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CONTENTS

LIST OF ABBREVIATIONS

CO_2	Carbon dioxide
DTQ	Domestic Tradable Quotas
EU ETS	European Union Emissions Trading Scheme
GHG	Greenhouse gas
HFC	Hydrofluorocarbon
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
MWh	Megawatt hour
N_2O	Nitrous oxide
OECD	Organisation for Economic Cooperation and Development
PCA	Personal Carbon Allowances
PCT	Personal carbon trading
PFC	Perfluorocarbon
RAPS	Rate All Products and Services
SF_6	Sulfur hexafluoride
TEQ	Tradable Energy Quotas
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change

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SUMMARY

The importance of household consumption as a contributor to greenhouse gas (GHG) emissions has lately been emphasised in Sweden. It has for example been pointed out that emissions from Swedish consumption are around 25 per cent higher than those caused by production in the country. Linked to this debate, the interest for policies targeting consumption is also growing. Personal carbon trading (PCT) is one such proposed policy instrument, where GHG emissions from household consumption would be limited by an overall emissions cap. Citizens would achieve emissions allowances which could either be sold in the trading system or surrendered when purchasing fossil fuels or possibly other products, depending on the scope of the scheme. While PCT has been discussed and analysed in the United Kingdom (UK), it has been less investigated in the Swedish context. This working paper explores the idea of PCT and assesses its potential for reducing GHG emissions caused by household consumption, specifically in Sweden. The main PCT proposals to date are reviewed, and the effectiveness, efficiency and equity of PCT are assessed. To analyse the potential role for PCT in Sweden, the paper further reviews the sources of Swedish GHG emissions and the current policies to combat these emissions. The findings suggest that, given the expected costs linked to PCT, the existing set of Swedish policies, as well as the sources for heating and electricity supply in Sweden, a PCT scheme similar to those suggested in the UK would not be an efficient approach to reduce GHG emissions in Sweden. However, PCT-like suggestions as an attempt to address emissions embedded in supply chains or to distribute mitigation burdens between countries could be further explored.

1 INTRODUCTION

Voices arguing for a stronger consumption perspective within international and national climate policy are increasingly heard in the policy debate. It has been suggested that, in the very long run, equal per capita carbon dioxide (CO_2) emission rights within nations and across the globe is the only fair and justifiable alternative (e.g. Wicke *et al.* 2010). Not only does this reflect the call for equity between developed and developing countries, but also the need to shift the focus from emissions arising from production to emissions caused by individual consumption. Our lifestyles and individual choices are what ultimately drive the world economy and give rise to the emissions. The need for a consumption, rather than production, perspective in climate policy has also been emphasised by for example China, which is a large net exporter of CO_2 emissions (Hallding *et al.* 2009). However, such a shift represents a significant paradigm shift in international, as well as national, climate politics and discussions have only just started.

A concrete policy instrument that has been proposed to start translating the consumption perspective into practice is personal carbon trading (PCT), which would target the emissions of CO_2 caused by individuals. A PCT scheme would resemble production-oriented emission trading schemes, such as the European Union Emissions Trading Scheme (EU ETS), but apply to individuals instead of companies. The basic idea of a PCT scheme is that an overall emissions cap would be set according to some principle for the relevant jurisdiction, and the rights, or allowances, to emit CO_2 would be divided across the population. Emission allowances would be tradable, so that people who consume less than their allowance could sell their surplus to others and those who emit more would purchase emission allowances, at market prices. The overall emissions cap would be set by an independent body, and could be decreased gradually to meet the emission targets.

To date, PCT schemes have mainly been debated and assessed in the United Kingdom (UK) and Ireland. The concept has received attention as an instrument which offers several advantages compared to the existing repertoire of climate policy instruments. First, it potentially offers certainty in emission reductions, by specifying an overall emission cap, as compared with CO_2 taxes with more uncertain effects on emissions. This means that international and national emission targets could theoretically be more easily complied with since annual carbon budgets could be calculated. Second, by targeting individuals directly in a very visible and tangible way, it could more easily lead to changes in personal consumption behaviour than with more indirect instruments. If near zero emission targets are to be fulfilled in the long term, not only increased efficiency and technological improvements are needed but also changes in personal behaviour. Third, it has been seen as an equitable instrument, at several levels. Within the jurisdiction where it applies, citizens would obtain equal allowances (unless some other principle applies) regardless of income and purchasing power. By allowing for trading, individuals could also opt to increase their incomes by reducing emissions and selling surplus allowances. Globally, the adoption of a PCT in a country could mean that a consumption perspective on emissions is approached, if the allowances would not consider whether CO_2 was emitted domestically or abroad in the production of the consumed good or service, in a scheme where also goods and services were included. This is considered more fair by many.

However, at the same time, PCT schemes are associated with several critical disadvantages, which means that the political will and interest to adopt them is currently limited. First, the political feasibility is severely compromised by the fact that politicians are generally unwilling to impose tough restrictions and targets directly on individuals, i.e. their voters. Furthermore, there is a lack of incentive to start implementing a consumption perspective unless no other countries do the same and restrictions on consumption could potentially counteract measures to stimulate the economy. Second, its efficiency in terms of individuals' capacity to trade allowances in a rational way and its equitability in

terms of setting equal allowances for people with different needs have both been questioned. Third, the technical feasibility is currently not in place since a PCT scheme would require an agreed and robust emissions accounting framework as well as infrastructure for monitoring and trading. Fourth, a PCT scheme would not operate in a policy vacuum but would have to work within a pre-existing mix of other climate policy instruments, which already cover parts of individuals' emissions in a direct or indirect way.

In Sweden, there is a growing concern about and interest for the emissions caused by our consumption. In the autumn of 2008, the Swedish Environmental Protection Agency published a report which achieved much attention, a report stating that emissions stemming from consumption by Swedish citizens are around 25 per cent higher than those caused by production within the nation (Swedish Environmental Protection Agency 2008). Yet, mainstream measures for emissions accounting and reporting focus primarily on emissions from production within the country. Along with the increasing awareness of this paradox, the interest for policy instruments targeting consumption is also growing. As one such instrument, PCT was given attention at a seminar organised at the Swedish Parliament in the spring of 2010 and in the book *Vår beskärda del – en lösning på klimatkrisen* written by Jonstad (2009).

However, while the potential role for PCT has been analysed and debated politically in the UK, it has been less investigated in the Swedish context. This study aims to assess the potential of PCT to reduce the emissions from household consumption, and specifically to find out if PCT can be a feasible way to target the emissions caused by consumption by Swedish consumers. The working paper is structured as follows:

- Section 2 provides an introduction to the sources of GHG emissions globally and introduces how these emissions can be regarded from a consumption perspective;
- Section 3 introduces PCT as a policy instrument and provides a review of the PCT schemes suggested to date;
- In Section 4, PCT as a policy instrument per se is discussed and its effectiveness, efficiency and equity are assessed;
- Section 5 provides an overview of the Swedish emissions of GHGs;
- Section 6 provides an overview of the current attempts to combat these emissions in Sweden; and,
- Section 7 discusses the potential of PCT to reduce Swedish GHG emissions, based on sections 5 and 6, as well as the assessment in section 4.

2 A CONSUMPTION PERSPECTIVE ON GHG EMISSIONS

Globally, anthropogenic greenhouse gas (GHG) emissions arise mainly from four principal processes – CO_2 emissions from fossil fuel use (57 per cent), CO_2 release due to deforestation (17 per cent), methane emissions from agriculture, waste and energy systems (14 per cent) and nitrous oxide emissions from agriculture (8 per cent) (IPCC 2007). Although the other gases are much more effective than CO_2, they occur at much lower levels in the atmosphere and have thus a much lower effect on the climate. In Sweden for example, if compared in CO_2 equivalents (i.e. the emissions of the gas times its global warming potential), 78 per cent of the GHGs emitted from production consist of CO_2 emissions (figure 1).

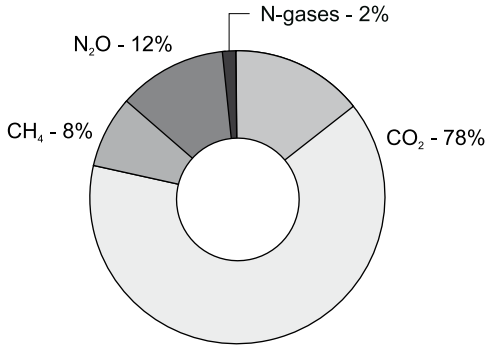

Figure 1: Swedish GHG emissions, compared as CO_2 equivalents, in 2006.
Source: Swedish Environmental Protection Agency (2007).

