THE SWEDISH EXAMPLE

THE REDUCTION IN GREENHOUSE GAS EMISSIONS

FORES

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To which extent can Sweden be considered an example?

Sweden is often mentioned as a prime example of how to proceed with reductions of greenhouse gas emissions while maintaining growth. This is exemplified by the curve on page 12 showing how emissions have decreased 12 per cent since 1990 while GDP has increased 50 per cent. This indeed is a heartening example to policy makers in other nations who despair about the possibility of acting forcefully climate change without handicapping the economy.

In this report we have tried to detail how these headline figures were achieved to make it easier for domestic and foreign observers to assess the validity of the Swedish example. We have compiled basic Swedish data on emissions by sector and related them to the respective policy actions and economic developments. Our hope is that this very simple exercise will distinguish what in the Swedish experience is truly transferable to other nations, what is due to specific natural endowments and accidents of history, and what may be dismissed as mere statistical illusions.
In summary the Swedish example is real, there has been considerable progress on emissions. Sweden is greatly helped in achieving low emissions by the abundance of hydropower. However progress in reducing emissions would not have been possible without policy actions. Some policy actions, such as the emission reductions due to the expansion of district heating (natural local and regional monopolies, largely publicly owned) have been greatly enhanced by the abundant supply of biomass (forest) as a fuel supply. But the main policy instrument, the early pricing of emissions through a substantial carbon tax and later also through the European emissions trading system, has been the most forceful instrument in all sectors, including the transportation sector where Sweden has no particular natural advantages. That experience is transferable to other economies. It indicates that the Swedish combination of strong growth in living standards and lower emissions can be achieved while reducing emissions in other nations as well.

However, Sweden’s relative success compared to other developed nations should not be mistaken for an absolute success in achieving sustainable emission levels. Emissions
per capita of green house gases are still much too high in Sweden and the reductions not nearly good enough. If the emissions per capita of the entire world would be as high as Sweden’s the goal of stabilizing global warming would be unattainable. To be a true example Sweden must therefore reduce emission much further, in particular the use of fossil fuels in transportation and the efficiency of industrial processes. The good news from the data is that the policy actions to reduce emissions have been much less painful than anticipated, which gives us great hope that further reductions in Sweden and elsewhere are easier to attain than we imagine.

This report is largely a product of joint efforts by FORES staff, but in particular Robert Kron deserves gratitude for his efforts. We would also like to extend our thanks to the Tom Hedelius and Jan Wallander Foundation for funding the translation of this study.

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Daniel Engström Stenson, director of FORES environmental program
Summary

In order to avoid serious climate change, it is vital that industrialised countries reduce their greenhouse gas emissions substantially. However, many believe that the necessary reductions are incompatible with continued economic growth. Nevertheless, there are cases, which prove that this does not need to be the case. Between 1990 and 2008, the Swedish economy grew by approximately 50 percent, a respectable rate in an international comparison. During the same period, greenhouse gas emissions in Sweden diminished by approximately 12 percent.
The purpose of this report is to present an overview of how Sweden has accomplished these results, by examining the sectors in which these reductions have taken place and the measures which have contributed to them. This report also discusses how this experience can be used in other countries, which have not reduced emissions at the same rate.

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1 “Other sectors” are not included in the figure. In 2008, “other sectors” supplied 6.1 percent of the total Swedish emissions. These sectors cover refineries, diffuse emissions, the production of solid fuels, the use of solvents and more. Emissions in this sector have not changed substantially since 1990.
The short answer to the question of how Sweden has managed to reduce its emissions is carbon tax, district heating and energy efficiency. In 1991, Sweden introduced a carbon tax in many sectors that has resulted in the reduction of carbon emissions by approximately 7 percent (see Figure 1). The biggest reduction has taken place in the emissions relating to heating private and commercial buildings. The main reason for this is the development of district heating, which benefits from the fact that more carbon-intensive heating methods are taxed at a higher rate. The expansion of district heating has also led to the reduction of emissions from waste, as waste is the primary fuel material for district heating.

