WORKING PAPER

3-04

A user's guide for economic instruments in domestic and international climate change policy

What role can they play in a Belgian climate change strategy?

Federal
Planning Bureau

Avenue des Arts 47-49
B-1000 Brussels
Tel.: (02)507.73.11
Fax: (02)507.73.73
E-mail: contact@plan.be
URL: http://www.plan.be

W. van Ierland

January 2004

A user's guide for economic instruments in domestic and international climate change policy

What role can they play in a Belgian climate change strategy?

W. van Ierland

January 2004

Federal Planning Bureau

The Belgian Federal Planning Bureau (FPB) is a public agency under the authority of the Prime Minister and the Minister of Economic Affairs. The FPB has a legal status that gives it an autonomy and intellectual independence within the Belgian federal public sector.

FPB's activities are primarily focused on macroeconomic forecasting, analyzing and assessing policies in economic, social and environmental fields.

Internet

URL: http://www.plan.be

E-mail: contact@plan.be

Publications

Publications:

The Economic Forecasts
The "Short Term Update"

Planning Papers (recent publications)

giving the results of policy analyses and assessments

93 *Les comptes environnementaux en Belgique*
Guy Vandille, Bruno Van Zeebroeck - June 2003

94 *Les charges administratives en Belgique pour l'année 2002*
Aurélie Joos, Chantal Kegels - January 2004

Working Papers (recent publications)

22-03 *Filialen van Belgische ondernemingen in het buitenland: De BELMOFI-databank*
A. Joos, H. Spinnewyn - December 2003

1-04 *Toekomstverkenning voor een duurzame ontwikkeling*
Methodologieën van de Task Force Duurzame Ontwikkeling, gepresenteerd door T. Bernheim - January 2004

2-04 *Financement des entreprises pour un développement durable*
N. Zuinen - January 2004

Responsible Editor Henri Bogaert
Legal Depot: D/2003/7433/3

This paper was written within the CLIMNEG/CLIMBEL-network, financed by the Federal Office for Scientific, Technical and Cultural Affairs.

Table of Contents

I Introduction

This paper resulted from the participation of the Task Force on Sustainable Development in a research project under the Global Change Program of the Federal Office for Scientific, Technical and Cultural Affairs. This research project was named "Climate change and instruments for emissions abatement in Belgium: an interdisciplinary analysis", the so-called CLIMBEL project. The Task Force on Sustainable Development was a sub-contractor for the Center for Operations Research and Econometrics of the Université Catholique de Louvain. The interdisciplinary research group also included the Institut d'Astronomie et Geophysique George Lemaître and the Centre du droit de la Consommation of the Unversité Catholique de Louvain and the Center for Economic Studies of the Katholieke Universiteit Leuven. I am also thankful for the assistance I received within the Task Force on Sustainable Development of two of my colleagues, Thomas Bernheim and Philippe Tulkens.

This paper provides an economic background for those less familiar with these mechanisms. Policy makers, in particular, are the target audience of this paper. It should allow them to better understand how they can utilise emission trading and taxes efficiently within their climate change strategies. Where many papers limit themselves to explaining the virtue of one policy instrument in particular, this paper goes beyond this partial framework. It tries to give some insights in a complicated question that policymakers will face in the coming years: *"How can the use of a mix of different policy tools, tailor made for the different regulated sectors, minimise emission limitation costs or reduction costs for society as a whole, and, what role can the flexibility inserted in the international Kyoto Protocol through international emission trading play in this?"*

Policy makers will not be able to avoid this question in the following years. Even though the USA already declared that they would not ratify the Kyoto Protocol, a sufficient number of other countries seem prepared to ratify it in order for it to it enter into force. If so, countries will be for the first time ever legally bound to limit their greenhouse gas emissions. This paper should be a useful input for those who will have to formulate an efficient answer to this challenge.

This paper resulted from the participation of the Task Force on Sustainable Development in a research project under the Global Change Program of the Federal Office for Scientific, Technical and Cultural Affairs. This research project was named "Climate change and instruments for emissions abatement in Belgium: an interdisciplinary analysis", the so-called CLIMBEL project. The Task Force on Sustainable Development was a sub-contractor for the Center for Operations Research and Econometrics of the Université Catholique de Louvain. The interdisciplinary research group also included the Institut d'Astronomie et Geophysique George Lemaître and the Centre du droit de la Consommation of the Unversité Catholique de Louvain and the Center for Economic Studies of the

Katholieke Universiteit Leuven. I am also thankful for the assistance I received within the Task Force on Sustainable Development of two of my colleagues, Thomas Bernheim and Philippe Tulkens.

II Climate change: is there a missing market for the atmosphere's services?

Climate scientists are seriously concerned about the likely impact of anthropogenic greenhouse gas emissions on the global climate. For certain local pollutants, limits to the atmosphere's assimilative capacities have been known for a long time. Londoners already used the word smog in the early 20th century to describe the severe local air pollution caused by the intense burning of coal.

In the sixties and seventies the scientific community started to study in depth the link between anthropogenic gas emissions and the earth's atmosphere. They discovered holes in the stratospheric ozone layer[1] and suggested that anthropogenic emissions of greenhouse gases could affect the climate system. Ever since, there has been an intense scientific debate on the causes of climate change and its potential effects. In 1988 the United Nations Environment Programme and the World Meteorological Organisation founded the Intergovernmental Panel on Climate Change (IPCC), which receives contributions of several thousands of scientists. In February 2001, the IPCC released a Summary for Policy Makers of its Third Assessment Report concerning the Science of Climate Change (IPCC 2001-a). The report concluded that: "*Concentrations of atmospheric greenhouse gases and their radiative forcing have continued to increase as a result of human activities. […] There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.*"

If one wants to formulate effective and efficient policies in reaction to the threat of climate change, the fundamental behavioural causes should be identified. Economic theory suggests that this might have something to do with property rights over the assimilative capacities of the global atmosphere, or rather a lack of them. Since nobody owns the assimilative capacity of the atmosphere, emissions of greenhouse gases are experienced as cost free and unrestricted. However, through their effect on the climate, these emissions reduce the quality of the services provided by the atmosphere. Those who emit only consider their private benefits and private costs and do not consider the costs inflicted on the whole of global society. In doing so, they create a global public bad[2], i.e. climate change.

1. The ozone holes concern losses of ozone in the stratosphere over the North and South poles. Scientific evidence has shown that human-produced chemicals, chlorofluorocarbons, halons, carbon tetrachloride and methyl chloroform, are responsible for the observed depletions of the ozone layer. The international community acted swiftly to tackle this problem and adopted the Montreal Protocol in 1987. This agreement regulates the production of CFCs and other ozone-depleting substances. Except for a few critical uses, production of the most damaging ozone-depleting substances was eliminated by 1996 in developed countries and will be eliminated by 2010 in developing countries (UNEP 2001).
2. A public good exists when the benefit received by an individual from a service or attribute does not reduce the benefit another individual can receive from that same service or attribute. This situation contrasts with that of a private good, where two individuals cannot jointly consume the benefits of a good. This is known as the non-rivalness characteristic of a public good. Another characteristic is the non-excludability. No one can be refused access to the service or attribute from a public good.

The damages inflicted by this public bad are indivisibly spread among the global community (characteristic of non-excludability) and the damage inflicted on one person does not lower the damages experienced by others (characteristic of non-rivalry).

If one wants to optimise the utilitarian welfare[1] of the global community, those who emit greenhouse gases should take into account the costs they inflict on others. The externalities of their emissions have to be internalised. If a state unilaterally decides to internalise the global externalities of its emissions, the benefits of reduced climate change would be distributed across the entire world, while the costs of lowering emissions would be carried all by itself. Its own costs would be higher than its own benefits, thereby making the unilateral reduction a welfare improving exercise on a global scale but a welfare deteriorating exercise on a national scale. Consequently, no country will be inclined to unilaterally reduce its emissions sufficiently to internalise all externalities.

A solution for this kind of cross-border externality can only be found through international co-operation. In December 1990, the UN General Assembly established the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change, which had to address exactly this cross-border problem of climate change. On 9 May 1992 the United Nations Framework Convention on Climate Change was adopted in Rio (UNFCCC 1992). This convention defines in its article 2 an 'ultimate objective' of stabilising atmospheric concentrations of greenhouse gases at safe levels that would prevent dangerous anthropogenic interference with the climate system. Article 4 urged industrialised countries in a first step to stabilise their emission levels at their 1990 levels. In 1995, the countries that had ratified the convention decided that more stringent and detailed commitments were necessary to reach the ultimate objectives stipulated in the Convention.

Great uncertainties remain concerning the level and costs of climate change and the costs of abating greenhouse gas emissions. Therefore, at present it is impossible to scientifically determine the welfare-optimising level of emission reductions. There is also an ongoing ethical debate on the burden sharing of emission reductions among industrialised and developing countries. Fixing intermediate emission reduction targets thus became a highly political affair. After two and a half years of negotiations, on 11 December 1997 the Kyoto Protocol was adopted (UNFCCC 1997). It sets greenhouse gas emission targets[2] for the industrialised countries, the so-called Annex I countries, for the period 2008-2012. Meanwhile the US, followed by Australia has declared it has no intention at all to ratify the Kyoto Protocol in the near future. Many countries have ratified it, in-

1. From a utilitarian point of view it is justified to impose a cost on one person as long as this cost is smaller than the sum of benefits experienced by all other individuals. In theory externalities of greenhouse gas emissions have to be internalised up to the point were the costs of reducing emissions equals the global benefits of reduced climate change.
2. The Kyoto Protocol commits the industrialised countries, which have historically contributed the most to climate change, (the Annex I countries in the Protocol) to individual greenhouse gas emission targets. Together these targets add up to a total cut in emissions of at least 5% from 1990 levels in the period 2008-2012. The individual targets for Annex I countries are listed in the Protocol's Annex B, and range from a -8% cut for the EU and several other countries, to a +10% increase for Iceland. Under the terms of article 4 of the Protocol, the EU may redistribute its target among its 15 member states (UNFCCC 2001-a). In appendix 1 to this paper a more detailed list of the targets can be found. The greenhouse gases concerned are long-lived greenhouse gases emitted by human activities, i.e. Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydrofluorocarbons (HFC), Perfluorocarbons (PFC) and Sulphur Hexafluoride (SF_6).

cluding the EU, its accession countries and Japan. Entry into force of the Kyoto Protocol now only depends on its ratification by Russie. Members of the Russian government have already declared on several occasions that Russia too will ratify. Therefore it remains likely that the Kyoto Protocol will enter into force in the near future. In the remainder of the text we refer to Annex I countries as those industrialised countries that will ratify the Kyoto Protocol and will be bound by the reduction commitments they took upon themselves in the Kyoto Protocol.

