent improvement in Norway. However, there were marked differences between the two countries in terms of the nature of the innovation that occurred. In the Netherlands, technological change was incremental, reflecting a steady diffusion of available (i.e. known) technology.

In contrast, Christiansen and Skjærseth (2005) find evidence of more radical innovations and adaptations by the Norwegian petroleum sector, including the development of energy-efficient gas turbines, installation of waste heat recovery units, process modifications and improved utilization of process heat. They conclude that the CO_2 tax played a key role in the development and implementation of these radical innovations.

However, Christiansen and Skjærseth (2005) also conclude that the impacts of the two instruments tax and agreements were conditioned by the political contexts in which they were applied and the problem characteristics in the respective countries (e.g. the economic significance of the sector, size of installations, etc.).

It is emphasized that the relationship between policy instruments (of all types) and technological change is extremely complicated. The authors argue that account must be taken of the political / industrial context in which policy instruments are introduced, and the nature of the environmental problem that they are intended to address. In particular, they make a distinction between "malign problems" where technological change involves net costs for target groups, and "benign problems" where there are widespread "no-regret" opportunities for change.

Based on a comparative analysis of four different case studies, they conclude that mandatory policy instruments (including environmental taxes) are more effective in

promoting short-term technological change when the problems are malign, but that low legitimacy (with the target group) may undermine long-term technological change. However, when problems are benign, or when long-term change requires cooperation, voluntary policy instruments are likely to be more effective.

5.3.7 Reduced phosphorous emissions from agriculture spurred by taxation

The Danish company Novozymes has developed an enzyme that can significantly reduce the amount of phosphorus excreted by livestock (TemaNord, 2006e). This enzyme (Phytase) improves livestock uptake of phosphorus. Phosphorus is an essential nutrient for building strong bones. Plants store a major part of the naturally occurring phosphorus in cereals and seeds as phytate or phytic acid, which animals such as poultry and pigs cannot break down. They simply lack the enzyme needed to break it down, and the phosphorus passes straight through their digestive system and is excreted.

Studies have shown that by adding Phytase to pig feed, release of phosphorus to the aquatic environment can be reduced by up to 30 percent. Such release is a considerable environmental problem in many countries.

The phosphorus tax introduced in connection with the Danish Action Plan for the Aquatic Environment III supports the use of Phytase. Research is being carried out to develop enzymes that improve the uptake of nitrate by animals as well. The production of these types of enzyme is based on genetically modified microorganisms.

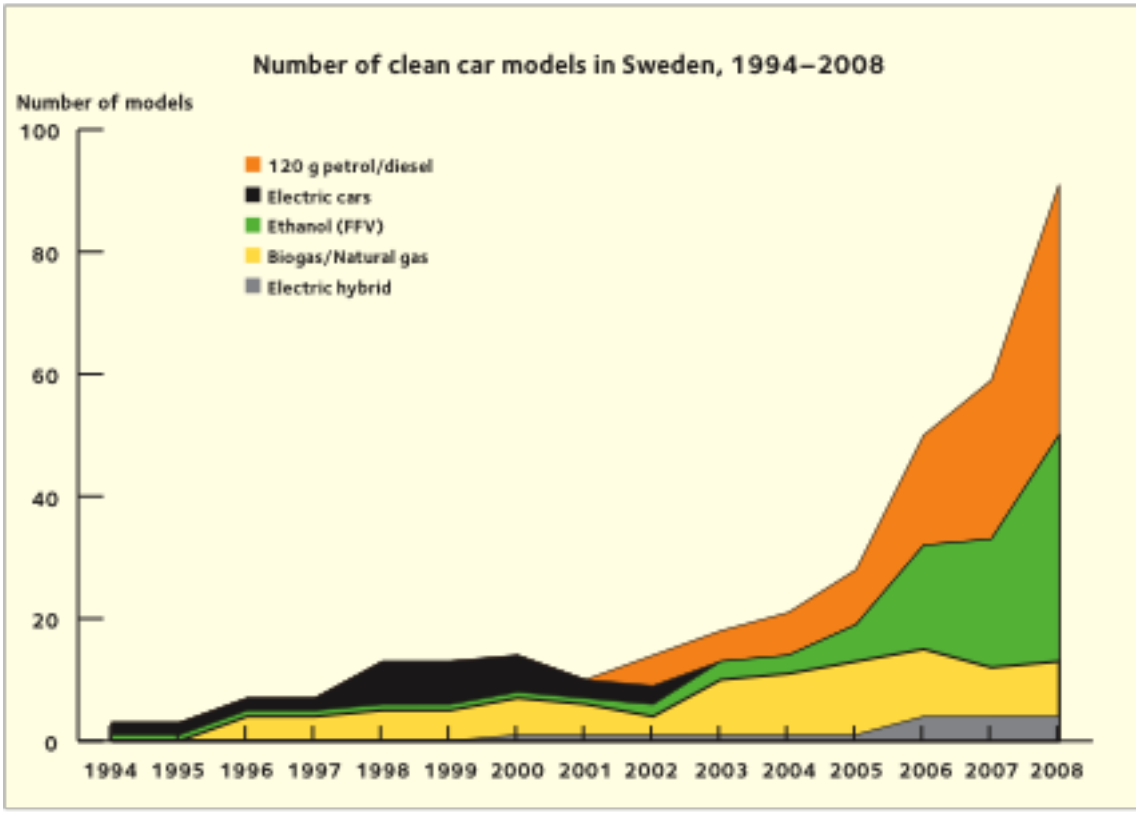
5.3.8 Biofuels in transport promoted through a mix of instruments

Sweden has high ambitions for the introduction of biofuels (i.e. ethanol and biodiesel) in transport. The overall target is that the vehicle fleet shall be independent of fossil fuels in 2030, and that the share of renewable fuels shall be 10 per cent in 2020 (www.regeringen.se).

The use of biofuels for transport in Sweden has increased rapidly in the last couple of years. From 2001 to 2009 the use of ethanol increased with a factor 8, the use of biodiesel (FAME) with a factor of nearly 200 and biogas nearly 6 times. In 2000 biofuels made up 0.4 percent of the total petrol and diesel consumption for transport operations calculated on the basis of energy content. By 2009 these fuels had reached 5.4 percent.

The number of environmentally friendly (clean) cars has also increased rapidly since 2005, see figure 5.5.

Figure 5.5 Development of clean car models in Sweden. Number of models.



Source: BEST (www.best-europe.org)

A policy mix has contributed to this development (www.regeringen.se):

- As from 2006 85 percent of all passenger cars purchased by authorities must be environmentally friendly, and 25 percent of all emergency vehicles.
- Carbon dioxide neutral fuels are exempt from energy and carbon dioxide taxes, making fuels like biogas, ethanol and RME commercially viable.
- Environmental friendly cars are exempted from the annual vehicle tax for the first 5 years. This policy was introduced in 2010 but also covered cars bought/registered in 2009.
- The annual tax consists of two parts, one based on the vehicle weight and one on emissions of carbon dioxide. The lower the emissions of carbon dioxide are the lower is the carbon dioxide fee. In addition cars older than 2009 that run on ethanol (E85) or biogas only pays half the carbon dioxide fee.
- Investment support is given to production of biogas.
- An obligation to provide renewable fuels at petrol stations from 2006 (the so-called pump act). During 2007 to 2009 petrol stations could apply for an investment support for rebuilding the station.

The pump act had a profound effect on the market, signalling to consumers that access to alternative fuel supplies would increase across the country. Between 2005 and 2008, the number of filling stations supplying E85 or biogas/compressed natural gas (CNG) increased from less than 200 to over 1,300. Around one third of all filling stations in Sweden now offer a renewable fuel.

In addition some cities have used measures like free parking and exemption from road or congestion fees. In Stockholm, environmental friendly cars were exempted from the congestion fee until 2010, but due to rapidly increased number of such cars this exemption was abolished (cars registered before 2009 will however keep the exemption until 2012).

Long-established R&D and demonstration efforts are the prerequisites of the successful introduction of biofuels in Swedish transportation. Sweden supports research, development and demonstration activities for developing more energy-efficient and cost-effective processes for the production of biofuels. The Swedish Energy Agency funds R&D measures as part of several different programs for developing production processes for motor fuels, where ethanol, dimethylether (DME), FT diesel, biogas and hydrogen are seen as the most interesting alternatives.