Carbon tax is also believed to have affected the transport sector, however the precise effect is difficult to ascertain. Other incentives that have proven to be effective are different versions of eco-car premiums, different kinds of regulation within agriculture, waste management and industry and the requirements for energy producers to guarantee a certain proportion of energy output for renewable energy through renewable energy certificates.
Carbon taxes in Sweden were set higher, and covered a broader array of sectors compared to other carbon taxes internationally. Moreover, countries such as Italy, Germany and the USA are considered to have great potential for the development of district heating powered by waste or biomass.

Although the climate issue requires international cooperation and global agreements, this report shows that the majority of the political decisions that achieve the actual emission reductions are made at the national level. Even if Sweden’s example is not completely transferable to other countries, a number of reforms are relevant for other countries.
1. Introduction

Between 1990 and 2008, Sweden achieved economic growth of over 50 percent, while its climate-affecting emissions – according to the definitions of the Kyoto Protocol – diminished by approximately 12 percent. If emissions from sea and air traffic are included in the calculations, emissions diminished in Sweden by just over 6 percent. This report attempts to elucidate why through an overview of basic data.

The report is based on statistics from the period between 1990 and 2008. The year 1990 is used as a base year in the Kyoto Protocol, which makes data from 1990 and onwards more easily available. Although there are some data for 2009, we have chosen 2008 as the end year for this report. The reason for this is that statistics from 2009 are strongly affected by the international financial crisis, which had a marked impact on world production and therefore also on

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2 The Swedish Environmental Protection Agency’s official statistics are based on the Kyoto definitions, United Nations (UN). which do not include the emissions from international shipping or aviation. If these emissions are included, the increase here compensates for the entire reduction in the rest of the economy.

3 Åkerman (2011)
emissions in Sweden and the world. A comparison with statistics from 2009 could be seen to skew the analysis.

The term “greenhouse gases” includes the following four gases: carbon dioxide, methane, nitrous oxide and fluorinated greenhouse gases. Carbon dioxide accounts for the majority of the emissions (approximately 78 percent) during the time period in question.

**Figure 2. Emissions and GDP 1990-2008**

![Graph showing emissions and GDP from 1990 to 2008](image)

Figure 2 illustrates the development of GDP and carbon emissions in Sweden since 1990. Carbon emissions have been reduced since 1990, and at the same time, Sweden has maintained economic growth throughout the entire period, the main reverse stemming from the financial crisis of the early 1990s, which was unrelated to climate policy. Although
the Swedish economy has grown by approximately 50 percent since 1990, the distribution of growth between the manufacturing and service industries has not changed significantly. Over this period, manufacturing accounted for approximately 25-30 percent of GDP, and the service industry accounted for 38-43 percent. Even though the graph above shows that emissions have been reduced since 1990, it is worth noticing that Swedish emissions have diminished since as early as 1970, and the rate of reduction was actually higher before 1990 than after.⁴ Important reductions in oil consumptions following the oil crises in the 1970s had been made already prior to 1990 and much of the simpler efficiency measures could have been expected to be exhausted. However, as shown above, emissions have continued to diminish since 1990.

⁴ Lindmarker (2010)
2. Swedish emissions between 1990 and 2008

At the same time as the Swedish economy was growing over the last 20 years, the emission of greenhouse gases diminished by just over 12 percent, from 72,490 thousand tonnes in 1990 to 63,570 thousand tonnes in 2008 according to statistics from the Swedish Environmental Protection Agency.

**Figure 3**

Greenhouse gas emissions in Sweden per sector 1990-2009

- Waste
- Other sectors*
- Industrial processes
- Agriculture
- Housing commercial property etc
- Production of electricity and heating
- Industrial combustion
- Transport
Figure 3 shows the development of greenhouse gas emissions in Sweden from 1990 to 2009 according to sector. The greatest proportion of emissions in Sweden comes from the transport sector. Emissions have remained on a relatively stable level in this sector, with a lower rate of increase in 2008 than in 1990. The reduction of greenhouse gas emissions in Sweden is, to a large extent, based on the reduction of emissions in the housing and commercial property sector, which is a result of more environmentally-friendly heating. Whereas the other sectors vary widely in percentage, the volume in tonnes in these sectors is still relatively small.

In order to provide a clearer picture of the diagram, a short description of emission, economic developments and policy actions in each sector is presented below.