The single most important result of the Convention and the Kyoto Protocol is the recognition of the atmosphere's greenhouse gas assimilative capacity as a scarce resource. The proposed intermediate reductions are far from sufficient to reach the ultimate objectives put forward in the Convention, but at least it recognises the atmosphere as being a limited resource. This de facto will create a new scarcity within the Annex I countries among other scarcities already experienced in the commodity, capital and labour markets.

The question to be asked is how to distribute the use of this scarce resource and its rents among the members of society. Adam Smith, in his book 'The Wealth of Nations' (Smith 1776), was one of the first to understand that scarce goods are distributed efficiently in a free market. Smith is most often recognised for the expression of 'the invisible hand', which he used to demonstrate how self-interest guides the most efficient use of resources in a nation's economy, with public welfare coming as a by-product (JEC 2001). This market oriented reasoning can also be found in the work of later neo-classical economists who believe that markets give correct price signals to private agents in such a manner that they maximise private and social utility. According to this view, government intervention in the market should be kept to a minimum. However in the case of climate change, the lack of a market has created the environmental problem in the first place. Without a market for the assimilative capacity of the atmosphere, the invisible hand will not maximise social utility. Put it this way, the invisible hand needs a foot to give it a shove. So, since markets tend to maximise social (utilitarian) welfare, what better solution than the creation of the missing market for greenhouse gas emissions?

III The Kyoto Protocol: creation of a greenhouse gas emission market

With the Kyoto Protocol a limit is put on the greenhouse gas emissions by Annex I countries for the period 2008-2012. This will make greenhouse gas emissions a scarce resource within Annex I countries. However, all Annex I countries will experience different costs to reduce their greenhouse gas emissions. Within the Kyoto Protocol a mechanism is foreseen that allows countries to exploit this in order for each country to reduce its cost to comply with the Kyoto Protocol, i.e. emission trading. This chapter explains how this instrument works within the framework of the Kyoto Protocol and how it reduces the costs to comply with the Kyoto targets, thereby creating the missing market for greenhouse gas emissions.

A. Initial allocation of scarce tradable emission permits

The Kyoto Protocol defines reduction commitments for every Annex I country. In the period 2008-2012, each country is allowed to emit an amount of emissions equal to its reduction commitment, expressed as a percentage of its base year emissions[1] multiplied by 5. In appendix 1 to this paper all the reduction commitments for the Annex I countries are listed. This total amount of allowed emissions of an Annex I country is the so-called assigned amount. Before the beginning of 2008, Annex I countries receive a number of emission permits equal to this assigned amount. Annex I countries are allowed to trade these emission permits among each other. A county will comply with the Kyoto Protocol if after the commitment period it can demonstrate that it owns at least as many emission permits as it emitted greenhouse gases during the period 2008-2012[2].

The Kyoto Protocol thus creates a new tradable scarce commodity. All Annex I countries taken together will have to limit their total emission to the amount of emission permits available. If one country values this scarce resource more than

1. For most countries the base year is 1990. Countries that are undergoing the process of transition to a market economy may choose another base year than 1990.
2. The emission permits traded by Annex I countries when they participate in emission trading under the Kyoto Protocol are assigned amount units (AAUs), Emission Reduction Units (ERUs), Certified Reduction Units (CERs) and Removal Units (RMUs). Each emission permit is good for the emission of one ton of CO_2 or an equivalent amount of other greenhouse gases. The emission permits that a country receives to cover its allowed emissions, i.e. the assigned amount, are AAUs. ERUs are nothing more than converted AAUs and are only issued for Joint Implementation projects. These are emission reduction projects within Annex I countries paid for by Annex I countries. CERs are issued when Annex I countries invest in emission reduction projects in developing countries through the so-called Clean Development Mechanism. RMUs are issued when Annex I countries can demonstrate that their natural sinks (for instance forests) on their territory remove greenhouse gases from the atmosphere due to additional human intervention. It is important to note that CERs and RMUs increase the total amount of emission permits that are available and thereby reduce the initial scarcity that was created by the Kyoto Protocol.

another, it can buy permits from the other country through the market for emission permits. As such the Kyoto Protocol creates the missing market for greenhouse gas emissions.

Since greenhouse gases are global pollutants, international trading of permits should not have a direct detrimental impact on the environmental effectiveness of the Kyoto Protocol. Wherever a tonne of emissions is emitted, it causes the same global greenhouse effect. Hence decreasing emissions has an identical positive effect on the global climate, wherever the abatement takes place. From an environmental point of view it doesn't matter where the reductions necessary to comply with the Kyoto Protocol take place as long as the total reductions are effectively achieved.

The following paragraphs will explain in detail how emission trading actually can reduce the compliance cost for achieving the emission targets in the Kyoto Protocol.

B. Differences in abatement costs between countries

To benefit from emission trading countries have to value the scarcity differently. The value of the scarcity in this case is the cost that a country experiences for its emission reductions. These costs can differ substantially. Some countries have more opportunities to decrease their emissions than others. This can be due to many reasons, such as differences in existing energy production mixes, energy efficiencies and economic growth. Countries with old and inefficient energy production facilities and consumption practices tend to have more scope to abate emissions cheaply. Countries whose primary energy demand is mainly supplied by coal can switch more easily to less carbon-intense fuels. Economies, which go through a recession, experience less upward pressure on emissions than booming ones. In the following, two real world examples of dramatic emission reductions clearly point out that countries can, for different reasons, good or bad, have large abatement opportunities:

- Countries whose energy production is highly dependent on coal can have important fuel-switching opportunities. If a large part of this energy production infrastructure is old and subsidised, these opportunities can become economically viable even without greenhouse gas emissions constraints. For instance in 1990, 65% of UK electricity generation was based on coal while less than 1% was based on natural gas. Privatisation of the electricity, gas and coal markets resulted in a dramatic fuel switch in the electricity market, i.e. the 'dash for gas'. Coal was not the preferred energy input for the privatised companies anymore. This resulted in a quantitative reduction of 50% of coal consumption by the electricity sector in the nineties. In 1999, coal accounted only for 32% of electricity production while gas now represented 34% of UK electricity generation (DTI 2000). This was the single most important reason for the decrease in CO_2 emissions in the UK in the nineties. Overall UK CO_2 emissions from fuel combustion decreased by 35 million tonnes, from 558 million tonnes in 1990 down to 523 million tonnes in 1998[1] (UNFCCC 2001-b).

1. CO_2 emissions of the energy transformation industries and other industries have decreased by 45 million tonnes in the UK whereas emissions of other sectors including transport and residential heating have increased by 10 million tonnes. Note that it are mainly the industrial and electricity sectors that consume coal.

- Decreases in the GDP can be another dramatic cause of reductions in greenhouse gas emissions. In Russia, for instance, GDP decreased by 25,5% during the period 1992-1997. At the same time CO_2 emissions from fuel combustion dropped by 27% (IEA 1999).

However, abatement costs do not only differ because of the different opportunities for emission abatements. They also depend on the level of reduction commitments that Annex I countries accepted in the Kyoto Protocol. For instance, the reduction commitments of the countries undergoing the process of transition to a market economy are rather lenient. Because they have experienced such dramatic reductions of their emissions during the economic turmoil in the last decade, their real emissions will probably be lower than the emission reductions they accepted in the Kyoto Protocol, thereby reducing their specific cost to comply with the Kyoto Protocol to zero[1]. These lenient targets illustrate that not only economic and environmental logic influenced the burden sharing agreement decided upon in Kyoto, but also a lot of political considerations.

C. Cost reducing mechanisms behind emission trading

The cost to abate an extra tonne of emissions is defined as the Marginal Abatement Cost (MAC). Countries experience an increasing MAC for every extra tonne of emissions they abate. As explained in the previous paragraph, these MAC can differ substantially between countries. Some will experience higher and faster increasing costs than others. Some will have tougher targets than others. These differences in MACs create an opportunity to lower the overall compliance costs for achieving the Kyoto Protocol targets. With emission trading, countries with low MAC can reduce more emissions than necessary according to their reduction target determined by the Kyoto Protocol and sell their surplus emission permits to other countries at a higher price than their MACs. On the contrary, those with high MAC can reduce fewer emissions than their target in the Kyoto Protocol requires them to do and buy emission permits from other countries at a lower price as their MACs. Emission trading provides a mechanism that allows countries to make trades between high MAC countries and low MAC countries. In appendix 2, a quantified example illustrates emission trading between two hypothetical countries A and B. This should allow those who are unfamiliar with the concept of emission trading to understand the exact mechanism at work and the benefits it can generate.

D. Estimating the benefits of international emission trading

Many partial and general equilibrium models have been developed to estimate the effects of the Kyoto Protocol on future economic growth patterns (e.g. Capros 2000, Ellerman 2000, Proost 2000). These models also looked into the possible cost reducing impacts of emission trading. The results tend to confirm the theory that emission trading allows for a dramatic decrease of the compliance costs. This is acknowledged by the IPCC in the Summary for Policy Makers of its Third Assessment Report concerning the Mitigation of Climate Change (IPCC 2001-b), which

1. This does not deny the fact that the economic crisis itself was disastrous and very costly for these countries. But these costs had nothing to do with climate change policies in order to reduce emissions to comply with the Kyoto Protocol.

appeared in March 2001. The report concluded that "*In the absence of emissions trade between Annex I countries, the majority of global studies show reductions in projected GDP of about 0.2 to 2% in 2010 for different Annex II*[1] *regions. With full emission trading between Annex I countries, the estimated reductions in 2010 are between 0.1 and 1.1% of projected GDP.*"

1. The annex II countries are: Canada, the member states of the EU, Iceland, Japan, New Zealand, Norway, Switzerland and the US.

