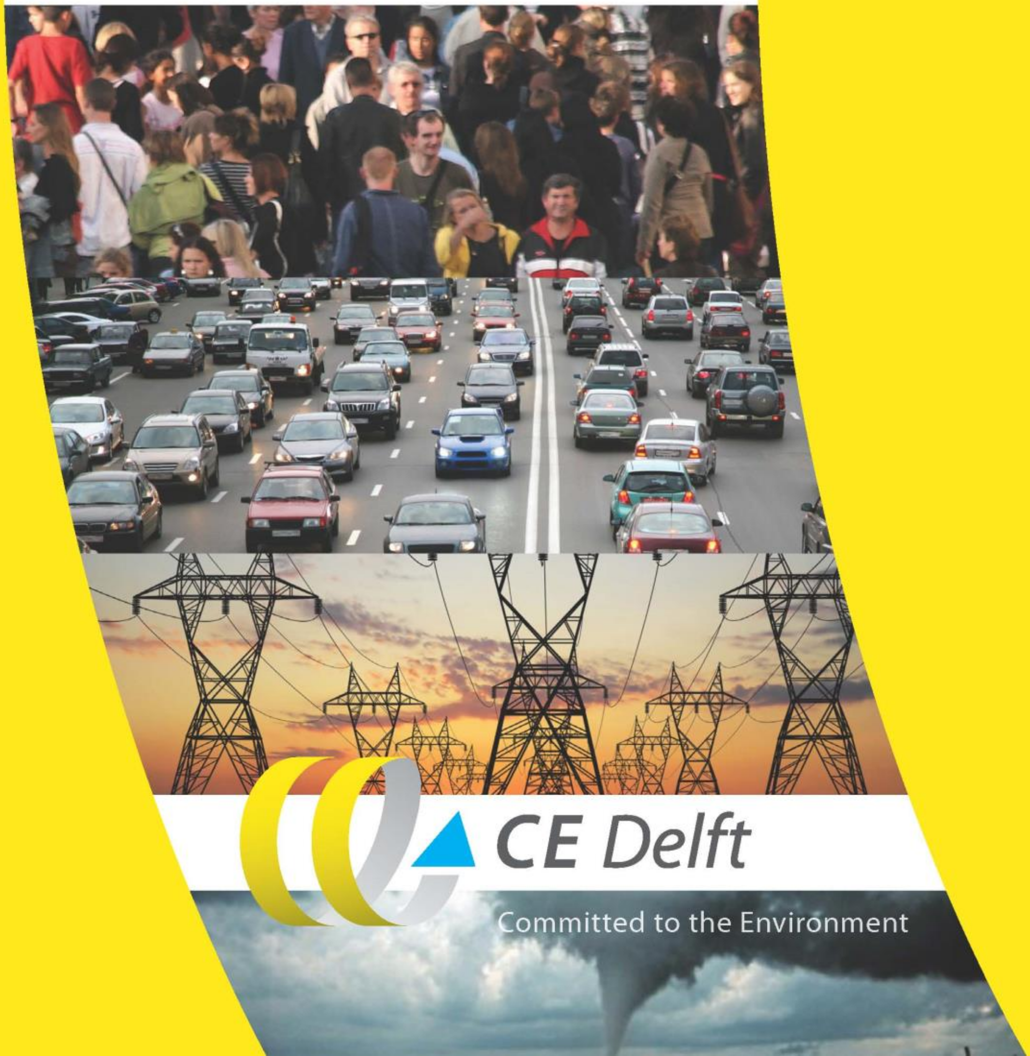
Carbon Added Tax as an alternative climate policy instrument



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Committed to the Environment

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Preface

The Carbon Added Tax (CAT) was proposed as a potential solution to the current climate crisis by Sander de Bruyn of CE Delft in the interdisciplinary project *the Matrix*. The Matrix was set up as a multi- and transdisciplinary project under the Dutch Bsik programme ‘Climate Change and Spatial Planning’ between 2009 and 2010. The aim was to develop concrete action perspectives on the climate crisis in a partnership between climate science, economics, urban planning and social sciences, each represented by a ‘steward’, with Sander acting as ‘steward’ from the economic sciences.

The stewards have each written an essay on the links between their discipline and the climate issue. From these essays there emerged a number of ‘common themes’ and a series of debates held in 2009 in the ‘Fundatie van Renswoude’ in Utrecht, the Netherlands.