**Transport**

Since 1990, greenhouse gas emissions from domestic transport have increased by approximately 9 percent, which is mainly due to the fact that the emissions from heavy transport (lorries) has increased by 35 percent. Carbon
emissions from passenger cars have in fact decreased somewhat over the same period.

In 1991, when Sweden introduced an excise duty on carbon dioxide, constructed in such a way as to tax carbon emissions per kilogram, the ambition to reduce emissions from the transport sector was an underlying factor. A carbon tax creates two kinds of incentive. First, it has the “demand effect,” whereby the demand for carbon-driven energy decreases as a result of the increase in price. It also creates the “substitution effect,” whereby the demand for other forms of energy increases. Studies have shown that the tax created both these effects. The Swedish carbon tax has decreased the demand for fossil fuel by approximately 7 percent since 1992, and has decreased carbon emissions, all else being equal, by around the same amount. The transport sector’s contribution to this decrease in fossil fuel usage is complicated to establish, but the tax has had a demonstrable impact on Swedish carbon emissions in general.

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5 Andersen, M. S. (2010)
Subsidies to eco-car owners have also been introduced by various governments to varying degrees, consisting of tax breaks, parking benefits and exemption from congestion charges. The number of eco-cars has also increased markedly since the eco-car premium was introduced in 2007 – today, every third car sold in Sweden is an eco-car. The actual impact of the premium is, however, difficult to determine due to the fact that international oil prices rose steeply before the financial crisis, from approximately $30 per barrel at the beginning of the 2000s to as much as $145 per barrel during 2008 before the crisis hit. This price development should, of course, have had an impact on the demand for vehicles that run on other kinds of fuel. Last but not least, technological development in the car industry and the development of more fuel-efficient cars, alternative fuels and low blends of ethanol in all 95-octane petrol, have drastically reduced the average carbon dioxide emissions from today’s vehicles.⁶

It is difficult to prove empirically what effects the carbon tax, the eco-car premium, high oil prices and the development of

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⁶ Bil Sweden
more efficient motors have had respectively on the development of greenhouse gas emissions in the transport sector in Sweden. During the period in question, the number of miles driven per car decreased by 6.4 percent. At the same time, the number of vehicles in Sweden increased by over 22 percent or 878,000 vehicles, which suggests that the number of miles driven in total has increased considerably. If the development of the eco-car, the more efficient motors and the incentive to buy these vehicles had not existed, one could assume that emissions from this sector would have been markedly higher. In order to reach the government’s goal for the entire vehicle fleet to be independent of fossil fuels by 2030, the rate of change presumably has to increase. The Swedish Transport Agency also believes that the measures taken have to be broader and that more cooperation between the different authorities is needed.

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7 Statistiska Centralbyråns (SCB)  
8 The Swedish Transport Agency
In summary, the transport sector has not contributed to the reduction in greenhouse gas emissions in Sweden. However, without the political decisions that were implemented, it is highly likely that the emissions in this sector would have been significantly greater.

**Electricity and heating**

The largest reduction in Swedish emissions since 1990 has taken place in the production of electricity and heating. That which is labelled in the diagram below as “housing, other buildings and agriculture”, refers to the heating of such buildings. In this sector, the climate impact has been reduced by over 64 percent, from 10,807,000 tonnes of
greenhouse gases for heating in 1990 to 3,857,000 in 2008. The main reason for this reduction in emissions is bio fuel powered district heating. Today, more than 50 percent of Sweden’s homes and buildings have district heating. Other leading heating methods are electricity or different kinds of bio fuel such as pellets, sawdust or woodchips.\textsuperscript{9} The cause of the increased demand for bio fuel driven district heating is likely to have been the carbon tax mentioned above.\textsuperscript{10} In 1998 – due in part to this tax – the cost of fossil fuel-driven heating was up to seven times higher than the cost of district heating.\textsuperscript{11} This is a good example of the demand and substitution effects mentioned earlier, as people voluntarily changed their consumption to more environmentally friendly alternatives due to incentive-driven taxes.