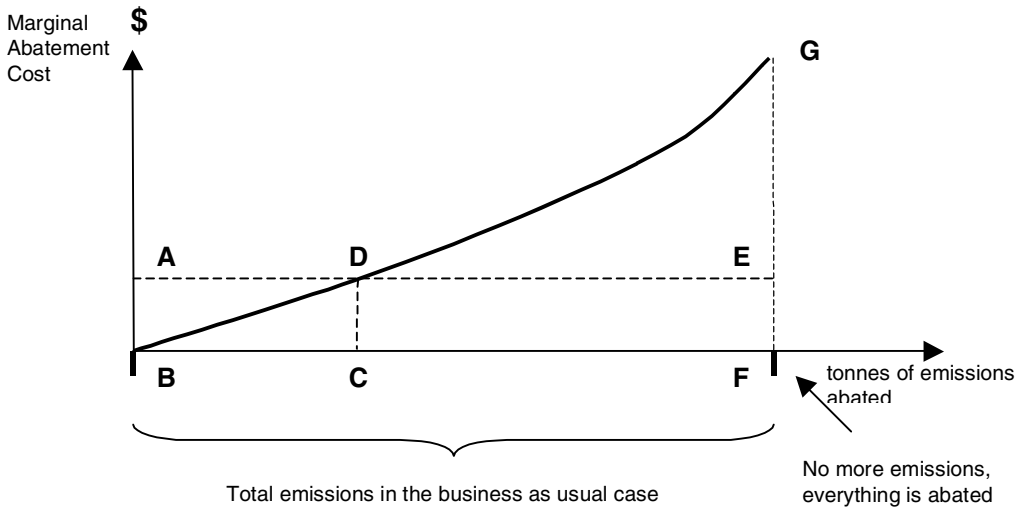
IV Complying with the Kyoto Protocol targets: policy instruments to limit domestic emissions

Countries whose greenhouse gas emissions in the business as usual case are higher than their reduction targets have two policy options. They can either reduce their emissions internally, or they can buy emission permits on the international market. The previous chapter explained how international emission trading could help countries to comply with their obligations under the Kyoto Protocol. This chapter looks at the economic policy instruments available if a country opts to reduce its emissions internally. The optimal mix of both strategies will be discussed in chapter VIII.

There are two kinds of economic policy instruments that countries can implement to achieve reductions efficiently. Historically the best known is a tax on greenhouse gas emissions, but this instrument has met a lot of resistance. More recently, however, emission trading has received a lot of the attention of academics and policy makers. Even the EU, opposed to emission trading in the early stages of the climate change negotiations, is now planning to introduce an EU-wide emission trading system for energy intensive industries.

The following paragraphs will look at the behavioural response of private entities to the introduction of both types of economic instruments. It is assumed that private entities (i.e. individuals and companies) always want to minimise their costs and maximise their profits or personal utility. Figure 1 presents a hypothetical marginal abatement cost curve of a private entity. In point B there are no restrictions at all on the emissions of the private entity. This is the business as usual case where profits or utility is maximised. At the other extreme in point F the private entity would abate all its emissions. It would then experience a total abatement cost equal to the surface BGF beneath the MAC-curve.

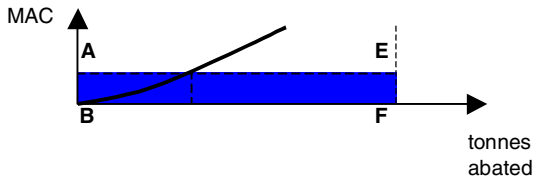
FIGURE 1 - Marginal abatement cost for the private entity



A. A tax on greenhouse gas emissions to regulate private entities

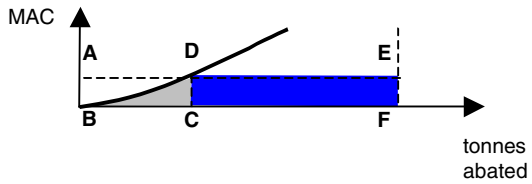
Let us now assume that a tax on greenhouse gas emissions is introduced in order to decrease the total amount of greenhouse gas emissions. The tax is set at a fixed level AB and expressed not as a percentage of a value but as a fixed amount for every emission unit. Should the private entity not reduce its emissions, it would have to pay a tax on all its emissions. In total it would have to pay an amount equal to the surface of the rectangle ABFE.

FIGURE 2 - Taxing emissions with no abatement: a sub-optimal outcome



But the private entity has some reduction opportunities that cost less than the tax level AB. As long as its MAC (which is its price to reduce one extra tonne of emission) is lower than the tax level AB, it will prefer to reduce one extra tonne and not to pay the tax on that tonne of abated emissions. Costs are minimised at the point where the MAC is equal to the tax level. Reducing beyond this point would make no sense because the private entity would have to pay a higher price for the additional abatements than it would pay for the tax.

FIGURE 3 - Taxing emissions with abatement up to equalisation MAC with tax level: an optimal outcome



In our example, the private entity would minimise its costs by reducing its emissions up to the point C. Then it would have a total abatement cost equal to the triangle BCD and pay a total amount of taxes equal to the rectangle CDEF. By abating its emissions up to the point C it reduces its total costs with an amount equal to the triangle ABD.

B. Domestic emission trading to regulate private entities

Just as emission trading can be used between countries, it could also be implemented by a government to regulate the emissions of private entities. The government could distribute an amount of emission permits to the private entities. Private entities can then buy and sell emission permits among each other. At the end of a predetermined period, private entities will have to demonstrate that they own at least as many emission permits as they have emitted greenhouse gases during that period. Total emissions during the period are limited to the total number of emission permits distributed by the government. Emissions are efficiently abated when MAC equalise between all the companies. If MACs are equal, no opportunities to trade exist anymore and the total cost for society to reduce a certain amount of emissions is minimised.

The most important government intervention in the market is the initial distribution of the emission permits. Two methods to distribute these permits by the government prevail in the literature. The government could give away tradable permits to the regulated private entities for free. This is mostly referred to as *grandfathering*. Alternatively, the government could sell these permits to the private entities through *auctions*.

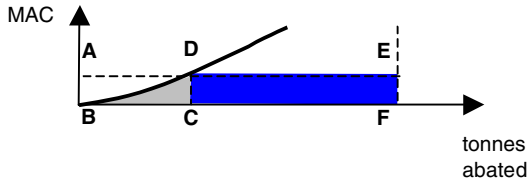
In both cases, a market for emission permits would emerge on which supply and demand will equalise, revealing an equilibrium price for the emission permits. With sufficient liquidity in the market, arbitrage would ensure that there is no price differential between the market price and the price paid at auctions. Market liquidity depends in particular on the number of participants in the market and their market dominance. In the rest of this paper it is assumed that there is sufficient market liquidity.

C. Domestic emission trading with auctioning of emission permits

Lets assume now that the government does not allocate any emission permits for free and that all emission permits enter the market through auctions. Private entities will then have to buy emission permits at these auctions or on the market at

market price. Then private entities end up in a similar situation as with taxing. They can either buy emission permits for all their emissions, or they can abate some emissions and only buy emission permits for the remaining emissions. As long as its own MAC is lower than the market price for emission permits it is better for a private entity to abate more emissions on its own. A private entity minimises its cost if it reduces its emissions up to the point where its MAC equals the market price for emission permits.

FIGURE 4 - Emission trading + auctioning: optimal outcome



Suppose now that the market price is equal to the tax level AB of the previous example. In that case the total cost for the private entity would be exactly the same as with a tax. It would abate emissions up to the point C at a total abatement cost equal to the triangle BCD and it would have to buy emission permits on the market for a total cost equal to the rectangle CDEF.

Emission trading with auctioning is therefore similar to a tax on emissions in terms of achieved emission reductions. If the emission permit price were equal to the tax level its result would be identical. In reality the price of emission permits will fluctuate over time, so both policy instruments will not have identical implications. With a tax, private entities are certain about the tax level they pay and the marginal abatement cost they will experience but the government cannot foresee with certainty the amount of emissions abated. The reason is that it is impossible for the government to calculate ex ante the MAC curves of all private entities. Instead, with emission trading, the government can foresee precisely the level of abatement that will be achieved but companies cannot foresee the price level and therefore the marginal (and total) abatement cost they will experience.

D. Domestic emission trading with grandfathering of emission permits

Most large industrial greenhouse gas emitters oppose any restrictions on greenhouse gas emissions through emission trading and advocate even less intrusive regulations[1]. If it comes down to emission trading they support the use of generous grandfathering schemes. They defend this view by pointing out the negative effects of auctioning on their profit margins and their competitive position. Consequently, this would oblige them to decrease their production and workforce.

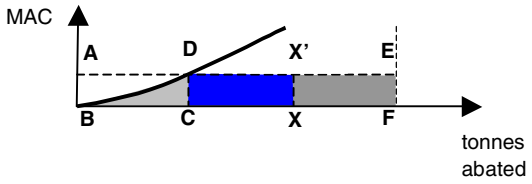
1. Many industries oppose emission trading with a fixed total cap on emission permits. They prefer a relative cap that stipulates maximum emissions per good produced without a limit on the total number of goods produced. The level of this relative cap is calculated on the basis of the best available technology. These relative caps can be introduced either through direct regulation or through Voluntary Agreements. The problem with relative caps is that there is no certainty about the total absolute abatement that will be achieved. Some even question whether such schemes go much beyond the business as usual scenario. Such schemes do not equalise the marginal abatement costs and are therefore sub-optimal from an economic point of view.

Decreases in production will reduce the supply of goods and thus increase prices for consumers. They indicate that with grandfathering the strain on profit margins will be less, less people would become unemployed, cuts in production will be smaller and prices will increase less. At first sight, it would seem they have a point. However, this reasoning is a bit short sighted. Again, one has to consider the marginal abatement costs to see what the real consequences for production will be. The following paragraphs look at the effect of grandfathering on a private entity's behaviour. First the case will be examined where the amount of grandfathered emission permits by the government is moderate. Subsequently, a case with more generous allocations will be examined.

1. Moderate grandfathering of emissions permits

Lets assume that the market price for emission permits is equal to the tax level AB and that the government allocates freely an amount of emissions permits X-F to the private entity. This amount X-F does not cover all emissions of the private entity in the business as usual scenario. Again the behaviour of the private entity will be the same as in the scenario with a tax or emission trading with auctioning. It will have the choice between buying extra emission permits or reducing emissions itself. In order to minimise costs it will abate emissions up to the point where its MAC equals the market price for emission permits and it will buy the remaining emission permits that it lacks on the market. The total cost it experiences consists of an abatement cost equal to the surface of the triangle BCD and the cost to buy the remaining emission permits equal to the surface of the rectangle CDX'X. Compared to the scenario with a tax or emission trading with auctioning, the cost to comply is reduced with exactly the value of the emission permits grandfathered, i.e. the surface of the rectangle XX'EF. Nevertheless the profits still decrease compared to the business as usual scenario with no emission constraints at all.