In 2013 the leader of the Matrix Project, Prof. dr. Dirk Sijmons, asked CE Delft to make the issue of the proposed CAT more lively by investigating its functioning and potential impacts up to 2050. This follow-up study served as the basis for an exhibit at the International Architecture Biennale Rotterdam, 2014. Since then, further calculations have been made as part of a submission to the Eo Wijers *Prijsvraag* – a public competition on ways to improve the quality of public spaces in the Netherlands.

CAT Exhibit at the International Architecture Biennale Rotterdam, 2014.

Summary

This research paper summarizes research into the functioning, monitoring and reporting requirements and impacts of introduction of a **Carbon Added Tax**. A Carbon Added Tax (CAT) is an alternative climate policy instrument which taxes the carbon embodied in products. It is designed similarly to the Value Added Tax (VAT), but instead of taxing *value* (the sum of salaries and profits), the CAT would tax *carbon*.

Why an alternative climate policy instrument?
Climate change is threatening the future wealth, stability and well-being of our societies. While governments have taken steps to implement climate policies for over a decade now, especially in EU countries, progress to date has not been enough to steer the world away from the business-as-usual path towards serious risk of a high, and partly uncontrollable, temperature rise. After a promising start in Kyoto, international climate negotiations have been proceeding at a cumbersome pace for several years now, with short-term financial interests appearing to prevail over long-term environmental considerations.

The present political crisis in the climate change debate calls for novel initiatives to tackle carbon emissions. One of the key problems in the current climate arena is that climate policy exerts leverage above all on the production side: it is the production of electricity, steel, cars and so on that is regulated by climate policies such as the EU Emissions Trading Scheme. Ultimately, though, the transformation to a low-carbon economy will also have to be achieved via the consumption side. It is on the basis of relative prices and individual preferences that consumers decide what to spend their income on.

It is therefore essential that environmental policies targeted at producers translate into price adjustments at the consumer level. In a world with a single, uniform carbon price this would indeed be the case, but with today's non-uniform prices inefficiencies will inevitably occur, disrupting translation to consumer prices. Given competition from regions where CO_2 is priced lower or not at all, companies may opt not to pass on the costs of CO_2 abatement in their prices. In addition, over the past two decades – and in all likelihood the preceding period, too – there has been a gradual shift of material - and energy-intensive production to non-EU countries, often to countries where CO_2 remains unpriced. This implies that a growing portion of our consumption is associated with CO_2 emissions with no price at all. The upshot is that as consumers we cannot make the right choices when it comes to purchasing products and services if CO_2 has no price and information is lacking on the carbon embodied in individual products and services.

Carbon Added Tax
One way to get around these problems would be to introduce a carbon tax explicitly at the consumer level. A Carbon Added Tax (CAT) on 'gross added carbon' could be designed analogously to today's VAT and form an instrument that could, with time, even replace it. In this research paper we investigate such a CAT: how would it function, what are the relevant monitoring and reporting requirements, and what are the likely impacts of its introduction?

The VAT system in place in the EU could serve as a blueprint for a CAT. Under the VAT scheme, the value added in each production step is taxed. Under a CAT scheme, the carbon additionally released to the atmosphere in each production step would be taxed. If well-defined, a CAT system should result in consumers paying the full carbon costs of a product over its entire production cycle. Under today's VAT system, every company basically operates as a tax-warehouse, not paying VAT themselves, but merely collecting taxes for the government. The VAT settled with the government equals the VAT on value added, the reward for own labour (gross wages) and capital (depreciation and profits) for all non-importing companies, hence the name Value Added Tax.

In a CAT scheme, envisaged as replacing today's VAT scheme, tariffs are expressed as a fixed sum of money for every kilogram of CO_2 equivalent emitted. The tax would be levied both on domestically produced and imported products in the EU. The CAT (and especially the levy on imports) necessitates a *benchmark*, defining for each product the benchmark CAT rate that would apply. Companies further down the product chain would add CAT on their own inputs, ensuring the CAT reflects the ongoing carbon footprint of the product, while paying only the CAT on their own added carbon.