\textsuperscript{9} The Swedish Energy Agency
\textsuperscript{10} Ministry of Environment DS 2009:63
\textsuperscript{11} Johansson, OECD
In total, 90 percent of Swedish electricity is generated from nuclear power and hydro power. Both of these power sources are already considered to be fairly efficient from a climate perspective. Emissions from these sources have not changed significantly during the period of this study, a reduction by only 4.4 percent. This can also be seen in light of the fact that consumption in this sector has increased by a modest 6.3 percent during the last 20 years. However, there have been changes in the energy sector. The energy standard system that was introduced in 2003 has clearly contributed to the increase in the production of renewable energy. Since the system was introduced, the production of renewable energy has increased by 11.5 THW since 2002, to 18 THW in 2010. The system means that producers of renewable energy
are handed a certificate by the government. The certificates are then sold to producers of non-renewable energy on an open market. Every producer is obliged to buy a certain share certificates in relation to quantity of the electricity they sell. The cost of the certificates is included by in the electricity bill, and thereby the consumers help develop the production of renewable energy. The idea behind the design of the system is that renewable energy producers gain an extra income, which in turn provides an increased incentive to invest in renewable energy sources.¹²

Lastly, emissions from the Swedish military, which is labelled “other” in the diagram above, have decreased by approximately 80 percent (or 664,000 tonnes of greenhouse gases) since 1990. Whether the reduced military budget is the cause or other factors is not clear.

**Waste**

At the same time as the volume of waste has increased by over 59 percent during the course of the last 18 years, greenhouse gas emissions from waste have decreased by almost 40 percent. Emissions are expected to decrease by a

¹² The Swedish Energy Agency
further 63 percent by 2020. The carbon tax mentioned above is thought to have had a significant climate impact. Sweden’s increasing demand for district heating and the expansion of this system over recent decades has meant that large proportions of waste and other residual products are used as heating material in the district heating system, which has contributed to lowering emissions. In addition a number of EU directives on the recycling of waste have led to a reduction in disposal in Swedish landfills. In 2003, the proportion of landfill waste had been halved. This trend has continued, and in 2008, approximately 140,000 tonnes of waste was disposed of in landfills, as compared to the total amount of waste produced was as much as 4,731,660 tonnes. In other words, less than 3 percent of Swedish waste was disposed of in landfills. Other material is recycled. It has been estimated that the correlation between economic growth and the amount of waste will have vanished by 2020 and that the required technology is already available today.14

13 Swedish Waste Management
14 Swedish Waste Management
Industrial processes and combustion

Industrial combustion is another sector in which the emission of greenhouse gases has decreased since 1990. Emissions have been reduced by approximately 15 percent, while at the same time production in the sector has increased by approximately 100 percent since 1993.\(^5\) Again, the carbon tax and technological development have probably played a part, but the dominant factor seems to be the inclusion into the European Emission Trading System (EU ETS), setting a price on carbon emissions. The companies that are included in the trading system reduced their emissions by approximately 350,000 tonnes between 2005 and 2007.\(^6\)

Emissions from Swedish industrial processes have increased by approximately 8 percent since 1990, as can be seen from Figure 6. However, according to the Swedish Environmental Protection Agency, this can be seen as a small step forward, considering the fact that for the projections in 2003 were of an increase in emissions of approximately 25 percent. Industrial processes have become much more energy-

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\(^5\) SCB

\(^6\) Damgaard (2009)
efficient since 1990. During this period the production in the mining and mineral extraction industry has increased by almost 500 percent.\(^7\)

**Figure 6**

<table>
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*Source: Swedish Environmental Protection Agency*

**Agriculture**

Emissions from agriculture have decreased steadily since 1990 (by approximately 10 percent), in parallel with an economic growth in the sector of approximately 25 percent. These reductions are, to a large degree, presumed to be the result of regulatory requirements to use nitrogen more efficiently and therefore to reduce the leakage of ammonia. Approximately 60 percent of the yearly agricultural subsidies that Sweden receives from the EU are used for the

\(^7\) Swedish Environmental Protection Agency (2003), SCB
creation of more environmentally efficient agriculture. However, there is room for improvement in this sector. Among the EU-15 countries, Sweden is ranked in 10th for the rate of reduction of greenhouse gas emissions in agriculture. The Federation of Swedish Farmers (Lantbrukarnas riksförbund – LRF) estimates that the climate impact of agriculture could be decreased by 15-20 percent by 2020 compared to today’s emissions. This calculation is based on technology that is available today.  