FIGURE 5 - Emission trading + grandfathering: optimal outcome

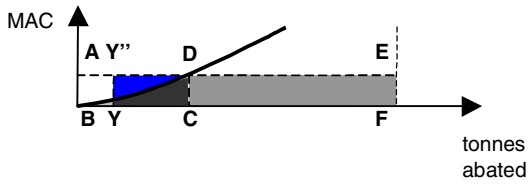


2. Generous grandfathering of emissions permits

The government could just as well allocate generously an amount of emission permits Y-F, just short of the total amount of emissions in the business as usual scenario. When the private entity abates its emissions up to the point Y it still has a MAC smaller than the market price for emission permits. In point Y the private entity has sufficient grandfathered emission permits to cover its emissions. On the other hand, if it would reduce one more tone of emissions it could sell an equivalent amount of emission permits on the market at a price higher than its own MAC, thereby generating net revenue for the private entity. Therefore it is in the interest of the company to reduce one more tone of emission and sell an equiv-

alent amount of emission permits on the market. The same reasoning applies as in the above cases. A private entity minimises its costs by abating emissions up to the point C, where its MAC equals the market price for emission permits. The private entity experiences an abatement cost equal to the surface of the triangle BDC but at the same time generates new revenue from the sale of the emission permits equal to the surface YY"DC. In this particular example the revenue YY"DC from the sale of emission permits is clearly greater than the total abatement cost BDC, thereby increasing the net profits of the private entity compared to the business as usual scenario with no emission constraints.

FIGURE 6 - Emission trading + grandfathering: optimal outcome with an increase of profits compared to business as uasual



What is not clear at first sight becomes apparent in the above examples: every grandfathered emission permit has an opportunity cost. Grandfathered emission permits are not a cost free input in the production process. If a company decides to use them in the production process then they consequently decide to forego the revenue that could be generated through the sale of these emission permits on the market. To maximise profits all costs have to be considered, including the opportunity costs.

By doing so, profit maximising companies will always equalise their MAC with the market price for emission permits. Therefore they will adapt their input factors in exactly the same way, whatever the method of distribution of emission permits. Consequently the change in the number of goods produced, the amount of labour employed, the capital stock used and the energy consumed will be the same with grandfathering as with auctioning. Consequently the price of goods will change in the same way. The major difference between grandfathering and auctioning is the impact on the profits. Profits for companies are always higher with grandfathering than with auctioning and visa versa. The opposite is the case for the revenue of the government.

Not only will companies produce the same amount of goods irrespective of the method of distribution of emission permits, they will also put an equal amount of effort into the development and introduction of more energy efficient production processes. This identical effect of grandfathering and auctioning is contrary to the view of many green NGOs, who prefer auctioning because they think it would induce faster technological improvement. Not the total cost for each company induces technological change but the marginal costs experienced by each company. It are these marginal costs that influence the profit maximising behaviour by a company.

E. Other issues concerning domestic emission trading systems

Allocation rules with grandfathering:

With grandfathering private entities get an amount of emission permits for free. The rules to allocate the emission permits to the private entities can be chosen by the government. These rules can for instance be based upon historical emissions, past efforts to increase energy efficiency or future growth prospects.

Monitoring, reporting, verifying and compliance:

The government has to create a legal framework for the emission trading system. Emissions have to be monitored and reported. It has to be verified that private entities own sufficient emission permits to cover their emissions and that private entities correctly monitor and report their emissions. A sanction mechanism has to be in place to assure compliance.

For a more elaborate discussion on these issues, see Bernheim (2001).

V Who might benefit and who might lose from constraints on greenhouse gas emissions?

A. The effect on prices

The previous section pointed out that consumers should be indifferent between grandfathering and auctioning because production and prices will be affected in an identical way. For many products, prices will increase because total supply will decrease. This decrease in production of goods is due to the introduction of a new scarcity in the production process, i.e. the limitation on the emissions of greenhouse gases. However, this is not true for all goods. Some goods, one could expect, will actually become cheaper. For instance, an increase in the demand for carbon free energy sources could lead producers to take advantages of economies of scale and increase investments in research and development. This could decrease prices over time considerably for goods such as solar and wind energy.

B. The effect on profits

Companies on the other hand, are not indifferent between grandfathering and auctioning. As explained in the previous paragraph, the allocation method does influence the profits of companies. If the total amount of emissions is limited through emission trading, companies will always prefer grandfathering to auctioning. However not only the extent to which grandfathering or auctioning are used have an impact on the profitability. Certain sectors and companies will always be net losers or winners of climate change policies. In what follows, some examples are given of sectors that could become winners and some that could become losers of climate change policies.

1. Companies that will always benefit from the introduction of emission restrictions

Companies that supply alternative technologies which lower the emissions of greenhouse gases stand to win from emission restrictions. Demand for these technologies will inevitably increase. Companies that supply the resources on which these technologies run will also benefit. Whether the restrictions are allocated through auctioning or grandfathering will not matter. Profit maximising companies will invest to the same extent in these 'alternative' technologies in order to equalise MAC with the market price for emission permits.

Examples could be:

- Producers of renewable energy technologies;
- Producers of combined heat and power plants;
- Producers of power plants based on gas;
- Natural Gas producers;
- Fertiliser producers who can develop techniques to reduce emissions from fertilisers in agriculture.

2. Companies that could benefit from the introduction of emission restrictions if emission permits are grandfathered

Companies that receive a considerable amount of grandfathered emission permits and that have a large reduction potential might benefit from emission restrictions. They can abate and sell emission permits on the market. These companies can increase profits when the revenue of the sale of emission permits is higher than the total abatement costs they experience (see chapter IV.D.2 for a theoretical example). An example could be electricity producers who produce their electricity with coal and whose infrastructure is up for replacement but who get a large amount of grandfathered emission permits based upon their historical emissions.

3. Companies that could benefit from the introduction of emission restrictions if emission permits are auctioned

Companies that already produce goods or services with a technology that causes few emissions might win from auctioning emission permits. These companies will have a competitive advantage upon those that produce the same good with a more carbon intense production technology. Examples could be electricity producers who already have facilities that produce electricity with low-emission intensive production technologies such as nuclear power, renewables and to a lesser extent natural gas.

4. Companies that will always loose from the introduction of emission restrictions

Companies that supply technologies, which have a high intensity of greenhouse gas emissions, will usually loose out. Again, companies that supply the resources consumed by these technologies will also stand to loose. Auctioning or grandfathering will not matter. Their customers will shift investments away from their technologies in order to equalise MAC with the market price for emission permits. Examples are producers of coal-fired power plants and coal producers.

Clearly not all industries will be losers if climate change is tackled. Many of the old industries could lose but even here, some can take advantage of the opportunities that could emerge if emission permits are grandfathered. Compared to these industries, most industries that benefit from emission constraints are still in their infancy and are less organised to defend their interests. Therefore the most vocal industries in the discussion concerning climate change are generally those that stand to lose out. Governments should be aware of this rent seeking behaviour and should not forget that it are those industries with less vested interests that could spur growth in a future greenhouse gas constrained world.

VI Grandfathering or auctioning: what should a government prefer?

Chapter IV explained that with good functioning markets the number of goods produced, the amount of labour employed, the capital stock used and the energy consumed by companies is the same with grandfathering as with auctioning. Only the profits of companies and revenue of governments differ between auctioning and grandfathering. The revenue for the government is larger and the profits for the companies are smaller with auctioning than with grandfathering and vice versa. In a world with perfectly working markets, the choice between grandfathering and auctioning will have no impact on the total abatement costs for society as a whole. From a utilitarian perspective, the government should therefore be indifferent between grandfathering and auctioning[1].

The government thus needs other arguments to decide which of the two allocation methods it should adopt. Many of these arguments relate to cases where markets do not function properly. Perfect working markets was a key assumption made in the previous chapters.

A. Arguments in favour of grandfathering

Proponents of grandfathering, mostly the energy intensive industries, also defend grandfathering by pointing out that auctioning could create problems with stranded assets, capital markets, recycling of rents and unfair competition.

1. Stranded assets

Stranded assets are investments that were made in a period when emitting greenhouse gases was regarded as harmless, but that decrease in value with the introduction of this new scarcity. Grandfathering of permits can be considered as a compensation for these stranded assets. Defining the exact loss of value of these assets is nevertheless troublesome and rent-seeking behaviour of the targeted companies will render this even more difficult.

1. A government's role should be to maximise welfare. If a government's welfare definition is utilitarian, governments should indeed be indifferent between auctioning and grandfathering. In reality governments are also influenced by the Rawlsian Welfare function, which seeks to maximise the welfare of the least well off individuals.

2. Restricting the possibilities to raise capital

In certain cases, restrictions on the possibility to raise capital could justify grandfathering. Companies with higher profits, i.e. those with grandfathered emission permits, have fewer problems borrowing capital at better conditions on the financial markets than companies with less profits, i.e. those without grandfathered emission permits. With easier access to the capital markets, companies with grandfathered emission permits could invest more in research and development and invest more in emission abating technologies than companies with auctioned emission permits. This could decrease total costs for society to comply with the Kyoto Protocol.

3. Distribution of rents of a scarce resource

Neo-classical economists believe that private markets are generally more efficient than governments in distributing rents among society. Some therefore defend grandfathering because they simply fear that the government would squander the revenues of the sale of emission permits.

4. Problems with unfair competition

On an international level, unfair competition arises between companies in different countries when allocation rules differ. This can happen in a sector where there is cross border competition. Companies in countries with grandfathering will have higher profits than companies in countries with no grandfathering. If this advantage lasts sufficiently long the former will attract more capital investment. Whereas a net transfer of capital within a single country from a company to the state or vice versa is considered as neutral in a utilitarian framework, the net transfer of investments across borders cannot be considered as neutral anymore. This reasoning is similar to concerns for environmental dumping raised by some opponents of too strict environmental legislation in the developed world.

Unfair competition also exists between companies located in countries with no reduction commitments at all (the non-Annex I countries) and those located inside countries with emission reduction commitments (the Annex I countries) in the Kyoto Protocol. Energy intensive sectors in Annex I countries that compete globally claim they will experience a substantial competitive disadvantage due to the emission reductions constraints imposed upon them. Fears are also expressed about delocalisation of these industries toward non-Annex I countries.

Although all previous arguments seem well founded, none of them is conclusive. Many policies have implications, good or bad, on the value of existing investments. Problems with raising capital exist for all kinds of new investments and technologies. Governments do not per definition squander their revenues. Specifically in the case of auctioning or taxes governments propose to use the revenue to lower other distorting taxes, such as those on labour. Finally, the discussion on environmental dumping and delocalisation due to too stringent environmental legislation generally is inconclusive.

B. Arguments in favour of auctioning

Strong arguments pro auctioning also exist. With auctioning there are less problems with new entrants, there is revenue available to pay for social relief funds for possible laid off workers, no allocation rules have to be defined and there is less scope for rent-seeking behaviour. Most importantly it opens opportunities to recycle revenue through taxes on labour, thus lowering the costs of labour and creating a double dividend.

1. New entrants

Grandfathering seems to favour established companies upon new entrants, who have no entitlements on grandfathered emission permits and will therefore have to acquire them on the secondary market. With auctioning, new entrants and existing companies would experience a level playing field, i.e. both will have to pay for all their emissions through the acquisition of emission permits.