In 2009 a research collaboration between the state and the automobile industry was launched (FFI, Fordonsstrategisk Forskning och Innovation, see www.vinnova.se/ffi), focusing on climate and environment in addition to safety. The first phase of this program runs until 2012, with an annual budget of nearly SEK 1 billion.

A R&D program on the use of black liquor was conducted between 2007 and 2010. In the program several universities, companies and authorities participated. Black liquor is a by-product in the digestive process where cellulose fibres are dissolved from wood chips by an alkaline liquid called white liquor. With modern gasification technology it can be a valuable resource for production of biodiesel (BioDME) especially suitable for heavy vehicles. Volvo has developed engines that can use this fuel. The first test plant had start-up late 2010, and will supply a fleet of Volvo trucks. Commercial production is planned to start in 2014.

5.3.9 Environmentally friendly ship engines spurred by a mix of instruments

Nordic institutions have for many years been at the front in developing more environmental friendly ship engines, based on strong R&D traditions and institutions in this field. Although domestic shipping has wholly or partly been exempted from many of the environmental and energy taxes (international shipping is fully exempted) high oil prices have led to great interest in this field. Furthermore, NOx regulations and taxes have been important, as well as public procurement and other instruments.

Denmark: Developing environmentally friendly marine engines

In Denmark, the company MAN B&W has developed an optimized fuel injection system which reduces NOx emissions by 20 per cent (TemaNord, 2006e). From 2000, all new marine engines manufactured by the company are based on this system. The system can also be mounted in existing marine engines in conjunction with renewal of fuel nozzles, which happens on average every 2½ years. About half of the world's 31,000 vessels of

more than 500 gross register tonnes are operated with marine engines constructed on the basis of a license from MAN B&W.

A new ambitious and expensive solution is to install a system of catalytic purification of exhaust from the vessels. This technology reduces NOx pollution from the vessels by 90 percent. Another MAN B&W project is a full-scale test with a SAM (Saturated Air Moisturing) system, a technique that can lower NOx levels by 40-50 percent.

Finland: innovations reduce NOx emissions

The company Wärtsilä has developed the Enviroengine, which by combining several innovative technologies makes it possible to reduce NOx emissions and obtain smokeless engines, as well as to reduce fuel consumption (TemaNord, 2006e). Wärtsilä has introduced dual fuel engines, which run on liquefied natural gas (LNG) and 1 percent marine diesel oil. This technology reduces NOx emissions by 90 percent and CO_2 emissions by up to 20 percent. Emissions of SO_2 and particles are eliminated. Wärtsilä also has developed a smokeless engine, which thanks to its flexibility in fuel injection, reduces emissions and ensures steady and secure operation of the vessel without smoke.

The use of steam is another way to limit the formation of NOx in the combustion process. In the applications developed by Wärtsilä the steam can be added into the process at several alternative stages. The maximum reduction of NOx emissions is as high as 60 percent, depending on the quantity of steam added to the combustion air. Also, Wärtsilä has succeeded– in cooperation with a range of mainly Nordic partners – in developing a new type of waste heat recovery plant for ships.

Norway: public procurement has led the way

The main road ferry connections in Norway are financed by the Public Road Administration. Through tenders or other contracts, they have a unique opportunity to introduce best practice by demanding the use of fuel from natural gas or use of environmental technology. Using public procurement, it is likely that within the next few years a significant number of Norway's approximately 100 "fjord ferries" will be fuelled by environmentally friendly natural gas or other alternative technology (TemaNord, 2006e).

The ferry, M/F "Glutra", constructed in 2000 and equipped with environmental technology, was the first ferry in the world to run on LNG. Today several ferries with similar technologies are under operation, both as a result of public procurement but also chosen independently by private operators. Also, the Norwegian marine are ordering vessels run on natural gas.

The overall environmental benefits of the gas ferries are substantial:

- Emissions of CO_2 will be reduced by 25 percent.
- Emissions of NOx will be reduced by some 85 percent – corresponding to the effect of 190,000 passenger cars, the equivalent to all the cars of the city of Oslo.

- Emissions of SO_2 will be eliminated.
- There will be no emissions of particles.

The new Norwegian ferries benefit from a range of technology innovations:

- LMG Marin has created an energy saving ship design resulting in reduced power consumption and thus reduced emissions.
- Fjord 1/LMG has developed new loading routines that reduces the need for the top speed operations and thus reduces emissions.
- Rolls Royce "Bergen Gas" main engine and system of propulsion result in substantial emission reductions compared to conventional technologies.

These technologies are ready for the market and, as they can be used in a range of other ship categories, including overseas ferries and freight transportation, they have significant potential.

5.3.10 Cleaning technologies developed in fertilizer production spurred by NOx regulations and GHG emission reduction agreement

The Norwegian company Yara is a leading producer of urea and ammonia for fertilizer production, and has plants all over the world. Based on their product knowledge in urea- and ammonia-handling the company has developed new technologies and services to clean NOx emissions from stationary and mobile sources, as well as technology to reduce emissions of the greenhouse gas N2O (www.yara.com).

NOx cleaning spurred by NOx regulations

Urea and ammonia are used as reagents for stationary and maritime NOx abatement applications. Yara has developed DeNOx technologies called Selective Catalytic Reduction (SCR), which can cut NOx output by up to 95%, and Selective Non-Catalytic Reduction (SNCR) from stationary NOx sources. SCR and SNCR can use either ammonia or urea to turn NOx into harmless nitrogen and water. Yara offers help to design and set up the right system, installation and on-site training, and can eventually also take on the daily running of DeNOx installation.

Yara has developed this further into a consept called NOxCare, which offers a total solution to reduce NOx emissions from maritime sources. NOxCare covers a portfolio of products (reagents), processes and services. It's offered to the international maritime industry through Yarwil, Yara's joint venture with Wilhelmsen Maritime Services. Yarwil offers a complete NOx abatement value chain:

- Engineering assistance in evaluating SCR technology solutions during vessel design/retrofit, based on extensive maritime experience.
- Supply of SCR equipment (reactor complete with all necessary auxiliaries)

- Supply of NOxCare NC solution (Yara's specially developed urea solution for maritime use) during the operation of a vessel to any port worldwide via the Wilhelmsen Ships Service (WSS) network covering 2,200 ports around the globe

- Supply of spares during vessel operation, also via Wilhelmsen Maritime Service's global reach.

Yara is also the world's largest producer of AdBlue® (DEF), the high-purity urea solution for NOx abatement in heavy-duty and off-road vehicles. These would have to comply with NOx emission standards. For this they use a reagent known as AdBlue in Europe or DEF in North America which is a non-toxic aqueous urea solution. It is used jointly with a Selective Catalyst Reduction system.

N2O emission reduction from fertilizer production

Nitric acid is used for making some kinds of fertilizers. Its production releases nitrous oxide N2O, which is a very powerful GHG. Yara has developed a unique catalyst technology that breaks down N2O in the burner of a nitric acid plant and reduces emissions of N2O by 70–90 percent, which is below EU BAT level.

Yara have successfully installed this technology in many of its nitric acid plants. Further implementation of the catalyst is planned where feasible, and Yara has made the technology commercially available. However, there are currently few or no regulations of N2O emissions around the world, not even in the Nordic countries.

The Norwegian government and the process industries' association in 2004 signed an understanding on GHG emission reductions, mostly from those plants not covered with any other policy instrument. According to Report no. 34 (2006-2007) to the Storting: Norwegian climate policy, this has spurred the emission reduction of N2O at Yara's Norwegian plants. Norway plans to include N2O emissions from fertilizer production in EU ETS from 2013.

6. Lessons and recommendations

In this chapter we summarize the lessons from the more than 30 years of environmental policies in the Nordic countries, focusing on lessons from the use of economic instruments. On the basis of these lessons some recommendations for policy makers in various countries are presented. The chapter is structured as follows: we start with some general lessons and recommendations, and then present some recommendations for industrial countries and emerging economies, and finally we provide recommendations more relevant for developing countries.

6.1 *Some general lessons and recommendations*

6.1.1 Use of economic instruments and high economic growth go hand in hand

The Nordic countries have since mid 1980s achieved substantial emissions reductions to air and water and improved local and regional environmental quality. During the same period they have experienced an economic growth at the average OECD level or above. Growth in emissions to air has been decoupled from the economic growth during this period.