The traditional approach to emissions accounting, and the way by which emissions reporting is done according to the United Nations Framework Convention on Climate Change (UNFCCC), targets the emissions from national production. This is also the principle based on which current Kyoto emissions targets have been set. The Kyoto protocol provides binding targets for 37 industrialised countries and the EU. However, production is increasingly being shifted from developed to developing countries and emerging economies without binding targets. For many developed countries, emissions of GHGs caused by the production activities in various parts of the world needed to support the country's consumption now exceed the emissions caused by the national production (Ahmad and Wyckoff 2003). A study targeting the UK for example, suggests that CO_2 emissions from UK consumption have risen and were 18 per cent higher in 2004 than in 1992 (Wiedmann *et al.* 2008). During the same period, the total national production emissions reported declined by 5 per cent. At the same time, emissions in other parts of the world have increased. For China, it has been suggested that about one third of its carbon emissions is caused by production of products exported from the country.

Emissions from household consumption can be divided into *direct* and *indirect* consumer emissions. The *direct consumer emissions* stem from direct use of fossil fuel for household heating and vehicle use. *Indirect consumer emissions* do not occur directly when products are consumed, but further down in the supply chain during production and transports of the consumer items. Estimating such emissions is inherently much more complex than estimating the direct ones and requires knowledge of the exact production processes and transports throughout the entire supply chain.

Although a large proportion of our emissions originate from our consumption, and in spite of the fact that much production to satisfy consumption in many developed countries now take place in other parts of the world, policy instruments to reduce emissions often tend to focus on production within the countries. PCT however, offers an approach to target emissions caused by consumption, while at the

same time making those emissions visible to consumers. In the next section, different policy instruments will be discussed, after which a review of the PCT schemes suggested to date will be presented.

3 INTRODUCTION TO PCT AND REVIEW OF PCT SCHEMES

In the strive to decrease emissions of GHGs, various policies have been suggested and implemented around the world. When classifying policy instruments, different approaches have been proposed. In this text, we refer to the one suggested by Vedung (1997) who argues that all instruments can be classified into *regulation*, *economic means* and *information* (table 1). He speaks about the stick, the carrot and the sermon, by which governments either "force us to do what they want, reward us or charge us materially for doing it, or preach us that we should do it" (Vedung 1997).

While *regulatio*n is the traditional approach in environmental policy making, over the past decades, attention has increasingly been given to *economic instruments*. Economic or market-based instruments include taxes and emission trading schemes such as the EU ETS and PCT as discussed in this working paper. It has been suggested that economic instruments have the potential to stimulate more innovative and cost-effective solutions to pollution abatement than regulation. In addition, it is sometimes argued that economic instruments require less information when the policy is set and that they have the potential to encourage the development of more efficient production technologies. However, regulatory instruments often achieve their objectives faster and with greater certainty than economic instruments. It is also suggested that with economic instruments, monitoring may often be more challenging and tax interaction effects are likely to be larger (Harrington *et al.* 2004).

Often, however, the three basic types of instruments tend to be complementary and a mix of different policy instruments rather than a single one may often be the most effective alternative to reach the desired goal.

Table 1: Different types of policy instruments, as suggested by Vedung (1997)

Type of policy instrument	Explanation
Regulation	Rules and directives formulated by government units that the addressees of the instrument need to comply with.
Economic policy instruments	Involve distributing or taking away material resources. The addresses of the instrument will benefit financially if they take certain actions that will contribute to the achievement of the goal intended with the instrument, but they are not forced to take such actions.
Information	Includes all attempts to influence people through knowledge transfer, communication of reasoned argument and persuasion.

In addition to making the distinction between regulation, economic instruments and information, in this text, it is also relevant to distinguish between instruments focusing on *consumers* versus those targeting *producers*. Two of the most common environmental economic policy instruments are *taxes* and *emissions trading*. While taxes have long been directed both to consumers and producers, emissions trading has so far in practice only targeted producers.

A tax to decrease emissions caused by fossil fuel use increases the fuel price, thereby creating an incentive for decreased fossil fuel use. The idea of carbon trading is instead that emissions are restricted by emission allowances that have to be surrendered upon purchase of fossil fuel. The number of emission allowances distributed is based on a decided maximum level of CO_2 emissions from the sectors included in the trading system. Trading is allowed so that those who wish to emit more than

their allowance can purchase emission allowances from others with a surplus of allowances. In this way, carbon trading also tends to increase the price of fossil fuels.

A carbon trading scheme could potentially cover the entire economy and all its emissions of fossil fuels, but the schemes suggested more often cover only certain parts of the emissions, by applying to certain sectors of the economy. One such trading system is the EU ETS, which mainly includes energy producers and some large industries.

A basic choice in the design of a carbon trading scheme is the one between a *downstream* scheme, where fossil fuel use is restricted by requiring users to surrender allowances when purchasing fuels, and an *upstream* scheme where instead fossil fuel producers need to surrender allowances. Upstream schemes place a cap on carbon emissions from the whole economy, while most downstream schemes caps the emissions of a subset of the economy. As will be described below, there are some suggestions of trading schemes where the upstream and downstream approaches are combined.

Most PCT schemes can be regarded as downstream schemes focusing on the fuel consumption by individuals. In Europe, studies and assessments of PCT have mainly focused on the British and Irish context. Among the PCT schemes suggested in the UK, some include both fuel consumption by individuals and organisations, whereas others target fuel use of individuals only, leaving other mechanisms to target the fuel used by organisations. But PCT or PCT-like schemes have also been suggested in countries such as the USA and Canada.

A review has been carried out of the PCT schemes suggested to date. The main focus for this review has been:

- emissions covered by the suggested scheme; and
- target group for the scheme, i.e. producers versus consumers, and the different types of producers/consumers targeted.

The results of the review are provided in table 2 and the proposals reviewed are also briefly described further in the text below.

Downstream PCT schemes

Many of the suggested PCT schemes share some common features. These include *the carbon cap*, which is often suggested to be set by an independent committee, based on a national emission reduction target. The carbon cap could be reduced each year, to reach the desired goal successively. *Emission allowances* would be distributed, most often to the adults in the country, based on some principle. Emission allowances have to be surrendered upon purchase of (most often) fossil fuel or electricity and the participants of the scheme (often adult individuals) are allowed to sell and purchase emission allowances, a process which is facilitated by banks and other market makers. The schemes then vary somewhat regarding what goods and services and thus what emissions that are included, as well as to what extent organisations are included and whether and how children should be included.

The *Tradable Energy Quotas, TEQs* suggested by Fleming (2005) and the *Domestic Tradable Quotas, DTQs* suggested by Starkey and Anderson (2005) are to a great extent similar. The DTQ and the TEQ schemes deal with the emissions from energy use within a country, including consumption of gas, electricity, coal, oil and road fuels, by individuals and by organisations, including governmental organisations. The main difference between the two schemes is that DTQ also includes aviation. The carbon allowances would be divided into two parts, representing the emissions that different sectors

Table 2: Overview of PCT schemes.

Scheme	Emissions covered	Target group
Domestic Tradable Quotas (DTQ)	Emissions caused by domestic use of fossil fuel and electricity by individuals and organisations (e.g. for heating, transport including aviation, in production).	All consumers of fossil fuel and electricity within the country, including: • households/individuals • public organisations • companies.
Tradable Energy Quotas (TEQ)	Emissions caused by domestic use of fossil fuel and electricity by individuals and organisations (e.g. for heating, transport but excluding aviation, in production).	All consumers of fossil fuel and electricity within the country, including: • households/individuals • public organisations • companies.
Ayres Scheme	All emissions of CO_2 from combustion of fossil fuels, during production as well as for household use. Imported goods would be targeted by border adjustments.	All consumers (including organisations) need to surrender allowances when purchasing fuel and electricity, but all allowances are allocated to citizens from whom organisations need to purchase allowances.
Personal Carbon Allowances (PCA)	Emissions caused by household use of fossil fuel and electricity (e.g. for heating, transport, including aviation, but excluding public transportation).	Households/individuals.
Rate All Products and Services (RAPS)	Emissions caused by household use of fossil fuels and electricity (i.e. for use in homes and for transport) *and* indirect emissions occurring during production of products and services purchased by households.	Households/individuals.
Hybrid Schemes	Emissions caused by all use of fossil fuels and electricity used by households and organisations (some suggestions exclude those organisations that are included in the EU ETS).	Fossil fuel producers (consumers would be affected by the increased fuel prices).
Sky Trust	Emissions caused by all use of fossil fuels and electricity, by households and organisations.	Fossil fuel producers (consumers would be affected by the increased fuel prices).
Cap and Share	Emissions caused by all fossil fuel use, globally.	Fossil fuel producers purchase emission permits from households.
Cap and Dividend	Emissions caused by all domestic use of fossil fuel, from foreign as well as national producers.	Fossil fuel producers.

are currently responsible for in the UK. In this way, 40 per cent of the allowances would be allocated for free to all adults for domestic use and the other 60 per cent would be auctioned to organisations. Individuals could sell their allowances to banks and later on purchase them alongside energy purchases. Tourists would have to purchase emission allowances in order to be able to purchase fuel and energy (Roberts and Thumin 2006).