The argument of new entrants is often used against grandfathering. This is actually incorrect if capital markets function perfectly. New entrants can then raise capital as easily with grandfathering as with auctioning. Capital markets should take into account the opportunity cost of emission permits when evaluating the profitability of existing firms. Therefore, capital markets should require that companies with grandfathered emission permits outperform their competitors without grandfathered emission permits, to the extent of the grandfathered emission permits. Entrants should only enter an industry if they are more efficient than incumbents, corrected for the grandfathered emission permits. Hence, new entrants and existing companies should experience a level playing field when they want to raise capital to enter the market or expand production capacity. *"It is possible that small new sources could be disadvantaged because of imperfect capital markets that limit their access to finance. But this problem is best rectified by addressing the sources of any capital market distortions."* (Fischer, Kerr, Toman 1998).

2. Job losses and social relief funds

Companies and labour unions sometimes proclaim that, to prevent massive job cuts, permits have to be grandfathered. This is an erroneous argument. As we saw above, grandfathering and auctioning will have exactly the same effect on the behaviour of firms (and on the choice of the optimal mix of production factors). On the contrary, the revenues generated through auctioning could be used to pay for social relief funds and retraining programs to avoid social turmoil in the worst affected areas. Auctioning could only speed up the adaptation of the production process because managers will be harder pressed to improve profitability and therefore be more willing to tackle such sensitive subjects as lay-offs.

3. No need for a specific allocation rule

Grandfathering emission permits demands some kind of formal allocation rule to be defined by the government. The government can choose whatever rule it thinks is appropriate and many rules exist for which a plausible justification can be given, e.g.:

- Governments could take past emissions as a reference to distribute emission permits if it wants to anticipate the problem of stranded assets;
- Governments could consider energy efficiency as a criterion to reward early efforts;
- Governments could look at projections of future emissions to avoid excessive constraints on expanding industries;
- Governments could grandfather emission permits to energy intensive industries according to their vulnerability for international competition.

These are only a few examples of possible allocation rules, each of them having a profoundly different impact on the amount of allocations distributed to each company within each regulated sector. Every rule has it merits and drawbacks, but obviously it is impossible to satisfy all rules at once. Even if a rule is eventually agreed upon, a lot of company specific data will still be required to actually allocate emission permits, e.g. past emissions, future emissions, energy efficiency data, marginal abatement cost curves, profit forecasts, etc. Most of these data are at best presently unknown or at worst simply impossible to calculate. Selecting allocation rules is therefore intrinsically a political choice. Rent-seeking behaviour will induce a large amount of industry-sponsored research into the gathering of missing data. This whole process can be painstakingly slow (Joskow, Schmalensee 1998) and consumes a lot of resources. With auctioning there is no need to define any allocation rule, no need to estimate all the missing data and there are less opportunities for the industry to embark in rent-seeking behaviour.

4. The double dividend

Neo-classical economic theory indicates that markets give correct price signals to private agents in such a manner that they distribute wealth efficiently and maximise utility in a utilitarian manner. Therefore, government intervention in the free market should be kept to a minimum. But in practice the government intervenes on many markets. One of the most profound interventions can be found in the labour market where the government taxes the supply of labour. The wider the gap between wages earned by the employee and wages paid by the employer, the smaller the quantity of labour employed in the market will be. All other things remaining equal, one could thus expect that decreasing taxes on labour would increase the quantity of labour employed. If the government auctions the emission permits, it could use the revenue to decrease the taxes on labour and as such lower unemployment and stimulate economic growth.

This is defined as the double dividend. The first dividend is the improvement of the environmental quality through the mitigation of climate change. The second dividend is the improvement of the labour market and consequently the decrease in unemployment and the positive effect on GDP.

Much research has already been conducted on this topic. Although many theoretical studies suggest that recycling revenues from auctioning can lower the total cost of complying with the Kyoto Protocol, they do not show an outright net positive effect on GDP. The double dividend can decrease the cost of compliance but it cannot guarantee a win-win situation. Goulder, Parry, Williams and Burtraw (1998) suggest that a net win-win situation is too optimistic. Disregarding the potential (financial) benefits of reduced climate change damage, they argue that the reduction of emissions will cause a financial cost to society, whatever the means of redistributing the revenue to society. Nevertheless, they do make it clear that a revenue generating measure, like auctioning, which is recycled by reducing labour taxes remains the best policy measure available to minimise total compliance costs.

Bosquet (2000) reviewed the practical experience and modelling studies available to date on the subject of the double dividend. He concluded that *"when environmental […] revenues are used to reduce payroll taxes, and if wage-price inflation is prevented, significant reductions in pollution, small gains in employment, and marginal gains or losses in production are likely in the short or medium term, while investments fall back and prices increase. Results are less certain in the long term. They might be more positive if models selected welfare instead of production indicators for the second dividend, and if several important variables, such as wage rigidities and the feedback of environmental quality on production, were factored into simulations."*

The result of a modelling exercise by the Belgian Federal Planning Bureau pointed out that under certain conditions, climate change policies together with the recycling of revenues can have a net positive impact on GDP (Bossier et al., 2001).

C. Governments should prefer auctioning over grandfathering

To sum up, the positive effects of the double dividend and the conceptual problems with the definition of an equitable allocation rule to grandfather permits, plead in favour of auctioning. This is also in line with the 'polluter-pays-principle'. Grandfathering should only be a temporarily allocation method. The right to emit greenhouse gases should not be bestowed forever upon the historic emitters, but remain in the hands of society as a whole. In an international context endowments based on historic emissions would be unacceptable because they would hamper developing countries severely in their capacity to grow in a carbon-constrained world. The atmosphere and its assimilative capacities do not belong to anyone in particular but to all of humanity.

Nevertheless, deciding upon the allocation rule that should be applied remains a political decision. To compensate for stranded assets, grandfathering can be considered over a limited period of time. When auctioning has a severe negative impact on companies in international competitive sectors, grandfathering could also be considered. Governments should nevertheless be conscious of the fact that the affected companies will most likely engage in rent-seeking behaviour and exaggerate the negative effects of auctioning.

Social inertia, rent seeking behaviour, competitive distortions and many other issues will most likely prevent the implementation of full scale auctioning in all Annex I countries during the first commitment period of the Kyoto Protocol (2008-2012). Nevertheless, it remains of the outmost importance that those who

are involved in the decision making process understand the basic economic principles behind these new and innovative policy instruments, before taking decisions.

VII Emission trading or taxation, when to use which instrument?

The previous chapter discussed the merits and disadvantages of grandfathering and auctioning as an allocation rule for emission trading. This chapter will look at the advantages and disadvantages of the use of emission taxes compared to emission trading. Both are economic instruments but in the framework of the Kyoto Protocol they have different implications.

A. Arguments in favour of taxation

1. Similar to emission trading with auctioning

A tax is similar to emission trading with auctioning and even identical if the tax level is equal to the emission permit price. Most of the same arguments can be used to defend taxes as those used to defend emission trading with auctioning. At first sight, taxes seem fairer for new entrants than emission trading with grandfathering to existing private entities. But the same counter reasoning can be used against this argument as in the previous chapter (see VI.B.1). Furthermore, taxing will raise revenue that can be used to pay for social relief funds and retraining programs. Neither is there a need for a specific allocation rule. The only thing the government has to decide upon is the level of the tax. This makes the decision making process a lot easier and simplifies the administrative burden. In addition, taxes raise revenue that can be used to generate a double dividend. The last two advantages are by far the most appealing aspects of taxation. Furthermore, policy makers are quite familiar with the concept of taxation. However, this familiarity with taxation could also be a disadvantage. Eco-taxation should primarily be considered as an environmental policy tool that allows for a behavioural change. It should not become merely a revenue generating policy instrument. The aim should primarily be to decrease the externalities caused by certain polluters.

2. A tax sets an upper limit on the MAC experienced by private entities

Private entities equalise their MAC with the tax level. Private entities will prefer a tax to emission trading with auctioning if they estimate that the market prise for emission permits will be higher than the tax level. The opposite is obviously true as well. Finally, private entities will probably never prefer a tax to emission trading with a generous grandfathering scheme because of the higher negative impact the tax may have on their profits.

3. Certain sectors are better suited to be regulated through fiscal measures

Monitoring and verifying emissions and accounting for emission permits from numerous small, dispersed and often mobile, emission sources is very cumbersome. This makes emission trading an expensive policy instrument to manage. For these kinds of sources, taxing could be the preferred policy tool because they can be implemented with a much lower administrative burden. Taxing fossil fuels is a good example. Every type of fossil fuel combusted generates a prefixed amount of CO_2 emissions, irrespective of the combustion technology used. Therefore, only a simple mathematical exercise is required to calculate the tax rate for every type of fossil fuel that corresponds to a certain tax on CO_2-emissions. This tax is then set at a fixed absolute amount per unit of fossil fuel, which is different from the VAT, which is set as a percentage of the variable sale price. Such a CO_2 tax can easily be used to regulate a large number of diffuse and even mobile emission sources, such as residential heating and transportation.

For small emitters taxation could be a less cumbersome instrument to comply with than emission trading with auctioning which needs more resources and time in order to effectively follow up the market for emission permits and engage in transactions on this market. A tax gives more certainty and price stability for private entities than emission trading, which could be beneficial to create a stable environment for future investments.

B. Arguments against taxation

1. Taxes do not always minimize the costs to comply with the Kyoto Protocol

Taxes are an economic policy instrument. MACs equalize with the tax level and assure in that way that all emission reductions cheaper than the specific tax level are achieved. The amount of reductions achieved with a tax cannot be achieved at a lower abatement cost with any other policy instrument if the markets are functioning well. As such a tax is an efficient economic policy instruments.

But the Kyoto Protocol also creates an international market for emission permits. Taxing emissions of greenhouse gases will not minimise national abatement costs when the tax differs from the price of emission permits on the international market. This is a major disadvantage of the tax. When the tax is too high, there will be too much abatement. It would have been cheaper to abate less domestically and buy more emission permits on the international market[1]. When the tax is too low, there will be too little abatement. It would have been better to abate more and buy less emission permits on the international market[2].

1. When a country is a net seller of emission permits this sentence has to be reformulated as follows: when the tax is too high, there will be too much abatement and it would have been cheaper to abate less and sell fewer emission permits on the international market.
2. When a country is a net seller of emission permits this sentence has to be reformulated as follows: when the tax is too low, there will be too little abatement and it would have been better to abate more and sell more emission permits on the international market.

Taxes cannot take into account the price changes on the international market. Within the context of the Kyoto Protocol, this disadvantage of an emission tax is often overlooked. So far, eco-taxation has always been introduced in the context of strictly national pollution abatement policies. When there is no international emission permit market, this disadvantage of taxing is not an issue. It is the Kyoto Protocol that for the first time creates an international emission permit market combined with fixed emission reduction targets for Annex I countries.