Other sectors

Other sectors include refineries, diffuse emissions, the production of solid fuels, the use of solvents and others. Emissions from these other sources taken together have not changed significantly between 1990-2008.

International trade

As shown in this report, Sweden has reduced its domestic emissions with the help of political incentives, public investment, better information, and, in some sectors, technological development. Some claim, however, that Sweden may well be able to reduce its emissions at home,

18 Interview with Jan Eksvärd from LRF
but that the increasing consumption of products that are produced abroad contributes to an increase in global greenhouse gas emissions. According to this argument, emissions from products manufactured abroad should be counted as emissions generated by the country in which they are consumed. This viewpoint is reasonable in the sense that if one includes consumption of non-domestic products and services, and excludes Swedish exports, Swedish emissions in 2008 would be approximately 65 percent higher.¹⁹ This picture is reinforced by other studies which have produced different results, but which all show a higher emission level for the total emissions for Sweden based on consumption, compared to the Swedish Environmental Protection Agency’s official statistics.²⁰

However, the relevant question in relation to the past 20 years of economic growth is how emissions, including those from trade, have developed over the same time period. In the recently published study by the Norwegian research institute CICERO, international trading data were connected to carbon emissions over time, in order to

¹⁹ Peters et al (2011)
produce an overview of countries’ import-related emissions change. The results showed that the emissions of the majority of developed countries since 1990 increased when import, based on the balance of trade, is included in the calculations. This, however, is not the case for Sweden.

Sweden has quite to the contrary reduced its emissions from consumption over the past 20 years. According to the simulations that the study presents, Sweden’s total consumption-based emissions have decreased by nearly 13 percent since 1990 when import is included. During this period of time, Swedish exports increased from 30 percent of the GDP to approximately 50 percent of the GDP. This means that either the increase in Swedish export has helped to reduce emissions in the balance of trade due to other countries’ increased demand for Swedish products, or that Swedish import generates decreasing levels of emissions. This could be connected to the fact that the origin of Swedish imports, to a large degree, are our neighbours, such as Germany, which have reduced the climate impact from their manufacturing of products and services, which in turn also reduces our import-based emission volumes. This presumption is backed up by a report from the Swedish
Environmental Protection Agency that shows that almost 70 percent of the emissions that result from Swedish import come from Europe, with only 5 percent from Asia.\(^{21}\)

It can, however, be noted that the calculations from the Royal Institute for Technology (KTH) show that the proportion of emissions from Asia increases by approximately 4-14 percent when country of origin is included in the calculations. However, this still represents a relatively small proportion of Swedish imports.\(^{22}\)

\(^{21}\) Swedish Environmental Protection Agency (2010)

\(^{22}\) Carlsson-Kanyama et al (2007)
3. How transferable is the Swedish example - discussion

To what degree is Sweden’s success dependent on Swedish conditions, and to what extent is it possible for other countries to use Sweden’s experience in order to succeed in a similar way in the field of emissions? In order to answer these questions, the conditions in five countries will be examined: China, Italy, Germany, Poland and the USA. A short description of their emissions situations will be followed by a discussion about how these six countries could apply the lessons that have been learnt in Sweden.

One need to bear in mind that Sweden to a large extent has favourable geographical and natural conditions. 45 percent of Sweden’s electricity is produced by hydropower from the rivers in the north of the country. Sweden also profits from an abundance of biomass in its forest. Still, there are active policy measures taken by Swedish politicians that can stand as examples to other countries of how to reduce emissions.
The presentation will only cover the sectors in which Sweden can clearly be expected to contribute with various kinds of knowledge. There are doubtless areas in emission abatement in which Sweden could learn from examples in countries cited below, but this is the subject for another report.