While the TEQ and the DTQ schemes include the use of fossil fuels and electricity by both individuals and organisations, the *Personal Carbon Rationing* or the *Personal Carbon Allowances* scheme, *PCA*, suggested by Hillman and Fawcett (2004) includes the use of fossil fuels by individuals only. It is presumed that another scheme like the EU ETS would work alongside the PCA scheme to manage emissions from organisations. Adults as well as children would receive annual emission rations, although those of children would be smaller. The emissions targeted are those from household energy use and personal travel, including aviation, but excluding public transportation since this helps to discourage personal car use.

Apart from the DTQ, TEQ and PCA schemes, some other, sometimes less developed, suggestions have been mentioned in the literature. Ayres (1997) for example suggests that trading systems targeting individuals could be applied for a range of environmental problems. Governments would have to specify the total quantity of the substance or emissions that is to be allowed within the country the following year. This would be divided by the number of adults in the country, which would provide the individual quota. Producers need to specify the content of the substance within the products, and the information would be included in the product label. All steps in the supply chains would have to be included.

While the PCA, DTQ and TEQ schemes include use of electricity and fossil fuel only, the *Rate all Products and Services scheme, RAPS*, suggests that 100 per cent of the UK emissions rights are allocated to individuals. Not only would emissions caused by consumers' use of electricity and fuel be included, but also all emissions embedded in the production of consumables, food and services (Starkey and Andersson 2005). Whenever an individual purchases any product or service under this scheme, carbon allowances would have to be surrendered corresponding to the GHG emissions occurring during production and transport of the product. In this way, individuals would be held responsible for all their emissions, both the direct and indirect ones. Such a scheme would at the same time include difficulties, since estimating emissions that occur throughout the supply chain while producing products would be very complex. Starkey and Andersson (2005) suggest that an easy-to-use and cost-effective scheme of this type is unlikely in the short and medium term.

Suggestions of *voluntary trading schemes* have also been made. Such schemes could be similar to the ones described above, but with the difference that participation is not mandatory. Such voluntary schemes could be useful to engage people to reduce their carbon emissions and could provide useful data on how people managed their carbon allowances. Voluntary schemes could also be such that rewards would be given for staying within a given carbon allowance, but no penalties for exceeding it (Roberts and Thumin 2006).

Upstream and hybrid carbon trading schemes

To overcome some of the problems connected to a downstream carbon trading scheme, including potential costs, practicability and political feasibility, a *hybrid* approach has been suggested (Mazurek 2002). A hybrid scheme would include trading by both *producers* and *users* of fossil fuels. In this way, it is suggested that the scheme would capture emissions from more sources than a downstream scheme. A hybrid scheme could potentially combine the benefit of an upstream and those of a down-

stream scheme, by controlling more emissions by including upstream producers, and by potentially trigger innovations similar to the idea with a downstream trading scheme.

An upstream scheme has also been suggested to work alongside the EU ETS (Environmental Audit Committee 2008). Fossil fuel producers would be responsible for the carbon content of fuel sold to downstream consumers not participating in the EU ETS and would have to surrender allowances when selling fuels. The cost of the allowance would in this way be passed on to consumers, and would appear like a tax on carbon-intensive goods and services.

A suggestion of an upstream trading system targeting suppliers of fossil fuels while at the same time including citizens, by distributing the income from the scheme to individuals, is called *Sky Trust*. In this upstream trading system, permits would be auctioned to fossil fuel producers. The revenues from this auction would be invested into a trust, which pays equal dividends to all citizens. The system focuses on organisations, i.e. fossil fuel suppliers, but will affect users – organisations as well as individuals – of fossil fuels and appear to these as a carbon tax (Roberts and Thumin 2006).

Another scheme, *Cap and Share,* which targets the upstream side, while at the same time involving individuals, has been suggested by the Irish NGO Feasta (2008). Emissions allowances would be distributed to all adults who could either sell their permits via banks and post offices or destroy them. Fossil fuel producing companies would have to purchase permits from these banks and post offices to cover emissions from the oil, gas and coal that they sell. This scheme has also been suggested as a global policy instrument. The total CO_2 emissions allowed would be decided internationally, by a maximum emissions cap that is revised yearly. National climate protection trusts would divide the emission rights to the citizens.

A scheme which is similar to the Cap and Share scheme is called *Cap and Dividend,* has been suggested as a national scheme in the USA. The emissions of CO_2 are targeted by limiting the total amount of fossil-fuel carbon that enters the US economy. This is done by establishing a cap, a limit on how much fossil-fuel carbon that is allowed to enter the economy yearly. This includes both fossil fuel produced within the country and such which is imported. The cap would gradually decrease over time. Based on this cap, permits are auctioned to firms that bring carbon into the economy – whether through domestic extraction or through imports. The revenue from the sale of permits is deposited into a trust fund and distributed equally to adults and children (Boyce and Riddle 2007).

Concluding remarks

Among all the schemes suggested, it is primarily the PCA scheme that has been discussed and assessed in the UK since it has been assumed that any PCT scheme targeting individuals would work alongside the already existing EU ETS. In addition, a PCT scheme including all the emissions embedded in the production of goods and services has been regarded as far too complicated as there does not currently exist any easy way to correctly estimate the emissions occurring during production through all the various steps of the supply chain. Because of this, it is a scheme targeting the direct consumer emissions, i.e. emissions from fossil fuel use for home heating, transport and use of electricity that has been targeted. In the next section, the potential of PCT to reduce these direct emissions from consumers is assessed, primarily based on the analyses made within the UK.

4 ASSESSING THE EFFECTIVENESS, EFFICIENCY AND EQUITY OF PCT

Having reviewed the main suggestions of PCT schemes, in this section, we seek to assess the potential of PCT to reduce direct consumer emissions, taking into consideration the assessments made in the UK. Policies may be evaluated after their implementation, so called *ex post* evaluation, or before their implementation, which is referred to as *ex ante* evaluation. Ex ante evaluations may often involve quantitative modelling, seeking to estimate the potential benefits of different policy options, based on data about the environmental problems and the economic context (OECD 1997). Although it would be interesting to study the potential effects of implementing PCT by means of a modelling approach, it is beyond the scope of this study.

For *ex post* evaluations, various criteria have been suggested by different authors. Two of the most common criteria occurring in the literature are *effectiveness* and *efficiency* (e.g. Vedung 1997 and OECD 1997).

Effectiveness refers to the degree of goal achievement, i.e. the outcomes of a policy are compared with the intended effects while disregarding the costs. For environmental policies, it is often the environmental effectiveness that is in focus, i.e. the level of achievement of the particular environmental objective. However, there are also other effects that can be targeted. OECD (1997) mentions also *wider economic effects, dynamic effects and innovation,* and *soft effects.* The *wider economic effects* refer to impacts on price level, technical innovation, income distribution, employment and trade. *Dynamic effects and innovation* refer to the way by which the policy instrument stimulates innovation in for example pollution control technologies which in turn may contribute to the goal achievement in the long term perspective. *Soft effects* include among other things changes in attitudes and awareness among citizens.

Efficiency also refers to the effects caused by the policy but in this case, not only the effects but also the costs are regarded. Here, the evaluation looks into whether or not the policy instrument has enabled a more cost-effective achievement of the specific policy objectives, compared to some other policy. The costs in focus are the direct costs of achieving the changes in polluter behaviour, including abatement costs by both households and individuals. For businesses, this may include costs for abatement equipment and costs for operating less polluting production technologies. For households, the costs could include measurable expenditures and costs of changes in consumption patterns (OECD 1997).

In addition to these costs for businesses and households in abating pollution, other costs could also be considered. *Administrative and compliance costs* relate to costs for administrative bodies to apply the instruments, as well as the corresponding costs among companies and households that are subject to the instrument. Revenues generated by the policy may also be targeted in the assessment. Administrative and compliance costs and revenues could also be regarded as separate criteria, but are in this text included and considered under the efficiency criterion.

As mentioned, one can distinguish between dynamic and static effects which can be of interest both in the discussion about effectiveness and in the one about efficiency. Harrington *et al.* (2004) distinguish between *static* and *dynamic* efficiency when comparing economic instruments with regulation. Dynamic efficiency refers to the efficiency in encouraging for example technological innovations, while static efficiency refers to the efficiency in achieving the direct reduction in pollution.

Although no PCT scheme has yet been fully implemented, in the following assessment, the criteria *effectiveness* and *efficiency* often used in *ex post* evaluations will be utilised. We will explore effectiveness in terms of:

- *static effects*, looking into the direct effects and the achievement of the goal of decreasing household emissions of GHGs, in a direct sense;

- *dynamic effects*, including here the more long term effects such as the potential of encouraging the development of new technologies and products that lead to further reductions in emissions; and

- *soft effects*, including effects such as changed consumption patterns due to attitude changes rather than as an effect of increased costs and limited availability of carbon allowances.

When discussing efficiency in relation to PCT, we will look at the expected effects of the policy instrument and compare these to the expected costs. The expected costs in this case are primarily *administrative and compliance* costs.