2. Certain sectors can better be regulated by emission trading

The government's should try to equalise national MACs with the emission permits price on the international market. Because taxes do not guarantee this, emission trading could be a preferred policy tool. If the government wants to create a double dividend, it can still auction the emissions permits and recycle the revenue.

Within the EU for years there has been a discussion on the introduction of a CO_2/ energy tax. However, due to different political sensitivities, this proposal has never been accepted. Many exemptions were foreseen for energy intensive industries. This would probably have resulted in tax levels lower than the price for emission permits on the international market and in a sub-optimal outcome. Within these energy intensive industries reductions opportunities would still exist with lower MACs than the international price for emission permits[1]. A possible way out could be to regulate these sectors through emission trading with grandfathering which could be more politically acceptable.

Furthermore, energy intensive sectors consist mainly of large companies with large emissions that have the resources required to comprehend the opportunities and hazards that come along with emission trading. Hence, they should relatively easily be able to develop the skills necessary to engage in emission trading and take advantage of the peculiar features of this market mechanism. From an administrative point of view, it is easier to monitor and control a limited set of large companies than a large number of small emitters. Therefore, large emitters are the principal candidates to be regulated through emission trading.

1. Total costs for society would reduce if more emissions would be abated in these sectors. Less emission permits can then be bought on the international market or more sold.

VIII An optimal policy mix in an EU framework

The previous chapters looked at the different economic policy instruments at the disposal of a government to comply with the Kyoto Protocol reduction commitments. Governments can buy emission permits on the international market, or they can decide to implement policies domestically to reduce emissions. Traditional command and control policies are not considered in this paper. They do not offer the flexibility that market based instruments do. Because of their rigidity, they tend to be less effective in minimising compliance costs. Nevertheless, they can be useful instruments to facilitate the functioning of the market mechanisms when there are market imperfections. For a more elaborate discussion on their use, see Bernheim (2001). In the rest of this chapter it is assumed that the government will only opt for economic policy instruments.

This paper emphasises the necessity for countries to try to equalise their domestic MAC with the emissions permits price on the international market. A country's policy mix is sub-optimal if a country's MAC differs over a long period of time substantially from this market price. When the MAC equalises with the market price, the country will over- or undershoot its reduction target under the Kyoto Protocol and become a net seller or net buyer.

The most important element of climate change policy should not be the decision to buy emission permits on the international market. Foremost, a government should decide on policies that should try to equalise the domestic MACs with the international market price. Consequently, it will become clear if the country is a net buyer or net seller of emission permits and only then should it determine how many emission permits it should still buy or could sell, allowing it to be in compliance with the Kyoto Protocol.

The government will have to choose between using emission trading or emission taxation as policy instruments. This choice will depend on its appreciation of the arguments in favour or against these instruments (see chapters V, VI and VIII). This paper does not put forward an ideal policy mix. Nevertheless, a preference for revenue generating policy tools was expressed, which allow for the creation of double dividends. Sectors with many diffuse emission sources are more suitable to be regulated through taxation. Sectors with large point sources seem more suited for emission trading.

A. An EU emission trading system

Under new EU legislation many of these large point sources will have to be regulated through emission trading. Member states' governments will have no choice in this anymore. The Council and Parliament have approved a directive[1] that will create an emission trading system for large point sources of CO_2 emissions within the EU. It covers such industrial sites as large combustion installations, mineral oil refineries, coke ovens, blast furnaces, etc. The CO_2 emissions from large point sources covered by the directive represent more than 40% of all greenhouse gas emissions in Belgium in 2000[2]. The EU emission trading system will start in 2005, three years before the beginning of the commitment period (2008-2012) under the Kyoto Protocol. Governments will be able to include additional types of emissions, sectors or private entities in this system. To do so, they must prove to the Commission that this would not distort competition within the EU and that the monitoring and reporting of the greenhouse gases are up to standards.

Important to note is that this EU emission trading system is not exactly the same thing as the international emission trading system under the Kyoto Protocol. Under the EU system companies will trade in a different kind of emission permit, called an allowance. Companies can freely trade these allowances within the EU market. They will be allocated allowances through grandfathering or auctioning by their governments, and on a yearly basis will need to demonstrate that they own enough allowances to cover for the emissions from their large point sources.

From 2008 onwards, for each allowance that the government allocates to its private entities on its territory (be it through grandfathering or auctioning), it will need to set aside a corresponding amount of emission permits[3] under the Kyoto Protocol (from now on simply referred to as emission permits). With each cross-border trade of allowances between private entities, a matching trade of emission permits will take place between the involved countries' authorities, free of cost. This double booking system will guarantee that governments of countries with net buying private entities on the EU allowance market receive an equivalent amount of emission permits that can then be used by the governments to comply with the Kyoto Protocol, at the end of the commitment period (2008-2012).

When allocating allowances to the sectors under the EU emission trading system, governments can choose to auction part of the allowances. This is limited up to 5% of the total amount of allocated allowances for the period 2005-2007 and may increase up to 10% for the period 2008-2012. All the other allowances have to be grandfathered. In this paper a clear preference was expressed for revenue generating instruments such as auctioning. But the specific requirements in the EU directive for grandfathering, will hamper governments in doing so within the sectors that fall under the EU emission trading system. This outcome clearly indi-

1. Directive of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC'. For more information regarding this directive, one can consult the website of the Commission: http://europa.eu.int/comm/environment/climat/home_en.htm.
2. Based on the yearly submission of the greenhouse gas emissions inventory by Belgium to the unfccc secretariat, i.e. the common reporting format.
3. Annex I countries trade in Assigned Amount Units (AAUs), Emission Reduction Units (ERUs), Certified Emission Reductions (CERs) and Removal Units (RMUs). The emission permits that Annex I countries get initially allocated up to their assigned amount are Assigned Amount Units (AAUs). ERUs and CERs stem from greenhouse gas reduction projects under Joint Implementation (ERUs) and the Clean Development Mechanism (CERs). RMUs are generated when there is increased absorption of greenhouse gases by natural sinks (RMUs).

cates that the arguments in favour of grandfathering (see chapter VI) prevailed during the negotiations on this subject in the Council and the Parliament at the expense of those in favour of revenue generating instruments[1].

The EU emission trading market will have a large number of participants, thus guaranteeing market liquidity. Arbitrage will ensure that allowances prices equalise between the different countries and sectors participating. This in turn will ensure that private entities equalise their MACs with the market price for allowances.

There is no direct link between the EU emission trading system and the international emission trading system under the Kyoto Protocol. Private entities in the EU emission trading system cannot trade and use emission permits for compliance under the EU emission trading system[2]. Private entities within the EU system can only use allowances for this. Only governments will use the emission permits for compliance under the Kyoto Protocol.

The lack of a direct link between the EU emission trading market and the international emission trading market under the Kyoto Protocol, can result in different price levels between the two systems. If prices differ substantially over a long period of time, the optimal outcome of equalising MACs with the price for emission permits on the international market will not be achieved. The Council and Parliament have chosen for the separation of the EU emission trading system and the international one to guarantee environmental integrity and achieve sufficient effective emission reductions within the EU. The long-term aim is to achieve sustainable development in the EU, meaning a sustained economic growth combined with real long-term greenhouse gas emissions reductions. Nevertheless, despite these potential price differences that could lead to a suboptimal outcome, it remains crucial that an efficient national climate change policy allows MACs to equalise with prices for allowances within those sectors that are regulated through the EU emission trading system. If companies would not be able to equalise their MAC with the price for allowances, then the economic efficiency of the EU emission trading system itself would furthermore decrease. Therefore governments should refrain from introducing command and control measures on top of emission trading that would hinder this equalisation.

1. Note that theoretically governments could circumvent this limitation on auctioning and still generate revenue by reducing the total amount of allowances that it allocates to the sectors under the EU emission trading system. This will free emission permits that need not be set aside for the allocation of allowances within the EU emission trading sector. This would allow the government itself to sell more or buy less emission permits on the international market, by itself a revenue generating measure. On the other hand governments will need to keep in mind that this would reduce the availability of allowances on the EU emission trading market, therefore reducing supply and thus creating an upward pressure on the overall allowance price.
2. Companies cannot buy AAUs on the international market for compliance. They will be allowed to invest in emission reduction projects under the project mechanisms of the Kyoto Protocol in countries outside the EU emission trading system, i.e. Joint Implementation and the Clean Development Mechanism. Emission permits generated from these projects can then be swapped into allowances to trade and used for compliance under the EU emission trading system. But the guidelines for this swapping are still discussed within the Council and Parliament and will most likely include several limitations on the kind of projects eligible for the swapping of emission permits into allowances.

B. An ideal policy mix

For those sectors that are regulated through the EU emission trading scheme a government will still need to decide how many allowances it will allocate to them and if it will allow for a limited amount of auctioning. The rules on how many allowances may be allocated in total and how they need to be distributed among the private entities remain very vague in the directive. This is unfortunate because this will not put a check on rent-seeking behaviour by the regulated private entities.

Due to the small share of Belgian emissions in the total of EU's emissions it is unlikely that the Belgian government's allocation decision would have a significant impact on the total amount of allowances available on the EU emission trading market and therefore on the price for allowances on the EU market at which Belgian companies will be able to sell or buy allowances. So when deciding on the total allocation and possible auctioning of allowances, the Belgian government should primarily focus on its appreciation of the positive and negative impacts on industry from emission trading (see chapter V) and the arguments in favour or against auctioning and grandfathering (see chapter VI). This paper does not try to give an explicit answer on what an optimal amount of total allocation, grandfathering and auctioning of allowances would be. Economic theory cannot tell with certainty what combination would be the most efficient in the short run. Nevertheless a clear preference was expressed in the previous chapters against too generous grandfathering.

For those sectors that are not part of the EU emission trading system, the government still needs to determine how to regulate them. As mentioned before, under certain circumstances the EU emission trading system allows for the inclusion of additional installations, sectors and greenhouse gases. More sweeping, however, would be to regulate any remaining sectors, directly through emission trading under the Kyoto Protocol itself. The Kyoto Protocol and its elaborated guidelines (Marrakech Accords, UNFCCC 2002) allow countries to authorize private entities to participate on the international market for emission trading. Governments who would decide to do so would need to set up a separate set of guidelines for a trading system that would allow private entities to trade in emission permits, and a separate allocation of emission permits through grandfathering or auctioning. Because this would be outside the framework of the EU emission trading system, the only obliged restrictions on this kind of emission trading would be those imposed by the Kyoto Protocol. But due to the regulatory burden to create a separate system of emission trading for private entities on top of the EU emission trading system, not many EU countries are expected to introduce such an additional system.