After starting out with mainly command and control instruments in the 1970s taxes on products causing emissions and to some extent also taxes directly on emissions have become important policy instruments to curb emissions to air since mid 1980s. Since the early 1990s, CO_2 taxes were imposed in all Nordic countries, and CO_2 emissions trading, notably through EU ETS, have played an increasingly important role since the mid 2000s. SO_2 and NOx taxes have been imposed in many countries together with direct regulations, and taxes on several other pollutants and products are in place. Command and control policy instruments still play an important role together with economic instruments and new approaches like agreements, information and eco-labelling and public procurement.

Economic instruments, if properly designed and administered, generally lead to more cost effective emissions reductions than command and control instruments. Furthermore, together with the use of economic instruments economic growth has been at least on par with other industrial countries.

6.1.2 Economic instruments could enhance and promote a greener growth

Environmental policy instruments are meant to contribute to reduced emissions and development of more environmentally benign products and technologies. In this report we show several examples where new technologies and products have been spurred by various environmental policy instruments. Economic instruments, if properly set up and administered, give polluters continuous incentives to reduce emissions in the cheapest ways. This promotes an overall efficient resource use and could contribute to increase *long term* economic growth compared with the use of command and control instruments. Economic instruments provide incentives to reduce emissions over time, and to look for more efficient ways of curbing emissions through developing new technologies. This would spur green technology development, and lead to growth among existing technology providers and creation of new technology suppliers.

Command and control policy instruments will only spur polluters to reduce emissions up to the required level if regulations are not strengthened over time. It is therefore

likely that use of economic instruments will result in lower long term emissions and a larger growth in green technology development than if command and control instruments are used, thus contributing to a greener growth. Through their open, flexible economies promoting innovation and structural industrial changes the Nordic countries have shown that high, green growth is possible also with extensive use of economic instruments.

6.1.3 Pricing pollution should be a key policy element which could yield broader gains

Putting a price on a pollution source or on the over-exploitation of resources through mechanisms like taxes, natural resource charges or tradable allowance systems should be the key element and the first best policy choice in a green growth strategy. This ensures a cost effective emission reduction and compensation for the remaining emissions (the polluter pays principle). Revenues from the use of these instruments can be used to offset more distortive forms of taxation, for instance on labour, to generate broader welfare gains. Given the urgent need to reduce government deficits following the current economic crisis, revenues could also be used for fiscal consolidation. In emerging economies, such revenues could finance other pressing priorities, such as education, health care, climate change adaptation or mitigation and poverty alleviation.

6.1.4 Show the benefits from using economic instruments

There is often considerable resistance against economic instruments. To overcome this it is important that stakeholders are informed about the benefits of reducing pollution in general, and the added benefits in using economic instruments in particular.

An example of such resistance is the opposition against congestion charges during rush hours in cities. It is often claimed that families have few alternatives to car use during rush hours to be able to deliver children in schools and day care and get to work in time. Thus, they will have to pay the charge, since there are no substitution possibilities. But they will also benefit most from the charge as congestion is reduced. Furthermore, resistance might also be reduced if the charge revenue is used for financing improved public transport. It is important to clarify the potential benefits from the charges to reduce the resistance against it, and facilitate the implementation.

6.1.5 Carefully consider the need for supplementary policy instruments

A great advantage of economic instruments over command and control approaches is that when the instrument is targeted as close as possible to the emissions or activities causing the environmental problem, polluters are faced with the true cost of their pollution. It could be left to them to decide whether or to what extent it is profitable to reduce their emissions. Those facing abatement costs lower than the price will reduce their emissions until the unit costs equals the price, and those with higher costs will not take any abatement actions. Thus, no other policy instruments are in general needed. If the authorities decide that further emissions reductions are needed, it is just a matter of increasing the tax.

Additional requirements, for instance by requiring that some special abatement technology should be used, that a particular share of the energy use should be renewable, or that a special kind of waste treatment should be implemented will only add to abatement costs, as it does not secure that these lead to cost effective emission

reductions or that the specifications represent the most efficient abatement solutions. Several examples of inefficient policies are presented in this report, where multiple instruments are used towards the same pollution source. Thus, it should be very carefully considered which additional policy instruments are eventually needed. This is especially important when the policy has developed gradually over time, and new instruments have been added on top of existing ones, as in the climate change policy.

6.1.6 Some supplementary instruments could be needed

However, there are also some examples where not all emission sources could be covered by an economic instrument, or that the instrument could not provide the right incentives for all actions. Then a different set of instruments may be justified. A similar situation might occur when economic instruments could be a supplement to existing regulations instead of replacing them, and strengthening the use of other instruments.

When information about environmental costs and possible benefits from e.g. energy saving is missing, approaches like voluntary and information-based instruments such as energy efficiency ratings and eco-labelling can prove important to transfer the relevant information. For example, eco-labels can be effective in strengthening the responsiveness of agents to price signals by raising consumer and producer awareness on the environmental damage caused by specific activities as well as on the availability of cleaner alternatives. Voluntary approaches can also help to reveal information about abatement costs and environmental damages.

6.1.7 The need for subsidies should be critically assessed

Subsidies are mainly used to promote energy efficiency measures and research and development (R&D) in renewable energy, and to some extent also for investments in renewable energy production capacity. Generally, subsidies should be limited to correct for so-called positive externalities. Typical examples of goods with positive external effects are R&D. Subsidies should be used to create incentives to generate an optimal level of externality. Positive externalities are normally present at the R&D phase. This applies to research on new technologies through learning-by-doing (see, for instance, Joskow and Rose, 1985). Other examples are network externalities. For example, electric cars are less attractive unless many utilize the technology to bring along enough charging stations for long distance transport. Subsidies can bring demand beyond a tipping point where it becomes profitable to establish charging stations at less central locations. Hence, subsidies should generally be used to R&D and eventually the pilot and demonstration phase

Importantly, the introduction of new technologies and “picking winners” should be left to the market. In practice introduction of new, renewable technologies are subsidized. This creates efficiency losses. Subsidies contribute to reduced energy prices by lowering production costs of some technologies, and thus spur increased energy demand and reduce the incentives to energy efficiency. Then innovation in non-subsidized technologies will be reduced due to lower market prices. Subsidies also potentially imply large budgetary costs and could have distortive effects on competition and trade. Hence, subsidies should only be used to correct for positive externalities. Technology procurement might offer some new ways of spurring technology development and market introduction in some fields that should be looked into. OECD recommends that

when subsidies are used, they should be time-bound and closely monitored (OECD, 2010c).

Particularly, so-called environmentally harmful subsidies should be avoided. Worldwide fossil fuel subsidies amounted to well above $400 billion in 2009 (IEA et al. 2010), or 0.7 per cent of world GDP. The support of fossil fuel consumption is most common in developing countries. In developed countries, one should be aware of new, emerging energy subsidies with other environmentally harmful effects, such as subsidies to wind-power and biofuels. The problem of environmentally harmful subsidies is hence two-fold; first to reduce the subsidies to negative externalities, second to reduce the exemptions from environmental taxes, which is another form of environmentally harmful subsidies.

6.1.8 Economic instruments useful also when technology development is not an issue

In this report, focus has been put on showing how economic instruments can spur environmental technology development and new abatement solutions. Perhaps pointing to the obvious, we would like to emphasize that economic instruments also are useful when it is clear that they will not necessary lead to innovations of new technologies, but simply accelerate introduction of existing, more environmental friendly technologies and products. Depending on the sector and niche, small and open countries like the Nordic often have a too small share of the foreign market to influence innovation.

In such situations, economic instruments may mainly enhance the introduction of new technologies. An early example is the introduction of unleaded petrol during the 1980s, when a tax differentiation between leaded and unleaded petrol was introduced. At that time, new cars running on unleaded petrol were available internationally, and refineries had started to produce unleaded petrol. The taxation contributed to speed up the introduction and use of unleaded petrol.

A more recent example is the differentiated car purchase taxation, which in most Nordic countries now is differentiated according to CO_2 emissions and/or energy efficiency. These tax regimes give incentives to buy low emission cars, but the impacts from the tax will depend on the availability of such cars in the market. For instance, differentiating the tax system further to spur the purchase of ultra low emission diesel or petrol cars as is discussed in some countries might have little or no impact in the short term since such cars are not available in the market today. Such tax differentiations in small countries should not be expected to have any impact on technology development unless many countries implement similar tax changes.