A common argument for personal carbon allowances is the equity aspect – an equal per capita allowance to emit carbon dioxide is by many regarded as "fair". When assessing the *equity* of PCT, we will include *if* and *how* the policy instrument affects people differently – if it can be regarded as a fair way to reduce carbon emissions, and how the implementation of the policy might affect the distribution of costs and benefits among different socio-economic groups. Equity can relate both to distributions between different groups within a country and across developed and developing nations. However, most of the PCT schemes targeted in this working paper are suggested as national policy instruments, so the equity discussion will primarily focus on the national perspective. The three criteria used in this working paper are listed in table 3.

Table 3: Explanation of the criteria used in the PCT assessment in this working paper.
Partly based on Vedung (1997).

Criterion	Explanation
Effectiveness	Degree of goal-achievement, disregarding the costs.
Efficiency	Programme effects, either monetarized or in physical terms, through monetarized programme costs.
Equity	Concerns the fair treatment of individuals by the authorities and how benefits and costs of policies are spread among those affected.

Effectiveness

One of the first questions to ask before starting to assess the potential effects of PCT is whether it would at all be feasible to implement such a system and whether it could function in practice. In the UK, much attention has been given to the question of the technical feasibility to introduce a system for carbon allowance transactions and for registering purchases of fossil fuel, including questions such as how fuel purchases would be registered, what types of cards that would be required and what types of accounts. However, Starkey and Andersson (2005) as well as Bird and Lockwood (2009) conclude that it would be technically feasible to set up and run a PCT scheme now, using an amended version of banking systems and their existing infrastructure for transactions and trading.

Other issues that affect the feasibility of PCT include political and public acceptability. Studies in the UK suggest that a PCT scheme would be more acceptable than a carbon tax (e.g. Bristow *et al.* 2008). However, such public preferences are very much linked to the context in the specific country and also dependent on the design of the PCT scheme versus the carbon tax.

Static effects

The expected static effects of most PCT schemes include decreasing the direct emissions caused by individuals' use of fossil fuel and electricity. The potential of achieving the stated emission abatement goals has often been pointed out as a main advantage of PCT. Emissions are expected to remain within the regulated cap since allowances to emit beyond this cap will not be available. The price of the tradable allowances depends on the level of the cap and on the demand of allowances, which is linked to the responsiveness of people to the carbon price in the market. If people are responsive, emissions are likely to decline smoothly when the cap decreases, and the price of carbon allowances will remain relatively low. But if people are very unresponsive, the price could become very high (Kerr and Battye 2008).

As Bird and Lockwood (2009) point out, few governments would be willing to expose themselves to the risk of introducing a cap and trade system where the price of carbon allowances could go infinitely high, which could among other things lead to fuel poverty for poorer households. Because of this, they argue, the most feasible PCT alternative seems to be a soft cap where the government would sell additional allowances into the market to prevent the price from going higher than a certain level. Another option would be a *hybrid* scheme, i.e. one that combines tradable allowances and taxes as suggested by Kerr and Battye (2008). In such systems, the cap and trade system is replaced by a tax when the price of the tradable permit becomes too high. Both these alternatives however would mean that there could be no guarantee that the emission reductions aimed for would be achieved.

Like a carbon tax, a trading system would increase the cost of fuel. A comparison between fuel prices and fuel use in the UK indicates that people's responsiveness to changes in fuel prices is quite low (Bird and Lockwood 2009). This suggests that neither a carbon tax nor a trading system would have the ability to significantly decrease people's fuel consumption. However, other studies suggest that the long term impact of carbon taxes is significant, and average fuel consumption of cars in Europe is significantly lower than in the USA due to the long term effects of higher fuel prices (e.g. Nilsson *et al.* 2009).

But a PCT scheme can be expected to influence people's fossil fuel use and electricity in other ways than merely as an effect of the higher price. The increased visibility of the carbon emissions that a PCT scheme brings about may drive people towards greater emissions abatement than the pure price effect would, since it could bring climate change to the forefront of people's decision making. In addition, as pointed out by for example the UK House of Commons (2008), the potential to save and even make money could motivate those with no interest in environmental issues. While the carbon tax only penalizes people who use more fuel than their allowance, a PCT scheme would also reward those making efforts to change. In this sense, PCT would combine the carrot with the stick, as described by Vedung (1997).

Dynamic effects

In addition to achieving direct emission reductions, PCT can also be expected to achieve long-term effects such as effects on technological innovations and development of new products stemming from increased consumer demand for low-carbon products, such as household appliances with low energy requirements, new equipment for energy savings in homes and clean vehicles. Such increased demand is by many regarded as one of the benefits of a climate policy instrument targeting consumption.

However, it is uncertain how large this effect would be. The effectiveness of downstream trading schemes depends on how well the downstream market functions, including access to information, availability of alternative products etc (Roberts and Thumim 2006). Kerr and Battye (2008) point out that compared to companies, individuals are less likely to have the information, time and desire to

adopt the costs needed for energy efficiency investments, and as pointed out by Bristow *et al.* (2008), large investments in energy efficient products may require further education with respect to more unfamiliar energy products. Further, depending on the type of dwelling, there are sometimes misaligned incentives. Landlords tend to underinvest in energy saving equipments if the energy cost is held by the tenants, and tenants may avoid investing if they do not benefit from the investment.

While consumers can increase the demand for low-carbon products, their incentive to demand low-energy production methods is limited – unless also products and services are included in the scheme as suggested in the RAPS scheme. To influence also production methods, trading schemes targeting companies are more suitable (Mazurek 2002).

Further, a PCT scheme could potentially help increase demand for low-carbon energy sources. However, if PCT should contribute to changes in energy production, there must be an option for consumers to choose the source of electricity depending on the emissions of GHGs during the production of it, and fewer allowances should have to be surrendered for electricity with lower emissions of CO_2. There is however little discussion about this in the reviewed literature.

However, it is not only changed behaviour and new products that are required for people to reach desired emission reduction targets. Measures such as new infrastructure and improved public transportation are likely to also be required. A study by Bristow *et al.* (2008) showing that individuals are only able to reach emission reductions by about 20 per cent, suggests that supporting measures, such as improved infrastructure for public transportation, may be needed to go beyond this reduction.

Soft effects

In addition to the static and dynamic effects discussed above, PCT may also affect people's consumption patterns in the long term in more subtle ways. Bird and Lockwood (2009) suggest that the spreading of norms that a PCT scheme may lead to could have long-term effects on people's behaviour and consumption patterns, beyond those behavioural effects that could give rise to emissions reductions in the short term. However, it is difficult to assess the potential level of such long term effects.

Efficiency

Assessing the efficiency of a policy instrument means assessing the costs to achieve the policy goal and comparing these to the costs of another policy instrument, which would give the same goal achievement. In general, a downstream approach like PCT targeting many small emitters is expected to lead to higher transaction costs, compared to an upstream taxation and upstream systems focusing on the production of fossil fuels (Kerr and Battye 2008). However, Kerr and Battye (2008) point out that although standard economic theory would suggest that a downstream trading system is less efficient than an upstream one or a carbon tax, standard economic theory does not necessarily represent well empirical evidence of human behaviour. As suggested previously, the increased visibility of CO_2 emissions that a PCT scheme would lead to could imply that people make emission reductions beyond what would have been caused by the price effect, although it would be difficult to estimate such effects.

In the UK, analyses have been made to compare the potential emissions reductions that could be achieved with a PCT scheme, with the expected costs. According to analyses by the UK government comparing potential reductions, in monetarized terms, with the expected costs, PCT would be a very expensive way of achieving a relatively small amount of additional emissions reduction. In these estimates, the administrative costs of setting up and running the scheme were found to be more than 15 times the value of the potential additional benefits – between 2013 and 2020, PCT is expected to deliver only 5 million tonnes of additional CO_2 emissions abatement, at a cost of £500 per tonne (Bird and Lockwood 2009).

However, Bird and Lockwood (2009) question many of the assumptions made in the assessment of the costs and benefits of PCT by Defra (the UK government department for environment, food and rural affairs) and propose other assumptions. By comparing the expected costs and the expected additional emissions reductions that a PCT scheme could potentially achieve, they come to the conclusion that to be cost effective, a PCT scheme would have to bring emissions abatement of around 10 per cent of 2013 emissions. In their estimation, however, also with their more optimistic assumptions, they found that the potential for PCT to add to the abatement until 2020 is in the range of only 3.5-8.5 per cent of 2013 emissions. The conclusion is thus that also with these lower cost estimates, a PCT scheme in the UK context would not be cost effective.

Equity

A benefit often emphasised by the proponents of PCT is the equity aspect of allowing all citizens to emit equal amounts of GHGs. According to Starkey (2008) it has been proposed that rights to emit GHGs should be allocated between nations on an equal per capita basis at least since 1988. Since then, several other suggestions have been made regarding how to distribute the rights to emit GHGs in a fair way between nations, as well as how to distribute the costs for the climate mobilization among different socio-economic groups. One of these proposals is the Greenhouse Development Rights Framework, suggesting how to reduce global emissions of GHGs, while at the same time allowing nations to develop (Baer *et al.* 2008). Another, recent suggestion by Wicke *et al.* (2010) proposes that equal per capita emission rights and a consumption perspective on GHG emissions would be a fair way to address the climate change problem globally, and one that could appeal also to developing countries and be a way to include all nations in a global climate agreement. However, most of the PCT schemes that have been analysed in the UK, as well as those discussed in this paper, are concerned with how to distribute the rights to emit GHGs *within* nations.