Another option is to use the taxing instrument to control emissions from the remaining sectors. The government should try to set the tax level as close as possible to the international price for emission permits because the private entities in those sectors will equalise their MACs with the tax level. If ex post the tax level differs substantially over a long period of time from the international market price for emission permits, the government should consider adapting the tax level to a more appropriate level.

The government will have to make sure that the country will be in compliance with its Kyoto Protocol target at the end of the commitment period. Ensuring that

it owns at least as many emission permits as there were greenhouse gas emissions on its territory in the period 2008-2012, does this. Governments need to set aside emission permits for the allocation of allowances under the EU emission trading system or for any separate emission trading system for private entities. By doing so and due to the nature of the emission trading instrument[1] they will always own sufficient emission permits to cover for the emissions of the sectors regulated through emission trading. These emission permits are no longer available for compliance for emissions from other sectors.

Only the remaining emission permits from the initially allocated assigned amount to the government, can be used to cover for the emissions of the other sectors that are not regulated through emission trading. If this remaining amount is smaller than the (expected) emissions in those other sectors, the government will have to buy emission permits on the international market and will not be able to sell any emission permits on the international market itself. Conversely, if after the deduction of the emission permits set aside for the allocated allowances or emission permits the government still holds more emission permits than it needs for the other sectors, then it will be able to sell them on the international market.

A country as a whole will be a net seller/buyer of emission permits on the international market if the sum of all sales and purchases on the market of allowances by its private entities and of emission permits by its government is a net sale/buy. Governments could try to become a net selling country by increasing the total amount of effective internal emission reductions through other policy instruments such as increased tax levels and command and control regulation. They cannot do so by decreasing the share of grandfathered allowances or emission permits in the total allocation because this would simply mean more purchases or fewer sales by private entities and fewer purchases or more sales by the government.

However, being a net seller should by no means be the objective of a climate change policy. It would be as foolish a policy as the search for autarky was for certain communist economies in the previous century. It would unnecessarily increase compliance costs if it would imply that internal MACs are higher than prices for emission permits or allowances. The primary message of this paper is that efficient policies should try to equalise MACs with the international and EU market prices for emissions permits and allowances in order to minimise total economic costs for society. In doing so it will automatically become clear if the country is a net seller or buyer on the international and EU markets. But this should depend on the country's reduction target that it took upon itself in the Kyoto Protocol, its MAC and the prices for emission permits and allowances on the international and EU markets and not on its own specific climate change policies in the case of an ideal policy mix.

1. If a private entity does not live up to its obligations under an emission trading system, the government will remain responsible for the emissions of this private entity on its territory under the Kyoto Protocol and will have to make up for the lack of emission permits. To avoid this in the EU emission trading system a system of penalties has been foreseen for private entities that are not in compliance. Penalties rise up to 100 euro per allowance lacking (one allowance covers the emission of one ton of CO_2 or equivalent amount of greenhouse gases).

IX Conclusion

This paper gave an introduction[1] into the characteristics and usefulness of market based mechanisms as instruments for climate change policy. Insights are given into the causes behind climate change from an economic point of view, i.e. missing markets for the atmosphere's assimilative services. The Kyoto Protocol is an attempt to create the legal framework for developing these missing markets. It creates a system in which countries try to manage the common use of the atmosphere. The Kyoto Protocol temporarily assigns a limited amount of the atmosphere's assimilative capacity to the Annex I countries. Through emission trading, these temporary property rights can be traded between countries and entities within each country.

Governments will need to develop national climate change policies in order to comply with the reduction targets defined in the Kyoto Protocol. National climate change policies should not try to make the country independent from the international emission trading market. The primary aim of an efficient climate change policy should be to equalise Marginal Abatement Costs with the international market price for emission permits. Then, depending on the reduction target that countries took upon themselves in the Kyoto Protocol, their Marginal Abatement Cost structure and the price of emission permits on the international market, it will become clear if the country will be a net seller or net buyer of emission permits on this international market.

Governments have at their disposal several economic instruments that allow them to do so, i.e. emission trading with or without auctioning and taxes. With taxation private entities reduce their emissions up to the point were their Marginal Abatement Cost equalizes with the level of the tax. This tax level should be set as close as possible to the price for emission permits on the international market. Under emission trading private entities reduce their emissions up to the point were their Marginal Abatement Cost equalizes with the price for emission permits. Economic theory indicates that these market-based mechanisms are cost minimising policy tools. However, economic theory cannot tell with certainty which of the mechanisms or combinations of mechanisms will be most efficient in the short run. Large uncertainties remain regarding the value of stranded assets, the level of the marginal abatement costs and the extent of the positive effect of the double dividend. Nevertheless, this paper does speak out a clear preference

1. Note that there are other issues that have an impact on the use of market based mechanisms that were not discussed in the paper, i. e. supplementarity, carbon sinks and multi-gas flexibility (flexibility in the means), banking (time flexibility), monitoring, compliance, liability issues, upstream or downstream emission trading, the problem of hot air, the commitment period reserve, activities implemented jointly, joint implementation, the clean development mechanism, technology transfer, capacity building, national registries, the specific modalities of the EU emission trading system such as opting out, pooling, national allocation plans, new entrants, etc. For information on several of these items, we refer to Bernheim (2001).

for revenue generating policies such a taxing and emission trading with auctioning. This last option is severely restricted in the new EU legislation introducing a mandatory emission trading system with grandfathering for large point sources.

Tackling climate change requires the development of innovative and creative policy instruments. This paper should help those with less economic expertise to better understand the economic arguments in favour of market-based mechanisms. It should make them aware of their limitations but most of all of the opportunities they create to efficiently regulate a global problem by taking advantage of global markets without loosing sight of the particularities of the national economic circumstances.

X Appendix 1: The reduction commitments for the Annex I countries

In this annex the reduction commitments for Annex I countries in the Kyoto Protocol are listed. The amount of emissions assigned to a country during the 5-year commitment period (2008-2012) is equal to that country's greenhouse emissions in it base year, multiplied by its reduction commitment, multiplied by 5. For most countries the base year is 1990. Countries that are undergoing the process of transition to a market economy may choose another base year than 1990.

For the countries of the European Union the reduction commitment is 92%. However, article 4 of the Kyoto Protocol (the so-called 'bubble'-article) allows the EU-countries to redistribute this target internally among the 15 member states. In the Council conclusions of 17.6.98 the EU countries agree upon this redistribution in the 'Burden Sharing Agreement'. These redistributed reduction commitments are included in the list below.

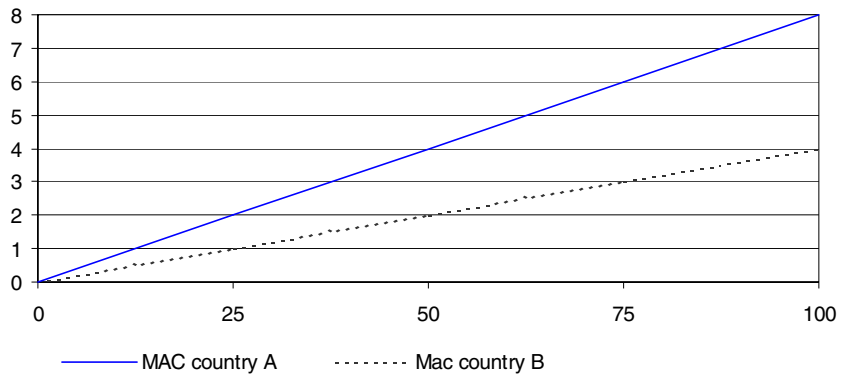
TABLE 1 - Reduction commitments

Luxembourg	72 %
Denmark	79 %
Germany	79 %
Austria	87 %
United Kingdom of Great Britain and Northern Ireland	87.5 %
Bulgaria	92 %
Czech Republic	92 %
Estonia	92 %
European Community	92 %
Latvia	92 %
Liechtenstein	92 %
Lithuania	92 %
Monaco	92 %
Romania	92 %
Slovakia	92 %
Slovenia	92 %
Switzerland	92 %
Belgium	92.5 %
United States of America	93 %
Italy	93.5 %
Hungary	94 %
Canada	94 %
Japan	94 %
Netherlands	94 %
Poland	94 %
Croatia	95 %
Finland	100 %
France	100 %
New Zealand	100 %
Russian Federation	100 %
Ukraine	100 %
Norway	101 %
Sweden	104 %
Australia	108 %
Iceland	110 %
Ireland	113 %
Spain	115 %
Greece	125 %
Portugal	127 %

XI Appendix 2: Emission trading, a theoretical example

Let us assume there are two countries A and B with different abatement costs. MACs are defined in this example as the cost to decrease one extra tonne of CO_2 emissions, the principal greenhouse gas (see figure 7). Country A's MACs are higher and increase faster than country B's. Zero on the horizontal axis represents the situation where no restrictions exist on the emissions of greenhouse gases. This is sometimes referred to as the 'business as usual' situation. Any other point on the horizontal axis represents a deviation from business as usual, where emissions are abated in comparison with the business as usual situation. The total abatement cost is equal to the sum of the MACs for each tonne abated. This corresponds to the surface underneath the MAC-curve. If country A would abate 100 tonnes of CO_2 internally, the total abatement cost would be 400 $. If country B would abate 100 tonnes of CO_2 internally, the total abatement cost would be lower, only 200 $.