Adding Monitoring, Reporting and Verification

The CAT would work more effectively if it were augmented with a monitoring, reporting and verification (MRV) scheme at the individual company level. Each company would then be obliged to keep track of the CAT, it pays on its inputs, the amount of carbon it releases during production or processing, and the CAT charged on its products and/or services. CAT invoices would be collected from suppliers and given to customers and clients. The MRV scheme would have two components:

1. MRV of the flows of CAT received and paid.
2. MRV of the CO_2 emissions added to the overall production process.

In practice, both these monitoring, reporting and verification schemes already exist. Under the present VAT scheme, there is MRV of the VAT paid on inputs, while under the EU ETS there is MRV of atmospheric CO_2 emissions .There are two major challenges ahead, though. First, the two monitoring schemes need to be integrated, implying departmental integration at companies.
Second, the level of the CAT would be adjusted if a firm manages to reduce its carbon emissions by investing in low-carbon technologies and practices. This would also mean a need for an authority to verify companies' previous-year bookkeeping and settle the tax rate for the current year.

For imports as well as for companies not wishing to adhere to an MRV system, product benchmarks would have to be set up defining the benchmark CAT rate for each particular product (made of flat glass versus hollow glass, etc.). Under the current EU ETS, such benchmarks have been defined for over 50 products. EU companies with an MRV system in place could apply for a lower CAT rate than the benchmark.

Impacts of a CAT

If designed with an MRV option for individual companies, a CAT scheme can become a major driver of low-carbon technologies and practices. In the long run, companies would seek to lower their sales price to remain competitive, achieved by limiting polluting inputs and increasing the labour- and capital-intensity (the share of value added) of production. A CAT scheme would thus facilitate and drive a long-term transformation to a low-carbon economy.
It would create an impetus for greater material and energy efficiency in the production of current goods and services, increase demand for less polluting

alternatives and benefit products with greater value added (e.g. products with greater knowledge intensity and services) which in a VAT scheme are implicitly taxed. The main rationale for a CAT scheme is to internalise the 'hidden' costs of emissions in the price of goods and services. As a side-effect, CAT revenues could be used to reduce more distortionary taxes, such as income tax and corporate tax.

Introducing a Carbon Added Tax to partly or entirely replace today's VAT would drastically change price patterns, even in the short run. Based on an analysis of effective carbon tax rates from the literature, we propose a CAT rate of € 146/tCO_2 in 2025, increasing to € 255/tCO_2 in 2050. This would be in line with efforts to stay below the threshold of 2 degrees warming that is deemed an acceptable risk. Such high CO_2 prices, over 30 times higher than current ETS prices, would initially result in major price changes for consumer products. They would imply cost increases of 40-80% for various carbon-intensive consumer products such as meat, petrol and animal fats. However, the government revenue generated would be such that the high VAT rate could be reduced from the current 21 to 4% in 2030. Price changes may be less pronounced in the long run, moreover, because a CAT scheme would induce major carbon cuts, implying that by 2050 the CAT would have to be accompanied with a larger share of VAT in order to safeguard governmental tax revenues.

For the construction sector, a CAT implies that traditional materials gain in importance: wood, sand, glass. Plastics, aluminium, construction steel and zinc would, in contrast, become rather more expensive. Price impacts on bricks and concrete would be fairly minimal. The greatest impacts would probably derive from higher costs of heating: buildings would inherently have to be more energy-efficient. Integration of energy generation (solar PV, geothermal, wind) in buildings is likely, moreover, since the costs of electricity and heat will rise quite substantially. Standard buildings could thus be equipped with solar rooftops or even solar panels on walls, possibly a more attractive variant. Small wind turbines may find their way into city landscapes.

CAT would make food more expensive. The smallest price increases would be for food served in restaurants. With home-cooked food perhaps one-and-a-half times more expensive, people will be more likely to eat out. Vegetables will feature more prominently than today, while meat substitutes will be more widely consumed, implying economies of scale and thus cheaper production costs. The opposite will hold for meat production, as lower volumes imply higher production costs. Meat may thus become a luxury item, served in smaller portions than today.

All products in which labour makes up a large share of production costs will tend to become cheaper. This would be the case for hotel costs as well as for products like musical instruments or cameras. This would occur because VAT constitutes an indirect tax on labour, since the value base of VAT derives mainly from the production factor labour. Introduction of a CAT is therefore in line with a shift in tax base from labour towards environmental impact.

In transport, there will be a continuing drive towards low-carbon technologies and modes of transport. Electric vehicles will become considerably cheaper than conventional cars, while public transport may become a more popular form of transport.

1 Introduction

1.1 Imagine the world in 2050

40 years from now planet earth will be inhabited by 9 billion people according to the United Nations Population Fund. As most of the worlds population will experience a rising level of welfare, and quite spectacularly so in emerging economies such as China, India and Brazil (PWC, 2013), the demand for water, arable land, fishing stock, metals, minerals and fossil fuels is set to grow considerably. As everyone can imagine, this may cause problems regarding the availability of scarce resources and associated pressures put on the environment and living conditions.