Starkey and Andersson (2005) point out that while many seem to assume that an equal per capita ratio of the right to emit carbon is equitable, few support this by evidence from literature. In a review on justice, Starkey (2008) comes to the conclusion that neither equal per capita rations between nor within nations, can be regarded as straightforwardly fair. People in different parts of the same country can live under different weather conditions, access to public services may vary as well as house types, all of which give households different starting points for decreasing their use of electricity and fossil fuels. In a study carried out by the Institute for Public Policy Research, IPPR, 70 per cent of the respondents agreed with the statement that PCT with equal per capita allocations would be unfair (Bird and Lockwood 2009). Participants with poor public transportation for example argued that they should have more than average allocation.

Starkey (2008) proposes that to be fair, personal carbon allocations would have to take into account factors beyond the immediate, short-term control of individuals, including location, number of children and age. Yet, Bird and Lockwood (2009) suggest, based on a study in the UK, that around 30 per cent of all households in the bottom three income deciles would be worse off, *both* under an equal per capita allocation of allowances *and* under an allowance scheme with modified rules, than without any scheme. To avoid this, low-income households could be compensated. Another approach to overcome potential unfairness connected to a PCT scheme would be to initially distribute allowances equally, but to hold back some for people who submit successful applications for additional allowances, as suggested by Hyams (2009). This would require a set of clear criteria and a system for fairly assessing the applications from those claiming their right to extra allowances.

Such suggestions would however further increase the administrative costs of the PCT scheme. In addition, a system with modified rules could potentially create incentives for people to continue pursue life styles that are not perceived as desirable in a low-carbon society, which would counteract the aims

Table 4: Advantages and disadvantages linked to PCT in relation to each criterion.

Criterion	Advantages	Disadvantages
Effectiveness	The increased visibility of the trading system could drive people towards greater emissions abatement than a pure price effect.	Under a soft cap or a hybrid tax/trading system, which are the two most likely options, there is no guarantee that the emission reduction target will be achieved.
	May stimulate the development of low energy household appliances, new technologies to decrease energy use in homes or alternatively fuelled vehicles.	It is unclear to what extent PCT could enhance technological development, since individuals don't always have the information, time or desire to make optimal investments.
	Could increase demand for low-carbon energy sources, if the source of electricity could be selected.	PCT targeting individuals' direct emissions will have little effect on production methods and the emissions caused by them.
		There are limits to how large emission reductions actions by individuals only can lead to. Supporting measures such as new infrastructure and public transportation are also many times required.
Efficiency		Analyses made in the UK suggest that a PCT scheme is not expected to be cost effective.
Equity		To be fair, a PCT scheme would have to take into consideration different situations for people – e.g. access to public transportation, weather conditions etc. This would in turn create difficulties regarding how to allocate emission allowances, and would create incentives for people to continue carry out unsustainable life styles.

of the PCT scheme. There would further be a risk for misjudgements and potential biased assessments of the applications.

There is also, as pointed out by Bird and Lockwood (2009), a risk that some individuals would be particularly vulnerable and require support and assistance to understand how the PCT scheme works and how to decrease their emissions. They even suggest that a widespread education programme may have to be introduced several years before any PCT scheme would come into operation, in order to develop the above mentioned skills among the broad public. All of this would likely further increase the costs of the scheme.

Concluding remarks

To summarise, although PCT cannot guarantee that emissions stay within the decided emissions cap, it could potentially lead to larger emission reductions than a tax scheme because of its ability to make emissions more visible to consumers and due to the potential of earning money from the system. However, the size of these effects is difficult to estimate. A PCT system could foster development of new technologies and products, such as low-energy household appliances, technologies to decrease energy use in homes and clean vehicles. However, it is not obvious that this could be achieved to any greater

extent, due to lack of information and knowledge among consumers. In addition, the ability for PCT to achieve changes in production methods appears to be limited. If people are to reach major change in their use of fuels, supporting measures such as new infrastructure would also likely be needed.

Even with relatively optimistic assumptions made in the UK context, the potential costs that a PCT scheme would bring about are too high to be justified by the benefits. A PCT system with equal per capita emission quotas is not expected to be equitable since for example people in different parts of the country have different access to public transportation. However, constructing a PCT system with adjusted allowances would be complex and the system would lead to additional costs. The pros and cons of PCT in relation to each criterion is summarised in table 4.

5 OVERVIEW OF SWEDISH GHG EMISSIONS

Having reviewed the main proposals of PCT schemes and assessed their potential effectiveness, efficiency and equity, in the following, we focus on how PCT could fit in the Swedish context. This is done by first briefly reviewing the Swedish sources of greenhouse emissions, the trends in these emissions and the Swedish emission targets in this section, after which the current Swedish policy mix to combat these emissions will be reviewed and evaluated in section 6.

When viewing the emissions from the traditional production perspective, the largest contributor to territorial GHG emissions in Sweden is the transport sector, followed by energy supply (Sweden's National Inventory Report 2008). This is slightly different from many other European countries, where energy supply generally plays a larger role (figures 2a and 2b). The large share of nuclear and hydro energy sources used for energy production in Sweden explains the lower contribution from energy production and contributes to the relatively low per capita GHG emissions.

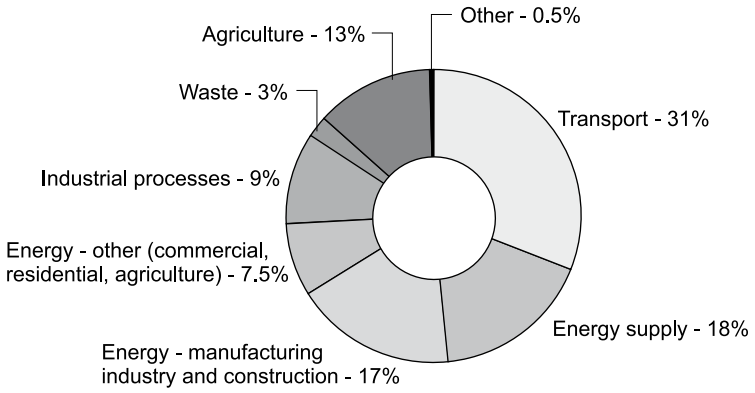

Figure 2a: Sources of GHG emissions in Sweden.
Source: Sweden's report to the UNFCCC, data from 2006.

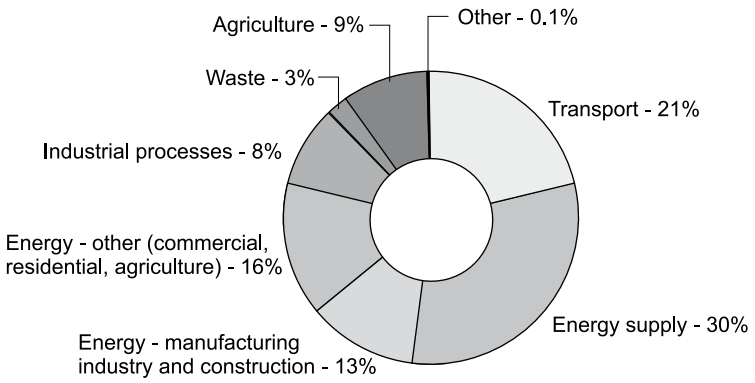

Figure 2b: Sources of GHG emissions in EU15.
Source: EU report to the UNFCCC, data from 2006.

Emissions of methane mainly stem from agriculture and waste deposits, but around 7 per cent is emitted in the energy and transport sector and from industrial processes. Most of the emissions of N_2O (69 per cent) originate from agriculture, but also from energy production, waste water handling and industrial processes. Emissions of fluorinated gases (PFCs, HFCs and SF_6) originate primarily from aluminium production, leakages from refrigerators and air conditioning systems, foam plastic manufacturing and foam plastic products.

Trends in Swedish GHG emissions

Globally, emissions of GHGs increase – between 1970 and 2004 global emissions increased by 70 per cent (IPCC 2007). At the same time, in Sweden, the emissions of GHGs seem to decline. Between 1990 and 2006, the Swedish emissions decreased by around 6.3 million tonnes (about 8.7 per cent), with current emissions in CO_2 equivalents totalling 65.7 million tonnes (Sweden's National Inventory 2008). For the EU-27, the GHG emissions also decreased by 7.7 per cent during the same period (EEA 2008). Similarly, Swedish per capita emissions have decreased, from 8.4 tonnes per capita in 1990 to 7.2 tonnes per capita in 2006.

The largest reduction in the Swedish emissions of GHGs has occurred in the energy sector. The main reason for this decline is that the use of oil for heating in the residential and service sector have decreased and has been replaced mainly by district heating based on biomass fuels (figure 3). CO_2 taxes, rising oil prices and subsidies for connecting to the district heating network have led to a decrease in the total use of fossil fuels.