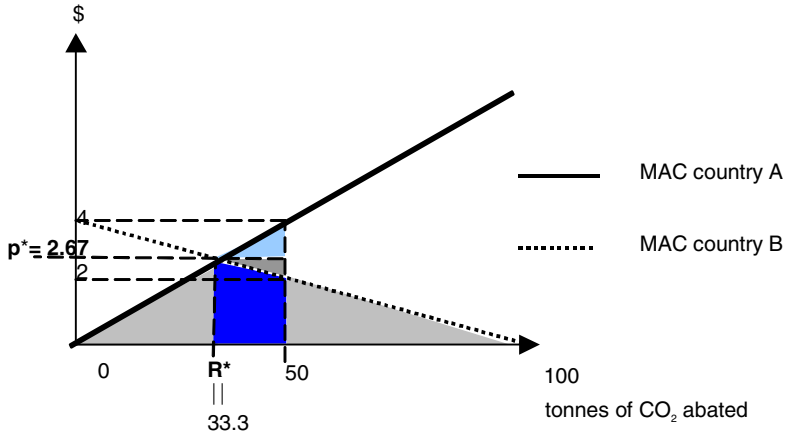
FIGURE 7 - Marginal abatement cost curves



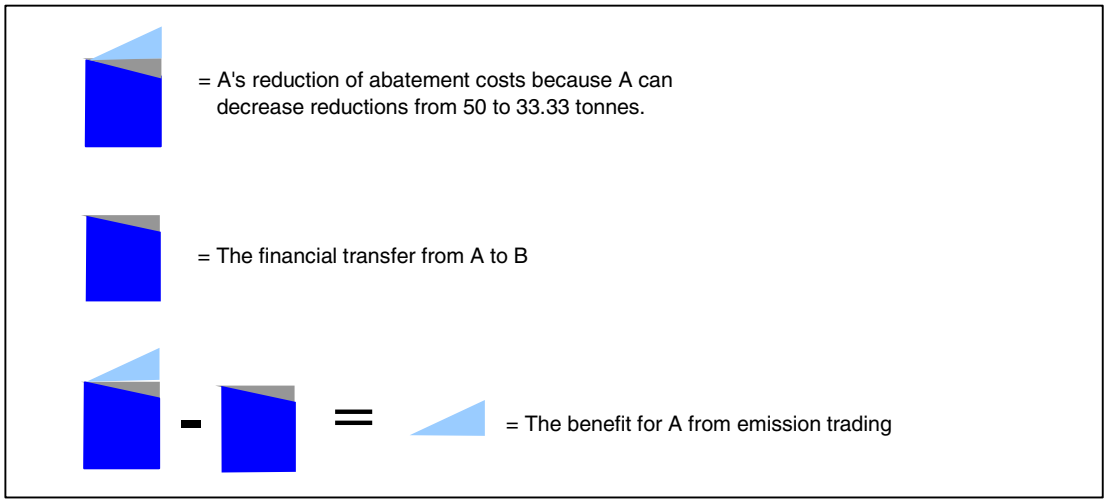
Assume now that both countries have accepted the same reduction target and that they both will lower their emissions of CO_2 with 50 tonnes in comparison with business as usual. In figure 8 the MAC curve of B is plotted on the opposite side. The horizontal axis now represents the total amount that has to be abated by the two countries together, namely 100 tonnes of CO_2. Any point on the axis defines a division of the total abatement commitment of 100 tonnes between the two countries. For instance, 0 tonnes of CO_2 abated on the horizontal axis would mean that A doesn't perform any emission reductions and B reduces its emissions with 100 tonnes. If they both abate 50 tonnes internally, the total cost of abatement becomes 150 $, equal to the shaded areas underneath the MAC curves (see figure 8). A's total abatement cost is 100$ whereas B's is only 50 $. A's MAC is as high as 4 $ whereas B's is only 2 $.

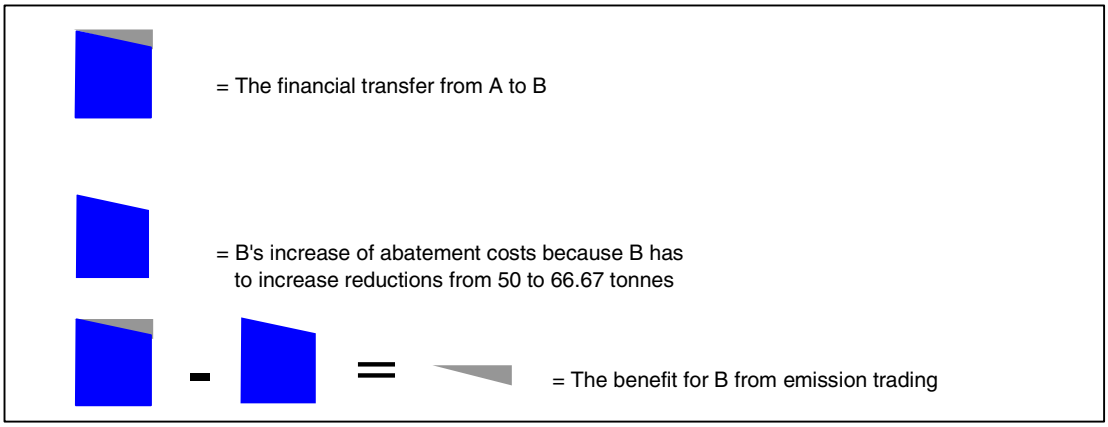
There is an opportunity to trade. B could abate one tonne more and A one tonne less, together still abating the necessary amount of 100 tonnes of CO_2. With A's MAC of 2$ per tonne and B's MAC of 4 $ per tonne, A can pay a price up to 4 $ to B to abate one more tonne, even though B's cost to reduce one more tonne is only 2$. Both countries are better off compared to a situation with no trade. Also for the next tonne there is an opportunity to trade, even though A's MAC has decreased and B's MAC has increased. These opportunities to trade exist until their MACs become equal. In this example this is the case when A abates 33,3 tonnes and B abates 66,7 tonnes. From this point on it becomes uneconomical for A to pay B for any extra reductions. Total abatement cost minimises at 133,33 $, down from 150 $ and the overall benefit of emission trading is 16,67 $. This benefit is split between A and B, depending on the price paid by A to B for each extra reduction. In figure 8 it is assumed that A pays B a constant price for each extra reduction, equal to the intersection of the two MAC-curves, i.e. 2,67 $. If there are frequent trades between many countries, the MACs for the last tonne abated will equalise between countries and converge to an equilibrium price for emission permits on the international market. This detailed example demonstrates that with emission trading there are no losers. Both sellers and buyers gain from emsion trading.

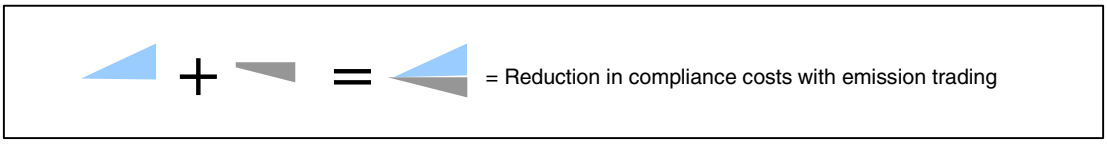
FIGURE 8 - Abatement costs with or without emission trading



From this figure it is straightforward to deduce the benefits for A and B:







XII Bibliography

Bernheim T. 2001: "Coopération internationale et instruments pour la prise de décision dans le cadre de la politique climatique", Planning Paper 89, Bureau Fédéral du Plan (also available in Dutch)

Bosquet B. 2000: "Environmental tax reform: does it work? A survey of the empirical evidence.", Ecological Economics 34, pp 19-32

Bossier F., Bracke I., Callens I., de Beer de Laer H., van Ierland W., Vanhorebeek F. 2001 "Évaluation de l'impact des mesures fiscales et non fiscales sur les émissions de CO_2", Working Paper 09-01, Bureau Fédéral du Plan

Capros P., Mantzos. L. 2000: "The Economic Effects of EU-Wide Industry-Level Emission Trading to Reduce Greenhouse Gases", Institute of Communication and Computer Systems of the National Technical University of Athens, http://europa.eu.int/comm/environment/enveco/climate_change/primes.pdf

DTI 2000: "Digest of United Kingdom Energy Statistics 2000", Department of Trade and Industries, http://www2.dti.gov.uk/epa/digest.htm

Ellerman D.A.1999: "Obstacles to Global CO_2 Trading: A Familiar Problem", In American Council for Capital Formation: "Climate Change Policy: Practical Strategies to Promote Economic Growth and Environmental Quality"

Ellerman D.A., Sue Wing I. 2000: "Supplementarity: An Invitation to Monopsony?", MIT Joint Program on the Science and Policy of Global Change, Report No. 59, Massachusetts Institute of Technology, http://web.mit.edu/globalchange/www/MITJPSPGC_Rpt59.pdf

Fischer C., Kerr S., Toman M 1998, "Using emission trading to regulate US greenhouse gas emissions.", Climate Issue Brief No 10, June 1998, Resources for the future, http://www.rff.org/issue_briefs/PDF_files/ccbrf10.pdf

Goulder L.H., Parry I.W.H., Williams III R.C. Burtraw D. 1998: "The Cost-Effectiveness of Alternative Instruments for Environmental Protection in a Second-Best Setting", Discussion Paper 98-22, March 1998, Resources for the Future, http://www.rff.org/disc_papers/PDF_files/9822.pdf

IEA 1999: "CO_2 emissions from fuel combustion 1971-1997", International Energy Agency, http://www.iea.org

IEA 2000: "World Energy Outlook 2000", International Energy Agency, http://www.iea.org

IPCC 2001-a: "Third Assessment Report, Working Group One, Climate Change 2001: The Scientific Basis, Summary for Policy Makers", Intergovernmental Panel on Climate Change, http://www.ipcc.ch

IPCC 2001-b: "Third Assessment Report, Working Group Three, Climate Change 2001: Mitigation, Summary for Policy Makers", Intergovernmental Panel on Climate Change, http://www.ipcc.ch

JEC 2001, "Adam Smith Bio", Joint Economic Committee, http://www.senate.gov/comm/jec/general/smith.html

Joskow P.L., Schmalensee R. 1998, "The Political Economy of Market-Based Environmental Policy: The U.S. acid rain program", The Journal of Law an Economics , April 1998

Kemfert C. 2000, "Emission trading and its impacts on world economies: Contemplation of baseline emissions paths and a ceiling on emission trading", Fondazione Eni Enrico Mattei Working Paper 1.2000, http://www.feem.it/web/activ/wp/abs00/01-00.pdf

Proost S., Van Regemorter D. 2000, "How to achieve the Kyoto Target in Belgium: modelling methodology and some results", working paper series n°2000-9, December 2000, Center for economic studies, Katholieke Universiteit Leuven, http://www.econ.kuleuven.ac.be/ew/academic/energmil/publications/ete-wp00-9.pdf

Smith A. 1776: "The Wealth of Nations: An Inquiry into the Nature and Causes", Everymans Library, reissue edition September, 1991

UNEP 2001, The Ozone Secretariat, United Nations Environment Programme, http://www.unep.org/ozone

UNFCCC 1992, "United Nations Framework Convention on Climate Change", http://www.unfccc.de/resource/convkp.html

UNFCCC 1997, "Kyoto Protocol to the United Nations Framework Convention on Climate Change", http://www.unfccc.de/resource/convkp.html

UNFCCC 2001-a, "Guide to the Climate Change Negotiation Process", UNFCCC secretariat, http://www.unfccc.de/resource/process/index.html

UNFCCC 2001-b, "Greenhouse gas inventory data from 1990 to 1998", UNFCCC secretariat, http://www.unfccc.de/resource/ghg/tempemis2.html

UNFCCC 2002, "Report of the Conference of the Parties on its seventh session, held at Marrakech, addendum, Part two: Action taken by the Conference of the Parties", http://unfccc.int/resource/repcops.html