Take for example the problem of spatial planning and transport. Currently lives for about half of the world's population in cities. By 2050, cities will account for 70 percent of world population. As a result, the demand for transport will consequently rise sharply. In a new report, ‘A Tale of Renewed Cities’, the IEA calls for a complete change in urban public transport.
The IEA expects that global urban passenger mobility under a business-as-usual scenario will more than double by 2050 and increase as much as ten-fold between 2010 and 2050 in rapidly urbanising, fast-growing regions, such as Southeast Asia and the Middle East. This growth means that global annual urban transport energy consumption under a business-as-usual scenario is expected to increase more than 80% over 2010 levels by 2050, despite expected vehicle technology and fuel-economy improvements.

….the global demand for transport in urban areas is about to double…..

The global demand for finite resources poses economical, geopolitical and environmental challenges. In the case of fossil fuels, the existing challenge of a finite supply – unevenly distributed around the globe - is severely aggravated by the role fossil fuels play in global warming. If humans would burn all fossil fuel reserves that are known in the world, the earth would warm by at least 8 degrees Celsius in the year 2300, both polar ice caps will be depleted and sea levels will rise by more than 7 metres (Bala *et al.*, 2005).

The IPCC has calculated that the impacts of such catastrophes can be contained if carbon emissions are reduced so that they are 50 to 85% lower in 2050 than they were in 1990 so that there is a 50% chance of meeting the arbitrarily defined target of limiting global warming to 2 degrees Celsius above the pre-industrial average by 2100.

This target is generally viewed as securing mankind with an ‘acceptable risk’ to climate changes.[1] The IEA has calculated that this implies that the world can use only up to 1/3 of the current known reserves of fossil fuels (IEA, 2012). Moreover, after 2050 global CO_2 emissions need to continue to fall, leaving much of the fossil fuel deposits useless if we want to prevent catastrophic climate change impacts.

….if we want to prevent catastrophic climate change about 2/3 of oil reserves are useless…

Will the world manage in curbing global emissions of greenhouse gasses by a considerable amount compared to today, while population and material needs are expected to grow? It is in this light important to realize that the problem of climate change is ultimately not a technological issue but a social one. The technologies required for creating a zero-carbon economy are all already available. Energy efficiency measures on a grand scale, wind turbines, solar panels, electric vehicles, underground carbon sequestration – it has all already been developed, tested and implemented. And by combining biomass with carbon sequestration we can even remove carbon from the natural cycle. What we are failing to do, though, is to organise the implementation of those technologies – and the funding thereof. Which immediately brings us to the pivotal issue: the earth’s climate is a collective, public good to which no-one has property rights. The climate belongs to everybody and nobody at all, and if we are to avoid the trap so seminally described by Hardin in his *Tragedy of the Commons* there is no choice but to embark on a complex journey of negotiations between governments, citizens and industry. It may justifiably be queried whether that journey can be completed in time, and whether the road ahead will not be paved with too many social obstacles.

….the technologies to move to a zero-carbon economy have all been invented and tested……

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[1] However, since irreversible man-made changes to ecosystems are also inevitable with the 2 degrees Celsius threshold (Lynas, 2008, see also Chapter 2), it is arguable a normative choice including certain implicit value judgments on acceptability and costs.

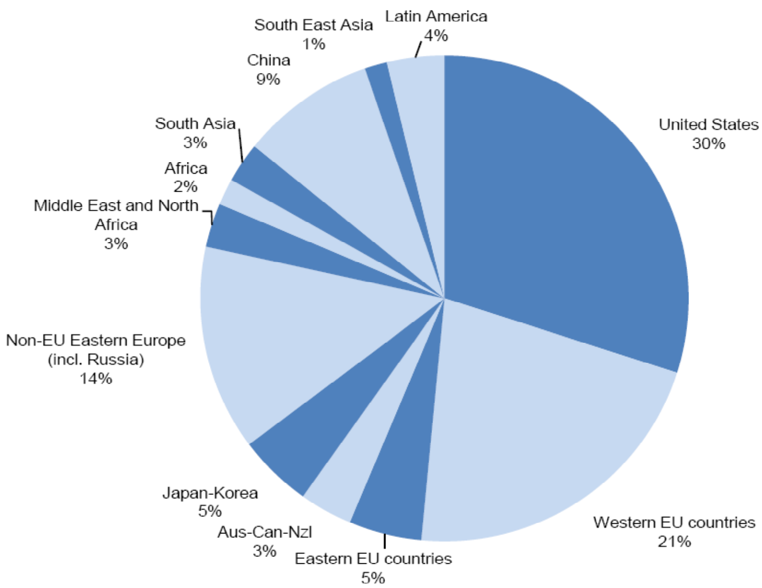
The recognition that *coordination problems* are behind current climate change problems is well taken, but solutions how to overcome these have not been very well addressed. This study adds a certain instrument, called the *Carbon Added Tax*, as a proposal to overcome the current coordination problems and be used as an economic instrument that prevents some of the problems current climate policies face.