6.1.9 Consider new ways of redistributing or recycling the revenue

Industry will generally oppose to the introduction of new emissions taxes increasing their costs. This has been experienced recently from the introduction of a NOx tax in Norway, where the opposition resulted in a transfer of the tax revenue into a fund financing abatement actions in the affected companies. Other redistribution mechanisms have been used in the Swedish NOx tax regime.

Finding ways of redistributing the revenue to the taxpayers without seriously destroying the incentives to reduce emissions could increase the acceptance for new

environmental taxes. While recycling tax revenue might not be in compliance with economic theory, it may offer a second best solution securing cost effective emission reductions. If the revenue is used for abatement purposes this might intensify the impacts of a tax, leading to over-abatement compared to a more optimal tax regime. Nevertheless, such schemes might perform better than direct regulations.

6.1.10 Use economic instruments also to provide ecosystem services and halt biodiversity loss

Payment for ecosystem services (PES) can be combined with existing natural resources regulation, and be used to engage private sector to undertake more environmentally friendly actions than the minimum regulation requires. This can be done by offering landholders compensation for preserving various land areas, reducing nutrient leakage to waterways, produce agricultural landscapes with high amenity values and preserving biodiversity in forests.

There is also significant scope for using PES to promote private sector engagement in biodiversity conservation with opportunities for positive financial returns as well as real biodiversity benefits. Potential areas for this include organic farming, aquaculture, conservation credits or offsets of sustainable forestry or carbon sequestration. Another option is the creation of biodiversity "banks" in both terrestrial and marine/aquatic ecosystems to offset degradation due to land development. Compensation to creating, restoring, enhancing or preserving these resources and services could yield large benefits at low costs.

In the Nordic countries, there is scope to improve the current application of PES through for instance introducing competitive bidding to increase cost-effectiveness or basing compensatory payments on the quality of the output of the activities rather than the activities themselves. There is also scope for expanding the use of PES in Nordic countries outside the EU CAP agri-environmental schemes, in terms of using PES as a 'top-up' measure for instance in forestry.

6.2 *Special challenges and recommendations for the Nordic and other industrialized countries*

Below are some special recommendations targeting industrialized countries and emerging economies that have already implemented some energy/environmental taxes, and have developed some tax collection systems.

6.2.1 Global cooperation based on national responsibility crucial to reduce GHG emissions

The most important global remaining environmental challenges are climate change, decreasing biodiversity and spread of toxic, hazardous substances.

In chapter 3 we show that emission growth CO2 are lower than the economic growth in the Nordic countries. However, GHG emissions are still growing in absolute terms in most of the countries. Furthermore, because of high income levels and consumption per capita, open economies and high economic growth, the Nordic countries are causing large emissions increases through their imports, thus causing relatively large global consumption-related emissions or "carbon footprints" (TemaNord, 2010b; Bruvoll,

2006). Thus, continued consumption growth in the Nordic countries should be expected to cause growth in global GHG emissions.

It should be underlined that it is not the economic growth itself that is the problem, but the environmental problems caused by it. For GHG emissions it could be argued that it is the content of the growth that causes emissions, and that changing the growth towards less emission intensive products and services together with new, green production technologies could spur a less emission intensive future growth. Improved resource efficiency and dematerialization could be keywords here.

According to international conventions countries are responsible for the emissions from their own territories. It has been discussed to let countries be responsible for the global emissions their final consumption causes, by correcting the inventories for emissions from export and import, and eventually make some border tax adjustments through taxing imported goods for their implicit emissions. Border taxes are increasingly accepted as means to allow countries to develop responsible environmental policies without having to wait for other countries. However, the first best option is that each country takes responsibility for the emissions from their territories, since these are emissions that they can potentially reduce. Border tax adjustments and similar are very difficult to operate, and there is a possible conflict of trade conflicts. Buts studies on "carbon footprints" could still be useful as background information showing the overall, global picture.

There is no alternative to global cooperation on agreements to reduce the climate change threat. Since most human activities cause some GHG emissions some way or another, using economic instruments should be a crucial part of the approach. Applying taxes or emissions trading would reflect the costs of GHG emissions, and through changing the relative prices of goods and services give producers and consumers information about how their consumption and production cause emissions. Such an approach would ensure cost effective emission reductions through change in consumption patterns, production inputs and energy use, and stimulate development and implementation of new technologies. Other countries could learn from the Nordic experiences and the EU ETS how to implement these instruments to fulfill their emission obligations.

6.2.2 Biodiversity loss should be handled locally

The loss of species is an increasing challenge globally and to an increasing extent also in the Nordic countries. Even though several areas are protected, and the Nordic countries are sparsely populated compared to many other countries, economic growth and related land use change is a growing challenge to avoid biodiversity loss. The increasing use of areas for new houses and in particular leisure houses and cabins in rural areas, building of roads, railways, wind power sites, power transmission lines, more intensive agricultural and forestry practices (for instance for biofuel supply) etc. are all potential threats to biodiversity if actions are not taken.

The best approach to ensure biodiversity protection and preserve endangered species etc. is to impose various forms of regulation, where Environmental Impact Assessments of larger construction plans could play a crucial role. Also, improving the enforcement of present regulations should also be considered. In addition, payment for ecosystem services (PES) could be implemented as indicated above.

6.2.3 Curbing use of hazardous substances needs international cooperation

The release of hazardous substances has local, regional as well as global dimensions. Many of these substances are transported over long distances, and emissions in Asia can reach as far as the Arctic. Nordic areas have become a sink for transboundary emissions for many of these substances. But local emissions also contribute to increased concentrations of many substances.

Consumption growth in the Nordic and other countries contribute to the use of many new products containing hazardous substances, that will be released through use or when the products end up as waste. These products are to a large extent imported, and the production may cause harmful emissions through the production processes.

To reduce the emissions of hazardous substances require international cooperation to switch from use of hazardous substances towards less harmful ones. Both production and use of products containing hazardous substances would have to be targeted, based on international agreements and cooperation like the EU REACH and similar approaches. Ban of products should be used if the (marginal) environmental damage is intolerably high. For hazardous chemicals this could be the case especially if there are some critical threshold levels that should not be exceeded. This implies that command and control regulations or a mix of quantitative regulations and economic incentives could be the best ways to control chemical use. Deposit refund system for used chemicals also represents a mechanism to consider.

6.2.4 Local car traffic needs special attention

The demand for transportation is expected to grow significantly in the years to come. Increased car traffic might cause local pollution problems and congestion in cities. Some technical improvements reducing emissions of PM and NOx could likely be expected, but local air quality may still continue at unacceptable poor levels in periods of time without policy intervention.

Several alternatives to curb pollution exist. One is to increase fuel taxation if the existing tax rates are lower than the marginal costs of local emissions, noise, road wear and tear, accidents etc. However, these marginal external costs vary considerably between cars, over areas and/or the time of the day, implying that the tax rates would only target these at an average level. Congestion charges as imposed in Stockholm offer a better approach when it comes to *congestional* concentrations of emissions, but these also cannot target all these external costs sufficiently. However, congestion charges have shown that it is possible to reduce the high emission levels in many cities, and offer a revenue that could be used for local abatement measures, improvement in public transport or similar.

Parking charges is another option to reduce downtown traffic (ECON, 1999). A fixed, not-time dependent parking charge could be imposed on drivers to reflect the external costs that they have caused on their way to the parking lot, and a time-dependent charge to pay for the use of the parking lot itself. Since this approach only covers those actually parking, and not those driving through city centers, this approach is not optimal either. Incentives for biking through construction of bike lanes and improved public transport are other ways of reducing congestion and local pollution.

In the longer run, satellite and land positioning systems may be able to charge actual car use according to driven distances in various areas and times of the day. This would facilitate optimal taxation. However, there are still challenges to overcome if such systems should be implemented.

6.2.5 Make car taxation and costs more transparent to consumers

In the Nordic countries, heavy emphasis is put on taxing the purchase and ownership of private cars for fiscal reasons. These taxes are differentiated using environmental criteria to also reduce emissions, mainly CO_2. Since these approaches do not target actual emissions, a better approach is fuel taxes. However, fuel taxes in the Nordic and many other countries are high already. To the extent that they do not cover marginal costs of all emissions, they could be increased.

Since income and price elasticities for car purchase are relatively high, the high levels of purchase taxes in Denmark and Norway is not a particularly efficient way of raising tax revenue. Thus NOU (2007) recommends that the general tax level for car purchase and ownership is reduced, while the differentiation according to emissions is kept. For those countries with high purchase and/or annual owner taxes, and in need to raise fuel taxes, this offers an opportunity for a tax change that could be easier approved than an isolated fuel tax raise. Reducing the purchase tax could be justified in itself, but this would likely have negative environmental impacts since people would buy larger, less CO_2-efficient cars. Calculations in COWI (2011) indicate this.