In the transport sector however, emissions have gradually increased, the main reason being an increase in the emissions from road traffic, where heavy goods traffic accounts for the largest proportion of the increase.

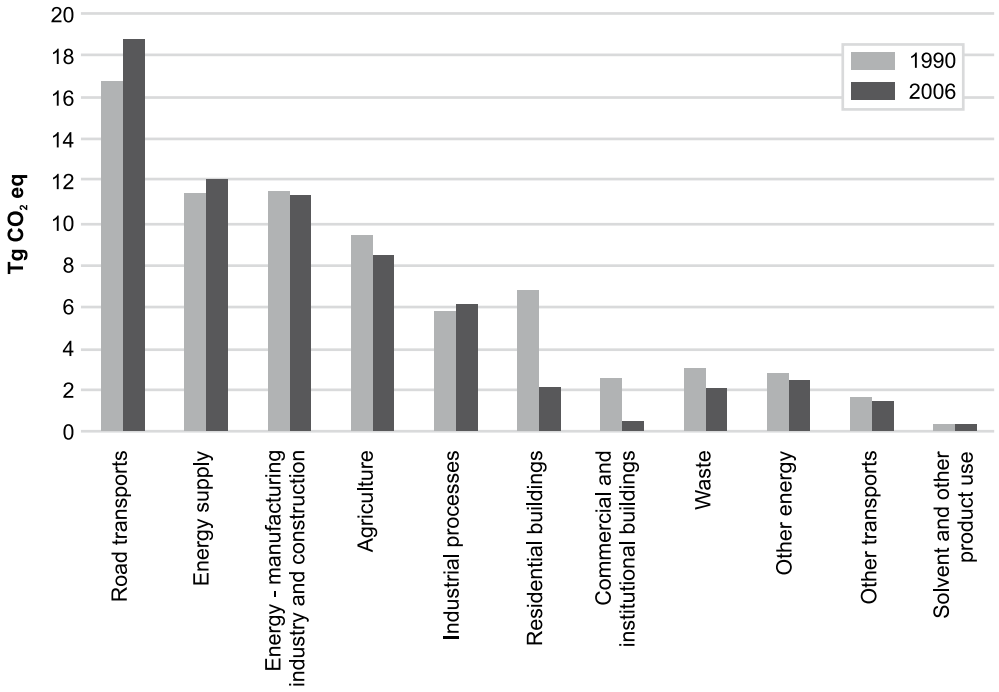

Figure 3: Swedish GHG emissions (in Gg CO_2 equivalents) in 1990 and in 2006.
Source: Swedish report to the UNFCCC.

Emissions of CO_2 from industrial combustion have been fairly stable in recent years. From the 1970s, manufacturing industries have decreased their use of oil and electricity. Between 1992 and 2006 however, fossil fuel use has increased. Due to improvements in energy efficiency, both use of oil and electricity per production value decreased between 1992 and 2006.

However, the emissions reported according to the UNFCCC format do not include international transports. If international transports by flight and over sea is added, Swedish emissions do not decrease, but are instead stable (figure 4). Thus, while the UNFCCC reporting format is the most comparable one, it omits this emission source which in the case of Sweden is significant and growing.

Sweden's emission targets

Before reviewing what policy instruments are in place today, it is relevant to consider what policy objectives and targets that have been formulated by the Swedish government. According to the Kyoto protocol, since EU member countries share the emission reduction target, Swedish emissions of GHGs can be up to 104 per cent of those in 1990, during the period 2008-2012. The Swedish Parliament however decided in 2002 that average emissions during this period should instead be 4 per cent lower than those in 1990 (Swedish Government 2006).

By 2006, Sweden had reduced its emissions by 8.7 per cent from the base year 1990 (EEA 2008b). This means that the Kyoto target and the national target to reduce emissions by 4 per cent have been achieved and exceeded.

However, more ambitious mid- and long-term emissions targets have been set. The EU member states are committed to achieve a reduction of at least 20 per cent of their GHG emissions until 2020 and are ready to reduce emissions by 30 per cent under a new global climate change agreement. Further, in 2020, 20 per cent of the energy consumed in the EU should come from renewable sources, energy efficiency should be increased by 20 per cent, and the percentage of biofuels should be at least 10 per cent (CEC 2008a). The climate goals for the EU should be partly reached by the EU ETS, with about 60 per cent of the reductions to be achieved in these sectors (CEC 2008b). For sectors not included in the EU ETS, including transport, housing, agriculture and waste, national targets have been proposed. The Swedish Parliament has decided that for the sectors not included in EU ETS, the emissions should be reduced by 40 per cent by 2020, compared to the levels in 1990 (Swedish Gov-

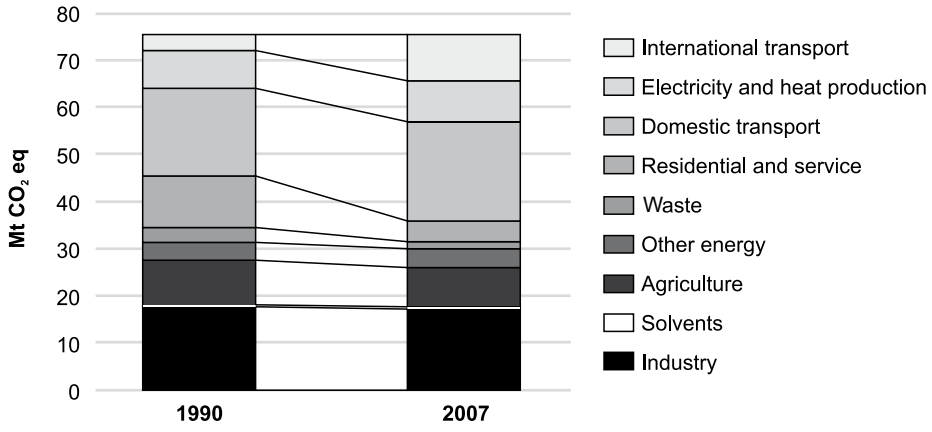

Figure 4: GHG emissions in Sweden in Mtonnes CO_2 equivalents with international transports added (includes fuel purchased in Sweden)
Data from Sweden's National Inventory, 2009.

ernment 2009). Further, the use of fossil fuels for heating buildings should no more be used in 2020 and in 2030, the Swedish vehicle fleet should no more be depending on fossil fuels. For year 2050, it is suggested that Sweden should no longer have any net emissions of GHGs.

Swedish emissions from a consumption perspective

From a GHG emissions reduction perspective, the overall picture for Sweden appears rather positive due to historical and recent political decisions related to for example energy supply and infrastructure. However, the emissions reported according to the UNFCCC principles only include emissions from the domestic production. If, instead of the domestic production, the consumption in Sweden is considered, including the emissions caused by production and transports of products, it appears that Sweden is a net importer of CO_2 (Minx *et al.* 2008). The precise amount of such emissions is difficult to assess and depends on the method used for calculating upstream emissions and the quality of the data available on foreign production systems.

In a recent report, the Swedish EPA estimated Swedish emissions using a consumption perspective. It was found that emissions of CO_2 equivalents are about 25 per cent higher with a consumption perspective rather than a production perspective (Swedish Environmental Protection Agency 2008). In another study, Minx *et al.* (2008) found Swedish emissions to be about 17 per cent higher with a consumption perspective. In these estimations, the emissions caused by products produced in Sweden and exported to other countries are excluded, while instead the emissions caused by production of products imported to Sweden are included.

With this consumption perspective on the GHG emissions, Swedish per capita emissions are around 10 tonnes CO_2 equivalents (Swedish Environmental Protection Agency 2008). Looking at the composition of emission sources from a consumption perspective, about 80 per cent of total emissions are caused by private consumption and 20 per cent by public consumption. Emissions from private consumption can further be broken down into food (25 per cent), housing (30 per cent), travel (30 per cent), and "shopping" (15 per cent) (Swedish Environmental Protection Agency 2008).

In spite of overall increased carbon efficiency in many industrial sectors due to technological improvements, emissions related to industrial processes increased between 1990 and 2006 (figure 3). In addition, in spite of improvements in use of oil and electricity per production value in the industrial sector, fossil fuel use increased in this sector from 1992 to 2006. Emissions are growing due to increased production, although there is large variation between years depending on fluctuations in production (Swedish Environmental Protection Agency 2007). The largest increase in emissions between 1990 and 2006 however, occurred due to increase in heavy goods road transports. Many improvements are thus still being outweighed by increased volumes of domestic production and transport.

To conclude, when adding international transports and using a consumption perspective on GHG emissions, Swedish emissions are no longer decreasing. It is thus important to consider how existing and new policy instruments can be used to tackle in particular emissions arising from consumption. In the next section, we will review the current approaches to combat the Swedish emissions of GHGs, before we go into assessing the potential of PCT to achieve further emissions reductions.