**Poland**

Between the years of 1990 and 2008, Poland diminished its emissions by 12.6 percent. This places Poland among the European nations that have reduced their emissions the most. Unfortunately, this does not mean that Poland is running an active climate policy. At the beginning of the 1990s, Poland still had many inefficient, unprofitable and polluting factories, an inheritance from the period of Soviet domination. These were closed in the early 1990s, which led to a substantial reduction in pollution. Therefore, this reduction was an effect of Poland’s adjustment to a market economy. Poland’s lack of interest in taking action to mitigate climate change was revealed yet again as recently as June 2011. The serving Polish environment minister questioned whether climate change was really taking place,
whilst also expressing doubt as to whether their coal power plants were really as harmful to the environment as many believed.\textsuperscript{23}

Given these statements from the country’s leading representatives, there is a surprisingly strong means of control in place to reform the country’s energy sector, in which coal and oil still make up 83 percent of energy production. Like in Sweden, there is also an energy standard system, which promotes renewable energy and is believed to generate incentives for new investments. The Polish energy sector still consists of relatively small proportion of renewable energy, this in turn means that each certificate yield a high price because other forms of energy production must be compensated by a certificate. This in turn creates strong incentives for new investment.\textsuperscript{24}

Poland has a well developed district heating system, however it is mainly driven by fossil fuels. With much of the infrastructure already in place, Poland would be well suited

\textsuperscript{23} Kühler (2011)

\textsuperscript{24} Dzi gielewska
to start produce larger share of its district heating by using biomass, waste etc.

In the transport sector, Poland has, however, not taken stronger measures. Emissions have increased by approximately 75 percent since 1990, partly as a result of the significant increase in the number of cars (77 percent since 1998). Just as the reduction of emissions in the industry can to a certain extent be explained by Poland’s adjustment to a market economy, so can the increased emissions from transport be linked to economic development. Poles have, in the past 20 years, become increasingly well-off, and consider themselves to be better able to afford this kind of consumption.\(^{25}\)

A carbon tax based on the Swedish model would possibly be able to break the trend of rising emissions in the transport sector.\(^{26}\) However, it is believed that such a tax would deal a harder blow to the poorer segments of the population, especially in rural areas. Studies have shown, however, that

\(^{25}\) Eurostat, UNFCCC

\(^{26}\) Eurostat
this is generally not the case.\textsuperscript{27} It also possible to use various types of compensation systems, such as ethanol-converting-subsidies or reduced vehicle taxation, can be used to compensate for such distortions.\textsuperscript{28}

\section*{Italy}

Italians do not emit particularly large amounts of greenhouse gases, emissions per capita were in 2008 lower than the EU average. Due to its geographical situation, Italy does not need as much energy and heat production as countries in Northern Europe. At the same time, greenhouse gas emissions in Italy increased by approximately 4.7 percent between 1990 and 2008. The country is politically divided as to whether or not the EU should impose stricter regulations on emissions.\textsuperscript{29}

The main reason for the increase in greenhouse gas emissions in Italy is to be found in the energy sector. Like Sweden, Italy has implemented a carbon tax. The difference

\textsuperscript{27} University of Gothenburg (2011)
\textsuperscript{28} Von Bahr (2009)
\textsuperscript{29} The Times (2011)
between the two countries is that the Swedish tax has been raised at various intervals since its introduction, whereas the Italian tax has been lowered by almost a quarter.\textsuperscript{30} This clearly sends the wrong signals and works against the original aims of the tax – as the demand and substitution effects in the Italian case go in opposite directions. Considering Sweden’s positive experience, the tax should instead be used in Italy so that the almost nonexistent district heating can be developed at the same time as the transport sector’s climate impact is reduced.

Finally, Italy has major problems in the waste sector. Many countries seem to have managed to reduce their emissions in the waste sector radically since 1990. Italy, however, has a long way to go. The waste sector in Italy suffers from high levels of corruption.\textsuperscript{31} Currently, in 2011, Italy is paying 400 SEK per tonne to export waste to Sweden, where it is used in the production of district heating.\textsuperscript{32} This is clearly not a sustainable solution. Instead of paying to get rid of the waste, the waste should be seen as a resource, both from an

\textsuperscript{30} Environmental News network (ENN)
\textsuperscript{31} Miljöaktuellt
\textsuperscript{32} Aftonbladet
economic and an environmental perspective. Better waste management through new technology, as is the case Sweden, and through the expansion of district heating, ought to be a more sustainable solution to the problem.