COWI (2011) emphasizes that car taxation (including fuel taxation) is complicated and the overall costs of different car types are not fully transparent to consumers. CO_2 emissions may be reduced further by making existing taxation and green transport issues more transparent to consumers, i.e. by informing about costs per kilometre travelled and total costs per year. According to this report one should also critically review all Nordic company car schemes for passenger cars to reduce or abolish tax incentives to buy larger cars and drive more. The Nordic countries should also cooperate on improved energy labelling of cars, particularly to include the overall annual costs, including fuel costs.

6.2.6 Remove tax exemptions

Tax exemptions for fuels and/or users are rather the rule than the exception in most countries. This is a form of environmental harmful subsidy. All exemptions cause inefficiencies in the tax systems, and increase abatement costs. Thus, they should be removed to reduce overall compliance costs for environmental improvements. Potential unwanted impacts for vulnerable groups and industries could be mitigated by other means, and eventually the revenues could be redistributed. This might harm some energy intensive industries, but it should not reduce overall, long term economic growth.

6.3 *Special challenges and recommendations for emerging economies and/or developing countries*

Below are some recommendations specially targeted towards developing countries and emerging economies. These countries face some special challenges that should be dealt with. Their main concern is eradication of poverty, and this should have first priority. Poverty often leads to degradation of land through deforestation, over-utilization of

other resources etc., implying that reducing poverty should also to some extent improve environmental conditions.

Particular challenges for many developing countries and emerging economies are (1) how to combine and articulate most effectively strategies to combat poverty and strategies to secure critical environmental values and services for present as well as future generations, (2) how to develop and adapt the most modern environmental and resource benign technologies to national and local climatic, economic and ecological conditions, (3) how to give priority to solving local health problems, affecting negatively both living conditions and national economic productivity, from unsafe water supply, indoor and local air pollution and unsafe treatment of hazardous waste and (4) how to ensure the continued functioning and resilience of essential ecosystem services vitally important, directly and indirectly, to local populations, rural and urban, and particularly to the poorest sections of the population.

6.3.1 Assess the costs of environmental degradation in the country

Developing countries and to some extent emerging economies often have poor statistics and lacking or no overview of the environmental and resource situations. The damages are not always known, and the link between emissions and damages may be poorly understood.

A particular concern in many developing countries (and in many developed countries as well) is the over-exploitation of renewable resources like forests, fish, wildlife, grasslands, water etc., which often leads to degradation and decline in the availability, and also cause environmental damages.

Improving statistics is important to get insight into the environmental situation and the damages caused. This could help the authorities to prioritize between areas where actions should be taken to improve the situation. This overview should also make it easier to get acceptance among the public for the necessary actions.

The World Bank has for several years carried out Country Environmental Assessments (CEAs) in several countries in the third world and emerging economies. These have been assessments of the environmental and resource situation, and the damages have been assessed and to a large extent valuated in monetary terms. The CEAs have shown that the annual damages could be of several percentages of GDP. This has emerged as a powerful tool for the countries in raising awareness about environmental damages and resource degradation. The World Bank would likely be helpful in financing and implementing CEAs in interested countries.

6.3.2 Remove environmental harmful subsidies

Many emerging economies and developing countries subsidize transportation and cooking fuels for social reasons to support poor people. While this may ease the daily life burden of many families through reduced fuel prices, it also increases the use of these fuels. This increases emissions to air, which deteriorates local air quality and causes damages to human health and other damages.

In many countries environmentally harmful subsidies place great burdens on public budgets, in addition to cause local pollutions and significant health problems. This is particularly true in developing countries with low GDP per capita, where consumption-

related fossil-fuel subsidies have exceeded 2 per cent of GDP for many years (examples are Turkmenistan with 15.2 per cent of GDP in 2008; Ecuador, 8.7 per cent; Egypt, 8.4 per cent (Ellis, 2010)). Expenditures relating to the subsidization of fossil fuels may override health and public-education budgets. Among 20 non-OECD countries, subsidies to oil products amount to 2.5 per cent of total GDP (Ellis 2010; Morgan, 2007).

These revenues could alternatively have been spent on investments with long term economic growth effects and improvements in peoples' life quality. Removing the subsidies will increase the strain on households' budgets. Energy subsidies first of all benefit those using most energy. There are many examples of how to alleviate the increasing costs by money transfers to households and support programs targeted directly at the poorest. Examples are cash rebates and expansion of the social safety net following the energy subsidy reform in Malaysia, and the cash transfers following the fossil fuel reform in Mexico and Indonesia (see Vista Analyse (2011), *forthcoming*). Mexico's main anti-poverty program, Oportunidades, targets human capital, i.e. education, health and nutrition of children. The distribution mechanism is cash transfer. Indonesia successfully designed targeted cash transfers that were adopted simultaneously with the fuel price increases in 2005 covering one third of the Indonesian population. The Bolsa Familia program in Brazil represents another example of instruments targeting the income distribution problems directly, and at a low cost. The program provides income support to poor families, subject to their fulfilling of certain human development requirements, such as education participation and health programs.

6.3.3 Consider imposing local resource management and fuel/emission taxation

When local resources like water, grasslands, fish etc. are not sustainably utilized, management of the resources is necessary. Nordic experiences offer several instruments that could be used for this. Tradable fishing quotas could be implemented to manage fish stocks and wildlife management through hunting quotas. Water shortage could be reduced by taxing the use of scarce resources, as could the use of grasslands. However, enforcement is often the most difficult part of resource management in developing countries, implying that the viability of these instruments should be carefully considered. Also, transboundary issues like upstream/downstream water use and general management of larger rivers and waterways might complicate the use of economic instruments. Payment for ecosystem services (PES) is in use successfully in several developing countries already, and PES has shown to be a good instrument to solve the problem of upstream/downstream conflicts.

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Annex: country overview

In this Annex we provide a brief overview of policy use, environmental challenges etc. in each Nordic country.

Denmark: low energy intensity

Denmark's environmental challenges have been driven by intensive agriculture and fisheries (including fish farms), which support a large agro-food industry that causes emissions to water and air (OECD, 2007). 66 percent of Denmark's total land area is used for agricultural purposes. Other severe environmental pressures stem from the transport sector and from the energy supply structure, which have relied heavily on fossil fuels. Environmental issues in Denmark are also related to North Sea and in particular Baltic Sea pollution and transboundary air pollution.

Environmental policies have according to OECD (2007) during the last years focused on air pollution, the aquatic environment (nutrient discharges and groundwater contamination), biodiversity, chemical substances, environmental health, and global issues such as climate change.

Denmark experienced an average annual growth in real GDP of approximately 2 percent during the years 1986-2007 (Source: OECD data). This is somewhat lower than the 2.8 average annual growth in the OECD area during the same period.

Denmark has successfully decoupled emissions of CO_2, NH3, SO_2 and NOx to air from economic growth, despite a rather high GDP growth. CO_2 emissions per GDP are below OECD Europe average (OECD, 2007). Also, the energy intensity has decreased, and is decoupled from economic growth. Denmark now has the lowest energy intensity of the Nordic countries, and among the lowest in the OECD area. According to OECD (2007) this is partly due to the absence of a large energy-intensive industrial base, but also to the efforts to reduce the country's energy use through stringent building and appliances codes, an extensive combined heat and power network, high taxes on energy use and negotiated agreements with industry to implement investments to improve energy efficiency in return for tax rebates. Also, the resource use that is important for water pollution has been considerably improved since 1990. Municipal waste has increased substantially, and the generation of household waste has been growing nearly twice as fast as GDP (OECD, 2007).

Direct regulations have played and continue to play a major role in Danish environmental policies. Land use regulations, particularly those applicable to rural and coastal areas are rigorous, and spatial planning contributes effectively to protection of the environment, nature, landscapes and coastal areas. This is partly due to that Denmark is a densely populated country that uses its land and sea area more intensively compared to the other Nordic countries. A large part of Danish territory is placed under various forms of protection (general habitat protection, conservation orders, protection zones along coast lines, Ramsar sites, EC Bird protection directives), covering almost all types of terrestrial ecosystems (OECD, 1999).