6 REVIEW OF SWEDISH CLIMATE POLICY INSTRUMENTS AND THEIR POTENTIAL EFFECTS

As part of the historical and evolving Swedish climate policy strategy, several policy instruments have been implemented to combat GHG emissions, both sector-specific and generic ones. To assess if Swedish emissions are targeted by the current policy instrument portfolio, in this section, the most important of these climate policy instruments are reviewed. Three main aspects have been in focus for this review:

- the *emissions* the respective policy instrument aims at targeting;
- the *target group* the policy instrument addresses, i.e. whether consumption or production is targeted and what consumers or producers; and
- the *intended effects* of the instrument.

The review, which is largely based on information from the Swedish Environmental Protection Agency and the Swedish Energy Agency in their review *Kontrollstation 2008,* is displayed in table 5 and summarised in the text below.

Taxes

Both *energy* and *CO_2 taxes* increase the price of fossil fuels in Sweden. The purpose of the energy tax has varied over the years. In the 1970s, the focus was to reduce the oil dependency but in the last two decades, climate change mitigation has been the main target. The Swedish energy tax is partly governed by the EU energy tax directive, which aims at improving the conditions for the internal EU energy market and encouraging a more efficient use of energy. To avoid international market distortion, most manufacturing industries, aviation and shipping are exempted from the energy tax. Instead, some industries are covered by a voluntary agreement – *Programme for increasing energy efficiency in energy intensive industries*. Analyses indicate that the energy and CO_2 taxes have not had any considerable effect on CO_2 emissions, although it is difficult to isolate the effects of taxes compared to effects of other policy instruments (Swedish Energy Agency and Swedish Environmental Protection Agency 2007).

In addition to the energy and CO_2 taxes, consumers' travel choices are also influenced by the *CO_2 differentiated vehicle tax*. Higher taxes are paid for vehicles with higher CO_2 emissions, which contributes to developing the market for clean vehicles and thus encourages car manufacturers to develop more efficient and alternatively fuelled cars.

Trading systems

The European Union Emission Trading Scheme – *EU ETS* – is one of the most important measures to reduce GHG emissions in the EU region. EU ETS is a cap and trade system, targeting electricity production installations and some energy intensive industries. A number of emissions allowances are issued to each installation and the emissions must be reported yearly. If the allowances are exceeded, a fee must be paid. An installation that does not use up all its allowances can sell the rest to other installations. In this way, the EU ETS aims at achieving emissions reductions where the costs are as low as possible. It is expected that a high price on CO_2 will lead to technological improvements, as long as this is economically profitable for the companies. However, critics against the emissions trading system claim that since installations receive emission allowances for free related to historic emissions, there are incentives for installations to even increase a CO_2 intensive production, so as to achieve a larger amount of allowances.

Table 5: Main Swedish policy instruments targeting GHG emissions.

Policy instrument	Emissions covered	Target groups	Expected effects
Economic policy instruments			
Taxes			
Energy and CO_2 taxes	Emissions from use of fossil fuels for vehicles and from use of some fuels for heating. Applies also to use of electricity.	Households, public organisations and companies. Manufacturing industries often exempted from energy tax. Production of electricity exempted, aviation, shipping and train transports exempted. Reduced taxes for fuels used in vehicles in farming and forestry.	Reduced use of fossil fuels (although the energy tax was originally a fiscal tax) and electricity. Stimulating a switch to alternative fuels.
CO_2 differentiated vehicle tax	Emissions from light duty vehicles.	Households and organisations using private cars and light duty vehicles.	Increased demand for clean vehicles. Encourage the development of more efficient cars from car manufacturers.
Waste incineration tax	Emissions from waste combustion.	Commercial actors and municipalities owning waste incineration plants.	Decreased combustion of waste. Increased levels of recycling.
Trading systems			
EU ETS	Emissions of CO_2 from energy production and in some other, energy intensive, industrial production.	Energy producers. Iron and steel manufacturers. Mineral industries. Pulp and paper industries.	Reduced emissions of CO_2 in energy intensive industries. Improved energy efficiency in affected industries, development of technologies to increase efficiency and reduce emissions. Reduced consumption of energy due to increased energy prices.
Green Certificates	Emissions from electricity production.	Commercial actors	Increased demand for and production of electricity from other sources than fossil fuels.

Subsidies			
Klimp	Various emissions at local level	Municipalities	Reduced emissions at local level through local projects.
Subsidies for clean vehicles	Decreased emissions from car use.	Households, companies and public organisations.	Increased demand and production of clean vehicles
Subsidy for wind power	Reduced emissions from electricity production.	Energy producers	Increased percentage of wind power in electricity production.
Support for use of renewable energy for heating in residential and service sectors	Reduced emissions from heating of buildings.	Households and public organisations.	Decreased use of fossil fuels for heating of buildings.
Other economic/market based instruments			
Public procurement of clean vehicles	Emissions from vehicles used by public authorities.	Public organisations.	Increased development and sales of clean vehicles
Regulations			
Environmental Code	Reduced emissions from industries, among other things.	Companies / industries	Various emissions kept at low levels
Obligation to supply renewable fuels	Emissions from transport (companies, households, public organisations).	Companies (petrol stations)	Enabling purchase of alternative fuels, thereby increasing use of, and stimulating a market for, alternative fuels and clean vehicles as well as decreasing use of fossil fuels.
Landfill ban on combustible and organic waste	Methane and CO_2 emissions from landfills.	Municipalities	Increased recycling and decreased methane emissions from landfills
Voluntary agreements / Information based instruments			
Programme for increasing energy efficiency in energy intensive industries	Emissions from energy use in industries	Companies	Increased energy efficiency and reduced CO_2 emissions in industry

Electricity and heat production are in Sweden influenced by several polices. In addition to the energy and CO_2 taxes and the EU ETS, an important means of targeting the CO_2 emissions in the energy sector is the system of *Green Certificates*. The system is today the primary instrument to introduce renewable energy production in Sweden. Producers of renewable energy receive a certificate for each MWh energy produced. The certificates can be sold on a market, where electricity providers and some industrial actors are obliged to purchase a certain quota of the certificates. From the introduction of the system in 2003 to 2006, production of renewable energy increased by 5 MWh.

Subsidies

A number of subsidies to reduce GHG emissions have been introduced. The *Climate Investment Programmes* (Klimp) aimed at achieving long term emissions reductions. Local authorities could apply for funding for climate investment programmes aimed at achieving CO_2 emissions reductions in areas such as electricity and heating, transport and waste.

A number of instruments form a set of incentives to purchase or lease clean vehicles (including electric and hybrid as well as biofuelled vehicles). For individuals, a subsidy has during a certain period been given for each clean vehicle purchased. As mentioned earlier, taxation of vehicles is linked to CO_2 emissions. In addition, 85 per cent of the vehicles for which leasing agreements are introduced by a Swedish public authority need to be clean vehicles. Finally, a range of local policies concerning public transportation, parking policies, and the exemption from congestion tax in Stockholm for clean vehicles further subsidise this category of cars. In recent years, a strong trend for increased purchasing of clean vehicles has been noted, an increase that is attributed to the full set of instruments.

Wind energy production has been supported in different ways over the years. This has now to a great extent been replaced by the Green Certificates system, with the exception of a subsidy for off-shore wind energy production.

A range of subsidies targeting heating in the residential and service sectors exist, including subsidies to encourage a switch from fossil fuels or electricity for heating to district heating or renewable fuels, and subsidies to install renewable energy technologies for new buildings. Consumers have responded extremely well to the incentive and use of oil for heating is in sharp decline.

Regulatory instruments

Regulations that in one way or the other regulate emissions of GHGs include the *Environmental Code,* the *ban to dispose organic and combustible waste* on landfills, and a regulation stating that petrol stations of a certain size are obliged to *supply renewable fuels*. The Environmental Code contains the general, overriding Swedish environmental legislation. According to the Environmental Code, new industrial installations need a permit from the responsible authority. In this permit, also emissions from the installations are regulated. The regulation requiring petrol stations larger than a certain size to supply renewable fuels facilitates the development of markets for renewable fuels and clean vehicles, but has at the same time had some adverse effects, since the cheaper option of ethanol has benefited.

Assessment of the current policy instrument mix

Having reviewed the Swedish climate policy mix, it appears that climate polices in Sweden consist of a mix of instruments, geared at different actors, activities and emissions. Instruments target companies as well as individuals and public organisations. From a production perspective, most sectors are covered by some climate policies, although some key exceptions exist. In the aviation sector, both domestic and international aviation is fully exempted from both energy and CO_2 taxes as well as from VAT on aviation fuel. However, aviation will be included in the EU ETS in the future. In addition, key emissions in the agricultural sector are only targeted indirectly.