1.2 Climate change politics as coordination failure[2]

At the G8 summit in L'Aquila in 2009 world leaders agreed that global temperatures should not be allowed to rise more than 2 degrees Celsius above the average temperature at the start of the industrial revolution.

To this end the G8 nations must cut their emissions by 80% by the year 2050, with a 50% reduction being asked of China, India and other emerging economies. The response of China and India was immediate: it was out of the question to demand such drastic emission cuts from them already, they said, for that would mean per capita emissions significantly below those deemed acceptable for the United States and Europe. What's more, if the historical emissions that have led to today's elevated greenhouse gas levels are factored in, the discrepancy becomes substantially larger. Europe, North America and Japan, with one-sixth of the world's population, are responsible for 75% of cumulative emissions since 1900, as Figure 1 shows.

Figure 1 Cumulative greenhouse gas emissions 1900-2004, excluding land use and forests



Source: EC, 2009.

This highlights one of the pivotal problems of climate policy: the need for international consensus on the allocation key to be used for what Hans Opschoor (1990) termed the 'environmental utilisation space'. The 'climate utilisation space' has been unequivocally described: to limit warming to 2 degrees Celsius we need to cut annual carbon emissions from

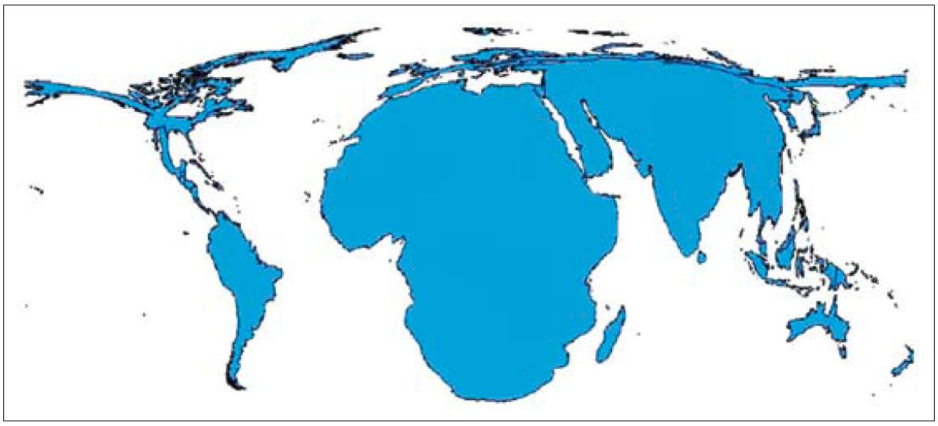
2 This Section is a translated summary of arguments presented in De Bruyn, 2010.

almost 50 Gt CO_2 equivalents today to 30 Gt CO_2 eq. in the year 2100. Compared with a business-as-usual scenario in which we continue to burn fossil fuels without carbon sequestration, this translates to emission cuts of over 100 Gt CO_2 by the year 2100.[3] Of these, 40 Gt would have to be secured by 2050 and global emissions would have to start declining within the next few years (Stern *et al.*, 2009). The problem, though, is that we simply have no idea how the available 'utilisation space' is to be allocated. In the long-term, some quantity will have to allocated uniformly among the countries and peoples of the world, but what is that quantity? Are we talking about per capita emissions, cumulative per capita historical emissions, per capita costs of emission cuts, costs per unit income earned or costs per unit utility or social welfare[4]? In this context the United Nations refers to 'common but differentiated responsibilities', but the exact meaning of the phrase is still far from clear.

….'common but differentiated responsibilities' lead to long debates…..

In practice things prove even rather more complicated, though. First, because the impacts of climate change will be very unevenly distributed around the globe. As a recent analysis by the Global Humanitarian Forum (2009) shows, the worst of the effects will be felt in the world's least developed nations (see Figure 2).