But Denmark was also an early user of economic instruments in the energy and environmental policy. Today the country uses environmental charges, taxes and other

economic instruments extensively. When purely considering the number of economic instruments implemented, Denmark is best among the Nordic countries.

A tax on transportation fuels was introduced already in 1917 for fiscal reasons. Today there are energy and CO_2 taxes on transportation fuels, a registration tax and an annual tax on ownership (vehicle excise duty). The latter taxes are differentiated according to environmental criteria. According to OECD (2007) taxes associated with car ownership are heavy in Denmark. Car ownership is relatively low compared to other EU countries, but total distances travelled by car do not appear particularly low.

For more than the past two decades, Danish energy policy has been strongly influenced by environmental policy objectives related to acid rain and the ambitious Kyoto targets and internal EU commitments where Denmark has made a commitment to reduce greenhouse gas emissions by 21 percent during the 2008–2012 period (TemaNord, 2006a). As a response to the oil crises in the 1970's, an energy tax on fossil fuels was introduced in 1977 to decrease the energy consumption in order to reduce the balance of payments deficit and to some extent stimulate the use of natural gas. Initially, the tax was only levied on oil-products, but in 1982 the energy tax scheme was expanded so that coal was included in the tax. In 1996 the energy tax scheme was expanded further to include natural gas as well. Today the tax is dependent on the energy content of the fuel. Excise duties on electricity consumption are also levied. Due to the tax freeze imposed in 2001 the energy taxes have remained constant in values since 2002 (TemaNord, 2009a). Danish enterprises have often been partly of wholly exempted from the taxes due to considerations about their competitive position.

In 1992 a CO_2 tax dependent on the carbon content in the fuel was introduced in order to increase the incentives to substitute towards less CO_2 intensive fuels. At the same time the energy tax was lowered to keep the overall tax burden constant (TemaNord, 2009a). Later, the sectors included in the EU ETS emissions trading system for 2008-2012 were exempted from the tax. Denmark was one of the first countries to introduce tradable carbon emission allowances. In the period 2000-2003 the electricity generation sector was exposed to an emission trading scheme providing them with a decreasing number of allowances each year.

A tax on sulfur emissions and on sulfur content in fossil fuels introduced in 1996 contributed to drastic decreases in SO_2 emissions, and SO_2 emissions per GDP are the lowest in the OECD area (OECD, 2007). In 2010 a tax on NOx was introduced to help fulfill the Danish NOx-commitment under the Gothenburg protocol. Denmark has introduced environmental taxes on ozone depleting greenhouse gases, taxes on PVC and phthalates, packaging etc.

Denmark's use of renewable energy has more than doubled since 1996 (OECD, 2007). Renewable energy contributed for 3.1 percent of total electricity generation in 1991, increasing to 25 percent in 2004. Wind power has had the largest growth, expanding at an annual average rate of more than 18 percent since 1993. Renewables also contributes to primary energy supply through heat production from waste and biomass. Several subsidy schemes have been in place over the years to promote renewable energy.

But there are still challenges. According to OECD (2007) one fifth of the Danish population is still exposed to unacceptable air quality, which is related to PM10 and PAH

concentrations. Emissions of SO_2, NOx and NH3, which causes acidification are among the highest in the Nordic countries. Background ozone levels are on the rise, connected to NOX and VOC emissions which need to be further reduced.

As the only Nordic country Denmark in 1997-98 introduced a charge on wastewater in addition to the water supply charge (TemaNord, 2006a). The wastewater charge is levied on the content of bioorganic material, nitrogen and phosphorous in the water. Both these charges cover the costs of providing the services (user charges) plus some environmental costs. All water use in households and industry is metered, and the increase in water prices during the period 1994-1998 brought a significant reduction in household water use, but not in agriculture where tax exemptions apply (OECD, 2007). The wastewater tax led to a significant reduction of nitrogen, phosphorus and organic matter in wastewater. The tax on water use has also contributed to less wastewater, which was the main intention with the implementation (OECD, 2007).

Due to a mix of direct regulations, voluntary agreements and a tax on fertilizer, the use of nitrogen and phosphorus in the agricultural sector was significantly reduced during 2000s and is now decoupled from agricultural production (OECD, 2007). Also the use of pesticides is decoupled from production and significantly reduced due to a differentiated tax.

Despite this positive development Denmark still has water quality problems, particularly in lakes and coastal areas (fjords), but also in rivers and groundwater (OECD, 2007). Nitrogen and phosphorous releases have to be further reduced.

Finland: first to introduce a CO_2 tax

The environmental concerns in Finland have mainly been related to emissions to air and water, noise and biodiversity issues (OECD, 2009). The country has a relatively large pulp and paper industry and basic metal industry that have been subject to considerable environmental concerns. Finland has achieved its targets to reduce many traditional acidifying air pollutants and heavy metals, and the urban air quality is generally good. Ozon and PM10 exposures are low by EU standards. Finnish lakes are recovering from serious acidification problems. Finland has pioneered the development of noise abatement policies and reduced the number of people exposed to excessive levels of noise.

Finland experienced an average annual growth in real GDP of approximately 3.7 percent during the years 1986-2007 (Source: OECD data). This is somewhat higher than the 2.8 average annual growth in the OECD area during the same period. Finland has been hit relatively hard by the financial crisis.

Finland was in 1990 the first country in the world to impose a CO_2 tax. As we see this has contributed to decouple CO_2 emissions from economic growth. Emissions of SO_2, NOx and NH3 are also decoupled from economic growth, which could partly be related to the SO_2 tax on transportation fuels. As in most other Nordic countries NOx obligations are not met. It is interesting to note that the heavy growth in industrial production have been achieved with a much lower growth level of energy use and emissions, which is mainly due to that this growth has come in the electronics and related industries. But the energy and material intensity of the Finnish economy is still high compared to other

Nordic countries and OECD average, which is to a large degree related to the use of abundant forest resources and some minerals (OECD, 2009).

However, emissions per unit GDP are relatively high compared to EU15 (OECD, 2009), and the acidification level is high by Nordic standard. CO_2 emissions have been growing in absolute terms which are a concern in relation to the country's target of stabilizing the GHG emissions at 1990 level during 2008-2012. CO_2 emissions are not decoupled from energy production and use.

Water withdrawals have decreased, and the intensity of water use is low by OECD standards (OECD, 2009). This is mainly due to the introduction of closed water systems in the manufacturing industry. The pesticide use has increased since 1998, but is still lower than OECD Europe average. Waste generation has been stable since 2000 and is lower per capita than in the other Nordic countries.

In the early 1990s a number of economic instruments were introduced for environmental and energy policy purposes, and since then the emphasis on taxation has gradually shifted from taxation of labor to taxation of polluting activities (TemaNord, 2009a). The most important environmental taxes are today taxes on fossil fuel and electricity use. There are no taxes on fuels for electricity production. Taxes on different kinds of waste and a registration tax on cars are also imposed. The latter was changed from 2008 to be differentiated according to the carbon dioxide emissions resulting from the vehicle's specific consumption of fuel. The annual circulation tax was also restructured in a similar way.

An energy tax refund scheme for energy-intensive industries has been in place for those facilities paying the highest revenues. The industry has also entered into energy efficiency agreements with the authorities. There are also several subsidy schemes for investments and R&D in renewable energy sources.

Efforts to reduce noise have a long history in Finland. Regulations (e.g. speed limit in city centres, noise emission and emission thresholds, regulations of aircraft take-off and landing) and investments (e.g. low-noise pavements, noise barriers, renewal of rail fleet and rail maintenance) have been implemented. The first economic incentives (air traffic noise charge, introduction of noise criteria in public procurement) have been recently introduced. Their objective is to reduce exposure to noise from city traffic and from night-time air traffic.

According to OECD (2009a) environmental legislation was significantly enhanced through the 2000 Land Use and Building Act and the 2000 Environmental Protection Act.

OECD (2009a) propose that Finland undertake an ecological tax reform as has also been indicated by the Finnish government, to review and revise prices, taxes and subsidies in the energy, transport, agriculture and industry sectors. This should contribute to reduce the energy and material intensities of the economy, and reduce GHG emissions. A tax on NOx to fulfil national emission obligations is also proposed, as is some forms of road pricing.

Some remaining challenges are according to OECD (2009a) to reduce the potential impact on human health from particulates generated by small scale wood burning for heating and by traffic. Finland should also implement more effective measures to protect biodiversity, which has continued to decline, and to expand protected areas. A further challenge would be to reduce nutrient loading from the agricultural sector into the Baltic Sea, which is heavily polluted by releases from the surrounding countries.