In addition, a range of instruments target *consumption*, including consumption by individuals, companies and public organisations. *Transport* is influenced by the energy and CO_2 taxes, where consumers are directly targeted. Other examples where Swedish climate policy instruments target individuals directly include the local and national support mechanisms for clean vehicles and alternative fuels and the CO_2 differentiated vehicle tax. For the consumption category *housing,* a range of policy instruments target consumers directly, including the subsidies to switch from fossil fuels for heating, to which consumers have responded extremely well. For consumption of *food*, emissions during production and transports throughout the supply chain are only indirectly targeted by the energy and CO_2 taxes. Finally, for *shopping*, all polices are upstream in the supply chain.

Thus, whereas there are a range of policies targeting the consumption side in the transport and housing categories, the categories shopping and food are only indirectly targeted. Moreover, many of the products in these categories have been imported, and the emissions during their production and transports of them are not covered by any Swedish climate policy instrument. According to the Swedish Environmental Protection Agency (2008), there are currently about 19 million tonnes CO_2 equivalents from production of imported goods that are not covered by any policy.

In the following, final section, we discuss if and how PCT could have the potential to achieve reductions of Swedish GHG emissions, additional to those achieved by or expected from the current Swedish policies.

7 DISCUSSION AND CONCLUSIONS

Having reviewed the Swedish sources of GHG emissions in section 5, and assessed to what extent these are covered by current Swedish climate policies in section 6, in this section, drawing on the assessment in section 4, we discuss the potential of PCT to achieve additional reductions of Swedish emissions and whether this could be done efficiently and in an equitable manner.

Targeting Swedish emissions from housing

As described in section 3, the PCT schemes suggested in the UK focus primarily on emissions from fossil fuel use for household residential heating and transport, and household use of electricity. As shown in the review of the emissions in section 5, in Sweden, the use of fossil fuels for heating is limited and, as pointed out in section 6, has decreased drastically lately due to a set of policies which has led to that district heating now dominates residential heating. Consumers cannot influence the production of district heating however, only 9 per cent of the production in Sweden originates from fossil fuels (Swedish District Heating Association 2010). As described in section 5, the CO_2 emissions from Swedish energy supply are relatively low, with hydro and nuclear power as the two main sources for electricity production. Also, policies such as the Green Certificates system, to encourage the generation of electricity from renewable sources are already in place. With these aspects in mind, it appears as if the potential for achieving additional decreases in CO_2 emissions from the housing sector by means of a PCT scheme in Sweden is rather limited.

However, as pointed out in section 4, a potential introduction of PCT could be expected to enhance technological innovations but at the same time, since individuals are not expected to make optimal investments in for example technologies to decrease energy use, PCT may not be the sole and preferred solution to stimulate the development of such new technologies. Further, the high expected costs connected to a PCT scheme found in the UK analyses would not be motivated by these limited additional savings in energy use and CO_2 emissions. While the potential costs might vary between countries, the potential emissions reductions from housing that can be expected from PCT in Sweden are lower, suggesting that PCT in Sweden might be even less cost effective.

PCT as a way to address emissions from transport in Sweden

Swedish emissions from transport are steadily increasing. In the UK, many of the studies carried out have looked into the effects from a potential PCT scheme versus those from a potential carbon tax. As described in section 6, in Sweden, there is already a carbon tax in place and several other instruments have also been implemented to encourage the purchase of clean vehicles, to which consumers have responded quite well. However, as pointed out in section 4, fuel consumption does not always decrease to a great extent when fuel prices go up. This finding is reinforced by for example a study of Swedish car ownership and car use by Pyddoke (2009), suggesting that use of light duty vehicles during some periods have even increased along with rising fuel prices. Other factors might have influenced this and in general, higher fuel prices are considered to lead to decreased vehicle use in the long term. For example, the former Swedish Institute for Transport and Communications Analysis, SIKA, suggested that emission standards for new vehicles in combination with increased CO_2 tax that would give a fuel price between 25 and 27 SEK per litre would decrease emissions to 80 per cent of the levels in 1990 in year 2020 (SIKA 2008). Emission standards alone would not be able to reach the same reduction. As mentioned earlier however, a PCT scheme can be expected to achieve additional savings beyond the pure price effect, but the exact level of such impacts are difficult to foresee.

A PCT scheme addressing household use of transportation in Sweden would affect different groups in the country differently. For people in urban areas, the availability of public transportation and the short distances facilitate low-carbon lifestyles, whereas in rural areas, and particularly in the north of

Sweden, long distances and scarce public transportation make it difficult to replace the car. For a PCT scheme to be equitable, modified emission quotas as suggested by Starkey (2008) may be necessary to avoid unfair distributional effects. As pointed out earlier however, such measures would further increase the already high costs and would have several other disadvantages.

Influencing indirect consumer emissions from food and consumables

As shown in the review of Swedish climate policy instruments, the consumption categories that are not directly covered by Swedish climate policies are food and consumables, which are instead targeted on the production side. In particular, the imported proportion of these categories is currently not covered by Swedish climate policy instruments.

As described in section 5, Swedish emissions from consumption largely exceed those from production due to a considerable proportion of the products purchased in Sweden having been imported. Consumption based policies could potentially be designed to target this yet unaddressed contribution from Swedish citizens to global emissions. However, targeting emissions embedded in supply chains by means of a PCT scheme has only been mentioned briefly in some of the PCT suggestions, including the RAPS and the Ayres scheme, but as explained in section 3, it has been suggested that this would not be a feasible option in the short term due to the many complexities, uncertainties and costs involved.

At present, international standards for producers to account the GHG emissions occurring during production of their products are being developed, including the ISO-standards ISO 14067-1 and ISO 14067-2. Yet, few producers so far provide complete and accurate information about the carbon footprint of their products. Encouraging producers and retailers to supply information about the emissions caused by production, or even requiring them to do so, could provide a catalyst to accounting for emissions occurring throughout the supply chains and would make these emissions visible for consumers.

Limiting fossil fuel intensive consumption

The close connection between growth and emissions of carbon dioxide (e.g. Scocco and Alfredsson 2008) has spurred many to argue for decreased growth, steady-state economics or even de-growth (e.g. Hinterberger *et al.* 2009; Jackson 2009; Victor and Rosenbluth 2007; Ayres 2006). But limiting consumption is controversial since it would threaten economic growth which is regarded as important for continued human wellbeing.

Emissions of GHGs are mainly connected to combustion of fossil fuels, which also explains the strong correlation between economic growth and GHG emissions. The awareness of this relationship, combined with the fear for global oil scarcity, has led to that some, like for example Jonstad (2009) have suggested PCT to be used as a rationing system to tackle both emissions of GHGs and a potential fuel crisis. To be effective in contributing to decreased use of fossil fuels while at the same time allow for alternative energy sources to be developed, consumption based emission policies should not primarily seek to reduce consumption overall, but try to shift consumption away from fossil fuel intensive production. To achieve this, implementation of consumption based policy instruments should ideally be foregone by a thorough analysis of the potential consequences on the overall economy as well as on individual industrial sectors, technological development and other potential effects in society.

Concluding summary

Due to the existence of the current set of Swedish policy instruments which have proven to be quite effective in encouraging a switch from fossil fuels for residential *heating*, along with the low emissions of CO_2 connected to the Swedish electricity supply, the potential for PCT to achieve additional reductions in GHG emissions in the housing sector in Sweden appears quite limited. For household use of fossil fuels for *transport*, the potential for emissions reductions could be more significant – although

Sweden already has energy and CO_2 taxes, emissions from transport tend to increase. However, given the different conditions for Swedish citizens across the country, equal per capita emission allowances would not be equitable, neither in the area of transport nor in the one of housing. Adjusted emission allowances would have to be calculated and applied, which is connected to a number of problems. In addition, given the uncertainty in the potential reductions that might be achieved and the potential costs involved, PCT similar to the schemes suggested in the UK does not appear as an efficient way to reduce emissions from neither transport nor housing in Sweden.

For consumption categories *shopping* and *food*, there is currently no simple way to include these in a PCT scheme due to insufficient information about embedded emissions during production and transports throughout supply chains. However, measures and standards to supply such information are being developed and can be encouraged, as a first step for producers and consumers to learn more about the emissions connected to different products. Further studying the potential effects of a PCT scheme including all products and services would be relevant, so as to find out the effects that can be expected on emissions, the overall economy and technological development.

Proponents of PCT often seem to view the instrument as the one solution that would replace all, or at least many, other existing policy instruments. Yet, it is often a mix of policy instruments rather than a single one that proves to be most successful in reaching the desired goals. Any potential PCT scheme is also unlikely to replace all existing policies but would rather work alongside a number of other policies. Although PCT may not be a feasible policy instrument currently in Sweden, it could be provided as a voluntary, information based instrument. Interested consumers could be informed about the allowed emission quota if all citizens were to have equal rights to emit GHGs. Combined with improved information about the CO_2 emissions during production of products and services, this could be a first step towards new consumer based policy instruments.

This working paper focuses mainly on PCT as a potential national policy instrument in Sweden. However, as recently suggested by Wicke *et al.* (2010), equal per capita emission allowances might be a way to address global emissions and a way to reach a global agreement, including all nations and emissions worldwide. This issue will likely remain on the political agenda for many years to come.

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