Germany

Since 1990, Germany has managed to reduce its greenhouse gas emissions by over 22 percent and thereby contributed greatly to the EU’s reduced emissions. It should, however, be noted that Germany, together with Denmark, is still in the top 10 in Europe for emissions per citizen.\textsuperscript{33}

As with Denmark, it is the conditions in the German energy sector that differ most from those in Sweden. Per citizen, emissions in the German energy sector are more than four times as high as those of the same sector in Sweden. In 2008, Germany’s energy sector emissions were allocated as follows: oil, 34.5 percent; coal 12.7 percent; brown coal, 10.9 percent; natural gas, 21.5 percent, nuclear power, 11.4 percent; and renewable energy, 9.6 percent.\textsuperscript{34}

\textsuperscript{33} UNFCCC
\textsuperscript{34} Bundesministerium
After the nuclear disaster in Japan in the early spring of 2011, Germany’s government decided to close all of its nuclear power stations by 2022, beginning in 2011. Nuclear power will, in the opinions of many, be replaced to a certain degree by renewable energy sources, but for the most part it will be replaced by natural gas and other fossil fuels.

One way for Germany to further reform its energy production would be to have a look at its Nordic neighbours and their widespread use of district heating. Today, district heating is used for heating only 15 percent\textsuperscript{35} of German homes, compared to 51 percent in Sweden and 62 percent in Denmark.\textsuperscript{36} One of the negative aspects of district heating is that it requires an injection of capital over a relatively long period of time, and therefore often requires state support for expansion. The German state has introduced certain subsidies for pipe-laying in preparation for a more developed district heating system. These subsidies will, however, only provide enough expansion to cover 20 percent of German heating requirements.

\textsuperscript{35} Umweltbundesamt

\textsuperscript{36} Swedish district heating, Statistics Denmark
The Swedish expansion of district heating is due not only to state subsidies, but also, as mentioned earlier, to the carbon tax. Germany also has a carbon tax which seems to have had a considerable impact on the transport sector. The German electricity and heating industry is, however, part of the European Emissions Trading Scheme (EU-ETS), through which the price of emissions is set. This reduces the possibilities for domestic taxation.

**China**

China is, from an environmental perspective, a land of extremes, as it has the world’s largest population, and, since 2006, the largest carbon emissions. Its emissions per capita have increased from very low levels to a level similar to that of Sweden. China has set itself targets in the Copenhagen Accord, but these are expressed in terms of “energy intensity”: the goal is for it to fall by 20 percent by 2020, compared to the level of 2005.

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37 CAIT (2011)
China’s energy intensity today is approximately 20 percent higher than the average in the OECD and about 85 percent of its energy stems from either coal or oil. The Chinese government has set very ambitious targets for the energy sector, aiming both towards the use of 15 percent renewable energy by 2020 and also to transform the economy from an energy-intensive manufacturing economy to a service-oriented economy. With more limited hydropower and biomass resources than Sweden the Swedish example would appear to be mainly relevant for energy efficiency induced by incentives such as the carbon tax. However there are some noteworthy parallels.

Like Sweden, China probably has opportunities to expand district heating in densely populated areas whilst also solving another urgent environmental issue: the increasing amount of waste. The OECD estimates that approximately 50 percent of private waste and nearly 80 percent of industrial waste in China is dumped in a non-controlled manner. The consequences are not only the creation of
emissions, but also the release of other types of detrimental substances into the environment.\textsuperscript{38}

This economic growth has resulted in parts of the population being lifted out of poverty, which in turn has caused the number of cars to skyrocket. Since the 1990’s, car sales have increased by an average of 27 percent annually, meaning that if this trend continues, the numbers of private cars on Chinese roads will double every three years. However, only 25 million people in 2007 had a registered car. The low number of cars relative to the size of the population, in conjunction with China’s strong economic growth, demonstrates the potential of the Chinese car market.\textsuperscript{39} One of the reasons for the increase in car consumption is assumed to be (at least from an international perspective) the availability of relatively cheap fuel in China. However, it is believed that this will change in the near future, because the Chinese government is planning to introduce a carbon tax for both industries and vehicles. This introduction is based on a study by officials in the Chinese government that confirms that a carbon tax is the most effective means of

\textsuperscript{38} Weeks, D. (2007)

\textsuperscript{39} Tillväxtanalys (2009)
control when aiming to reduce carbon dioxide. This has also proven to be the case in Sweden.