Iceland: champion in fish resource management

As Iceland is more sparsely populated than most other OECD countries, it does not suffer from the same order of pollution problems as many densely populated countries. The economy depends heavily on the country's rich endowment in natural resources: the fishing industry on marine resources, the aluminium and ferrosilicon industry on hydropower and the tourism industry on nature and natural beauty. Fish exports and tourism development thus depend on a high-quality environment and a positive, "green" international image (OECD, 2001a).

After sluggish growth in the early 1990s, Iceland's economic growth performance since 1994 and till the financial crisis struck the country in 2008 has been one of the best in the OECD, averaging 4.5 percent in real terms since 1986 and bringing Icelandic GDP per capita above the OECD average.

Because electricity and heat supply from hydropower and geothermal energy dominate the energy supply to stationary sources, only the use of fossil fuels in road traffic and fisheries causes harmful emissions to air (TemaNord, 2009a). Due to this and an oceanic climate and steady winds the outdoor air quality in Iceland is generally quite good. Freshwater resources are abundant and of high quality. However, there are some problems regarding water pollution from fertilizer runoff and inadequate wastewater treatment.

Also, deforestation and afforestation have for a long term been a problem. Revegetation and reforestation have been major parts of Icelandic environmental policy during the last century.

Iceland now has CO_2 taxes on fuel use in stationary combustion and transportation as well as taxes on electricity and heating water from geothermal sources. There are excise duties on transport fuels, and there are duties on the purchase of cars. The latter duties are somewhat differentiated according to engine capacity. There is also an annual car tax based on the car weight, and motor vehicles over 10 tons of weight are subject to a special weight distance tax (TemaNord, 2009a).

Car traffic is the main cause of urban pollution in Iceland. The number of motor vehicles per capita is now among the highest in the world. Private cars are used in over 70 percent of the kilometres driven, while public transportation is used in less than 5 percent of instances. Over 60 percent of the trips taken in private vehicles are shorter than 3 km, and roughly one-third are shorter than 1 km (TemaNord, 2009a).

Iceland produces a substantial amount of waste, and the amounts are increasing. There are local municipal fees for household and industry waste, and recycling fees are imposed on several products to finance their collection and treatment when they are ending as waste (TemaNord, 2009a).

Future challenges are mainly related to air emissions from increases in road traffic. Furthermore, reducing pollution load to water from municipal and agricultural sources, improving waste management, enhancing soil and nature conservation would also be an issue.

Iceland was one of the first nations in the world to introduce individual transferable quotas (ITQs) in fisheries. The ITQ was first implemented in 1979 for herring and was supported by the fishing industry. In 1984, the ITQ was introduced for other fish species as well. The Icelandic fishery sector was over-capitalized at this time and the stocks were overfished.

The system is described as follows in TemaNord (2009a):

"Central to this policy are the individual transferable quotas given to each fishing boat for each species on the basis of its average catch of that fish over a three-year period. This settles the boat's share of the total allowable catch (TAC) of that fish for the entire country. The size of this total is announced each year on the basis of scientific advice from the independent Marine Research Institute.

Subject to certain conditions, quotas can be traded among boats. If the boat owner has exhausted its quota, the owner must buy one from another boat. 20 percent of a quota may be carried forward a year, and 5 percent of the next year's quota can be claimed in advance. Equipment carried on all vessels send electronic signals to make satellite monitoring possible at all times, and each boat is likely to go to sea with an inspector aboard twice a year. All catches are rigorously recorded as soon as they are landed. The Marine Research Institute knows exactly how much each boat is catching and where. It claims that 95 percent of the total is well reported.

By looking at the Directorate of Fisheries' website fishers can see all landings by date and species and thus work out whether to sell their catch fresh or frozen, and whether to buy, sell or carry forward quotas. All quota changes, catches and landings are posted on the internet, enabling everybody to see what is going on. The idea is to let fishermen be guided by the market.

The owners of a quota are charged a fee of ISK 1530.00 per tonne of catch to finance a fund to facilitate rationalization in the fishery sector. The operations of the fund have stopped and the financing is linked to down payment of loans that the fund incurred when it was in operation.

This system was seen as a necessary and temporary remedy to overcome the deep crisis of over-fishing of herring prevailing at the time. There has been some discussion about this quota right, which one may sell, lease out or use oneself like any other possession. Debate has arisen about some of the effect of this management system on fishing practice. Recently, many have made enormous profits by selling fishing quotas which were allocated to them free of charge. Newcomers to the industry find it hard to buy the licenses and quotas they need to start fishing. As a result, the number of boats is falling. Yet Iceland no longer suffers from overcapacity, and the catch per boat is increasing. Ownership, however, is growing more concentrated.

Also, there has been discussions about that the rights of fishing have been transferred to specific individuals free of charge on a long term basis, thereby excluding others from fishing, which many people still find morally wrong."

Norway: innovative in car purchase taxation

Much of Norway's economy depends on the use of its natural resource base oil & gas, wood, fisheries and hydropower. The economic performance to a large extent reflects the rapid growth of the Norwegian offshore oil and gas industry. Extensive hydroelectricity resources supply a range of energy intensive industries and space heating, and per capita electricity consumption is the world's highest. Fisheries and particularly aquaculture have registered high production growth (OECD, 2001b).

Norway's economic growth has been on about OECD average level, with an annual average real GDP growth of some 2.7 percent from 1986 till 2007. The country has been hit less hard by the financial crisis than the other Nordic countries.

Awareness of national and international environmental issues has long been high in Norway, which is exposed to air and coastal water pollution influenced by emissions from other countries (OECD, 2001b). Pollution of air and water is reduced, but urban air quality in some larger cities is not satisfactory, especially in winter days. Main sources for this are road transport and wood burning for space heating. Other pressures on the environment are associated with loss of biodiversity and species in sea and land, aquaculture (emissions to water and threats to the wild species of trout and salmon), biodiversity protection, GHG emissions, hazardous chemicals, release to water from abandoned onshore sites and harbor sea bottom sites, noise, protection of cultural heritage and environmental protection in polar areas.

A new Biodiversity act and the existing Space Planning Act are the main instruments to reduce biodiversity loss and ensure sustainable use of land and sea areas. Some 16 percent of Norwegian land area is protected as national parks and other types of protected areas (Ministry of the Environment, 2010).

Although direct regulations still play an important role, Norway has a long tradition of using economic instruments in the environmental policy. Several commissions have since the 1990s proposed shift towards more use of environmental taxes, which has gradually taken place.

Along with the other Nordic countries Norway has successfully decoupled GDP growth and emissions to air and water. A CO_2 tax on the use of oil products was introduced in 1991, and Norway is now part of EU ETS. The latter also includes CO_2 emissions from offshore oil and gas sector, which was previously subject to a CO_2 tax. The CO_2 emissions from this sector are still taxed, but at a lower rate. Generally, the CO_2 tax is not uniformly imposed according to the carbon content, but differs across fuels and sources. Some other GHG gases than CO_2 are also taxed. GHG emissions from power intensive industries have been curbed through agreements between industry and government (TemaNord, 2009a).

SO_2 emissions have been dramatically reduced through a sulfur tax on oil products introduced in 1970, standards for sulfur content in fuels and regulations of fuel use in special areas and of emissions from large sources (TemaNord, 2009a). NOx emissions

are reduced through emissions standards and other regulations, but not enough to fulfil Norway's obligations in the Gothenburg protocol. The NOx charge implemented in 2007 (see previous description) should contribute to reducing emissions further.

There is a tax on electricity consumption, exempting users in some northern parts of Norway. Industry pays EU minimum tax rates. There is a general tax on the use of fuel oil to avoid substitution from electricity to fuel oil because of the electricity tax. There are also several schemes for support to energy conservation measures and to invest in renewable energy. Norway will join the Swedish Green Certificate system for renewable electricity.

No environmental taxes are imposed on water pollution or water use, only local charges to cover water supply and wastewater treatment. Taxes on waste for landfills and incineration have been imposed, and for incineration they are imposed on monitored emissions from various harmful substances. Taxes and deposit-refund systems for various products, beverage containers and hazardous substances are also implemented.

There are several environmental related taxes on transportation. Gasoline and diesel are subject to a CO_2 tax and a fuel tax to cover external costs related to accidents, congestion, road wear and tear and local air emissions (TemaNord, 2009a).

In 1955 Norway introduced a purchase tax on passenger cars and other motor vehicles to reduce the increasing problems with the trade balance through increasing purchase prices on new vehicles and thus reduce demand (TemaNord, 2009a). The initial tax rate was set at 10 percent of the import value and was gradually increased over the years. The tax scheme has been changed several times.

In 1982 a gradual change of the tax started towards a combined weight- and value based tax, which was fully completed in 1991 (NOU, 2007). In 1996 the purchase tax scheme on motor vehicles was changed again to being entirely based on environmental merits (weight, horsepower and piston displacement). One of the aims of the new tax design was to encourage consumers to buy smaller cars – in terms of weight and power – and hence cars with a lower environmental impact (TemaNord, 2006a).

The registration tax system in 2006 indirectly taxed CO_2 emissions through the weight, displacement and engine effect components. A major change in the tax was made in 2007 when a CO_2 component was introduced, replacing the tax on engine displacement. Today the registration tax consists of vehicle weight, engine effect and CO_2 emissions components. All the elements are progressive. From 2009 the progression has been further developed with a deduction for low emission cars (less than 120 g/km), but total registration tax cannot become negative. Furthermore, high emissions vehicles (more than 250 g/km) have been rather heavy penalized by the tax system.

Electric cars powered from a battery only or through fuel cells pay no registration tax. Also hydrogen fuelled cars are fully exempt from the tax, also if the hydrogen engine is combined with an electric engine. Vehicles that can run on concentrated ethanol could deduct an amount from the vehicle tax, as will plug-in hybrid cars when they enter the market. The registration taxes for motor cycles and snow scooters have similar, progressive tax systems based on displacement and engine effect as well as a general tax per unit (motorcycles), and on weight, displacement and engine effect (snow scooters).

The purchase tax change from 2007 has lead to a considerable increase in the share of diesel vehicles of the total number of new passenger cars sold, and that emissions per kilometer have been reduced substantially for new cars. The government has indicated that the tax rates will be further differentiated in the coming years to stimulate purchase of low CO_2 emission cars and increase the costs of cars with high CO_2 emissions. The transformation of the tax system also facilitates a more overall treatment of for example hybrid and electric vehicles. All cars will have engine effect and weight, but in the future there will be an increased supply of cars without displacement, like electric cars.

Norway also has an annual excise duty on motor vehicles, differentiated between diesel cars with and without particle filter and gasoline fuelled cars. Vehicles with a total weight of more than 12 tons are subject to an annual weight-related excise duty. Norway has a long tradition in the field of road charges as the first toll rings around cities and to pay for new roads and fjord-crossings were introduced already in the late 1980s and early 1990s. Though they might have had some environmental effects, these charges have not been actively used for environmental purposes for instance to curb traffic during rush-hours.

Other taxes include tax on the purchase of boat engines and a landing charges on Norwegian airports. There is also a tax on pesticide use.

Sweden: innovative user of economic instruments

Sweden's economy is based on advanced industry products and a well developed service sector. A considerable amount of Sweden's industrial output is based on mechanical engineering, other important branches are medical products, information and communication technology and environmental technology. Traditional industry based on the country's most important raw materials wood and iron ore still plays some role (OECD, 2004).

SO_2 and NOx emissions have decreased, contributing to an improved local air quality. Sweden has fulfilled its NOx obligations in the Gothenburg protocol. However, PM and ozone levels are often exceeding recommended values in local areas. Over 10 percent of the population is disturbed by noise at home. Sweden has a very advanced urban wastewater treatment system, and releases from agriculture have been considerably reduced. Fertilizer and pesticide use have decreased (OECD, 2004). Generally, salt and freshwater quality has improved, but there are still challenges in some areas. Nature conservation and biodiversity have been prioritized, and 10.6 percent of the national territory is subject to some kind of protection. There are still challenges related to biodiversity loss, especially in the marine environment related to overfishing among other issues.

Sweden has during the period 1986-2007 had an average annual real GDP growth of some 3.2 percent, which is somewhat over OECD average. The country has been hit hard by the financial crisis, but not as hard as several other Nordic countries. Sweden has successfully managed to decouple economic growth and emissions of important substances to air and water.

Environmental issues have been high on the agenda, and large improvements have been made over the years because of reduced emissions to air and water. Sweden has had great success in decoupling economic growth and emissions to air and water. The

environmental quality is also highly dependent on emissions in other countries, e.g. Baltic Sea pollution and transboundary air pollution (OECD, 2004). Few subsidies to promote environmental improvement have been used (OECD, 2004).

The country has over the years strengthened its environmental legislative and planning frameworks, and has been a forerunner in the use of economic instruments in the environmental policy. Since the 1990s a "green tax shift" has taken place, where higher environmental taxes have been shifted against increased personal allowances and lower social security contributions (TemaNord, 2009a). In this tax shift the government has increased the CO_2 tax introduced in 1991, the electricity tax, the diesel tax, the waste tax, the tax on gravel, the pesticide tax, the road vehicle tax and petrol tax, and introduced a small electricity tax for industry (TemaNord, 2009a). However, the energy tax and the diesel tax for agriculture and forestry have been lowered, but still this was a net increase in the tax on fossil fuels along with reductions in salary taxes. This tax change has contributed to some SEK 30 billion tax shift between 2001 and 2010. Efforts have recently been taken on scaling back tax reductions for agriculture and industry not covered by emission trading, implying that tax rates would increase for these sources in the years to come (OECD, 2010c).

The CO_2 tax constitutes the most significant part of the duties levied on energy in Sweden (TemaNord, 2009a). This tax covers almost all fossil fuels used by those who are not part of the EU ETS. Since 1991 a sulfur tax on mineral oil products has been implemented, contributing to a large reduction in SO_2 emissions. Sales taxes on electricity and most fossil fuels are levied. Users in northern municipalities pay a reduced electricity tax rate, and industry pays the EU minimum rate.

In 1992 Sweden introduced a charge on emissions of nitrogen oxides (NOx) from large stationary combustion plants. The NOx charge is a supplement to emission limits set in operating permits. The main aim of the charge was to combat acidification and reduce emissions beyond the emission limits (TemaNord, 2009a).

From 1997 the charge covers combustion plants generating more than 25 GWh/year. A further criterion for liability to the charge is that the energy produced is used to heat buildings to generate electricity, or in industrial processes. The initial charge introduced in 1992 was SEK 40 per kilo of nitrogen oxides emitted, calculated as nitrogen dioxide. From 2009 this charge was raised to 50 SEK/kg. Initially the tax covered around 5 percent of total Swedish NOx emissions.

All proceeds from the tax are refundable to the collective of regulated plants based on plant output as fraction of total useful energy produced by regulated plants. This means that plants with low emissions compared to the energy production are net receivers of funds, while plants with high emissions in relation to energy production are net payers. According to OECD (2010b) this refunding was established to avoid serious distortions in competitiveness. The Swedish NOx tax has been widely highlighted as an example of an innovative use of environmental taxes to spur emissions reductions and technological innovation.

Swedish industrial users can be charged with wastewater pollution charges. Municipalities levy charges for water supply and wastewater treatment for households and industry. In the waste sector taxes on waste delivered to landfills and incineration

have been imposed, and various deposit refund schemes are in place. Also taxes on several products (including packaging) to cover collection and treatment costs are in place.

Sweden has no purchase tax on cars, but an annual owner tax with a component depending on the specific CO_2 emissions from the car. Vehicles heavier than 12 tons are subject to an annual road charge.

Stockholm has introduced congestion taxes intended to reduce congestion on the roads and streets in and around central Stockholm, and reduce emissions of pollutants that are harmful to health and the environment. The tax also has a fiscal purpose since most of the revenues are intended for investment in public transport. Trials with the system started in August 2005 and the Government proposed that the system should be permanent in the spring of 2007 after the system was evaluated through a city referendum in 2006 (TemaNord, 2009a).

Different tax rates are levied on different hours of the day. Motorists entering or leaving the city centre will have to pay a time dependent tariff between 6.30 a.m. and 6.30 p.m. Newly registered environmentally friendly cars are no longer exempt from the tax (as from January 1, 2009) while already registered environmentally friendly cars are exempted until August 1, 2012. Congestion tax expenses can be deducted in people's declaration for income tax payments, thus potentially reducing some of the impacts of the tax on peoples' driving behavior.