In addition, another relevant lesson from Swedish practice is the introduction of eco car premiums, which as of yet do not exist in China. As previously mentioned, sales of eco cars increased dramatically in Sweden after the introduction of the premium, and today every third new car sold is classified as such. If the same development can take place in China in the future, it would constitute an extremely successful reform from a climate perspective, given the size of the Chinese car market.

\[40\text{ Jiawei (2010)}\]
United States

The US is one of the largest emitters per capita in the world. Americans emit more than three times as much as citizens in Sweden per year (2008). During the period from 1990 to 2008, American greenhouse gas emissions increased by almost 14 percent. This increase is in itself almost as large, in tonnes, as the total emissions from the UK, Ireland, Norway, Denmark, Finland and Sweden together, during 2008. These emissions are generated primarily by the American energy sector, which increased its emissions by almost 16 percent during the time period in question.

It is, however, important to mention that it is difficult to discuss the US as one example, as the situation varies depending on the state in question, hence also policies. Political decisions like those made in Sweden have been made in some cases in the US, but on a state level rather than at the federal level, which complicates the analysis. The general recommendations below are based on the situation for the entire US, but are probably of varying degrees suitable for the different states.
Against this background, more concrete changes can be discussed. As previously mentioned, the energy sector in the US accounts for the majority of the increase in greenhouse gas emissions in the US. The production of electricity and heating accounts for a 30 percent increase, and the transport sector for an increase of over 20 percent. President Barack Obama has introduced a type of eco-car premium which benefits the scrapping of old, fuel-thirsty cars and their replacement with new, fuel-efficient cars. The Swedish experience shows that a carbon tax, for both transport and energy production, could stimulate the consumption of more climate-friendly products without significantly hampering economic growth.

Unfortunately, there is today a strong resistance to a federal carbon tax which, it is believed, would have a negative effect on production. There are, however, variations on such a tax. In 2006, the city of Boulder in Colorado chose to introduce an inside-out carbon tax, according to which those citizens

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41 United States Department of Transportation
42 Prasad (2008)
who use renewable energy get a tax rebate. This initiative is presumed to have increased the production of renewable energy in this area, which in turn has led to lower prices and therefore to further incentives to use renewable energy. The city hopes, with the help of this project, to reduce its emissions by approximately 7 percent at the same time as creating new job opportunities in the production of renewable energy. The project is, however, still too new to be able to make a proper evaluation of its impact.
4. Conclusions

The reduction in emissions in Sweden between 1990 and 2008 seems to have been driven, to a large extent, by politically created incentives, regulations and (to a certain extent) technological development. The political decisions which have been made regarding carbon tax, energy standards with certificates for renewables, the European emission market EU-ETS, waste regulation and district heating have together created strong incentives for Swedes to consume in a more environmentally friendly way, while at the same time not hampering economic growth. Some of the reductions should also be accredited to technological development in, *inter alia*, the car industry, waste management and industrial combustion. The development of these technologies has not necessarily taken place in Sweden, but with the help of new state initiatives, there has been a market in which domestic and international actors can develop their environmentally-friendly technology and market it in Sweden. This is hopefully something that other countries can emulate.
When Sweden introduced the carbon tax in the early 1990s, it was the single price regulation of carbon emissions. Therefore, to introduce a new or extended carbon tax today could be considered difficult from a political perspective due to the pre-existing EU-ETS emissions trading system that already creates carbon pricing and regulates European-wide emissions in many sectors. However, many of the national initiatives that have been implemented in the field of climate protection are fully transferable to other countries. The Swedish carbon tax has both reduced emissions and created new markets, for example through bio fuel and waste powered district heating, which would be a desirable development in countries such as Italy, Poland and the USA, as well as Germany to a certain extent. Other measures, such as electricity certification and eco-car premiums, are also relevant.
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Between 1990 and 2008, the Swedish economy grew by approximately 50 percent, a respectable rate in an international comparison. During the same period, greenhouse gas emissions in Sweden diminished by approximately 12 percent.

This report presents an overview of how Sweden has accomplished these results, by examining the sectors in which these reductions have taken place and the measures which have contributed to them. The report also discusses how this experience can be used in other countries, which have not reduced emissions at the same rate.

The short answer to the question of how Sweden has managed to reduce its emissions is carbon tax, district heating and energy efficiency.