Figure 2 World map of projected mortality due to climate change



Source: Climate Change and Global Health: Quantifying a Growing Ethical Crisis, 2007.

[3] IPCC (2007); stabilisation at 2 degrees Celsius temperature rise interpreted as the B1 scenario, BAU as the A1F scenario.

[4] The difference between income and utility/social welfare is that in the latter the utility of earned income is also taken into account. Clearly, € 500 annual costs for the average Chinese citizen represents a far greater loss of utility than the same figure for a European.

What this map shows, in no uncertain terms, is that climate change is inescapably bound up with 'Third World' issues of malnutrition, drinking water shortages and premature mortality from malaria and other diseases. Moreover, this map shows that the countries that have the highest CO_2 emissions per capita (like the United States) are the least affected by the detrimental consequences from climate change. This makes a solution to the global warming problem complicated.

The second problem is that current estimates of the costs of mitigation to stay below the 2 degrees Celsius are probably overly optimistic. Nicolas Stern (2009) has estimated the loss of income arising if we opt to stick to the 2 degrees Celsius limit at 2% of global income at the very most – equivalent to just one year's average growth in nominal world GDP. However, this analysis is based on overly optimistic reduction curves assuming, a 'Tinbergenesque' central planner: a benevolent and perfectly informed world government that will implement the measures in the most cost-effective manner possible. What has emerged in economics over the past two decades, however, is an increasing interest in *government failure*. Government failure is analogous to market failure in the private sector and occurs when government intervention leads to less efficient allocation of goods and services than projected on the basis of economic analysis. In *A blueprint for a safer planet* Stern mentions this potential for government failure, stating, without further analysis of the issue, that this would push up costs by 25% at most. However, current ex-post analysis of climate change policies often point at the relatively high costs, negating the very low costs that Stern seemed to have observed. In the Netherlands, for example, climate policies started in 1998 with an impact assessment assuming total costs not to exceed € 25 per tonne of CO_2. These costs of climate policy, estimated *ex-ante*, proved *ex-post* to be around three times higher.[5]

Following the high costs, a third problem emerges, as already described in Section 1.1.: the Earth's climate is a collective, public good to which no-one has exclusive property rights. No single country can solve the climate problem – just as the case that no single country can be held responsible for the damages due to climate change. Only if the vast majority of countries and consumers of energy are willing to undertake action to reduce CO_2 emissions, the effort can be enough to prevent catastrophic climate change to occur. However, there is no free lunch (as economists tend to say) and to reduce CO_2 emissions is in most cases more costly than to burn unlimited fossil fuel. This implies that every country has an incentive not to ratify international climate negotiations and to act as a 'free-rider'. This would lower costs for this country while at the same it would reap the benefit from lower risks of catastrophic climate change. Since the costs of taking climate action are high, the benefits to act as a 'free-rider' are similarly high which effectively hampers the willingness of countries to enter international negotiations to limit its own emissions of CO_2. This may be one of the factors that there has been considerable less progress in the international climate negotiations compared to the Kyoto-agreements in 1997.

[5] De Bruyn et al. (2005), Evaluatie doelmatigheid binnenlandse klimaatbeleid: kosten en effecten 1999-2004. CE Delft.

….earth climate is a collective good for which only coordinated action can be taken…….

The fourth problem is that the most obvious political instrument to combat climate change, putting a price on CO_2 emissions, seems not to be available. Many economists have pleaded for a carbon tax so as to disincentive the use of fossil fuels and safeguarding the planet. Moreover, a global CO_2 tax would be the most efficient instrument to reduce CO_2 emissions. However, a global uniform price of CO_2 is unfeasible from an economic perspective, because economic efficiency and social equity are at fundamental odds with one another. Given the very uneven global distribution of income as well as the uneven climate change impacts (see Figure 2), a situation will never arise in which a single, global price for CO_2 is feasible. It would be fundamentally unjust for a Chinese citizen to have to pay the same carbon tax as a European, because in terms of utility he or she would then have to make a far greater sacrifice than the European.[6] As a result, the marginal costs of emissions abatement are not the same across countries or industries. There are economists who hold that a worldwide emissions trading scheme should be established, with any issues relating to burden-sharing being addressed through judicial allocation of emission allowances. By allocating China a greater number of emission credits than the wealthy nations as measured against current emissions, justice is done to the fact that China is a poorer country requiring further scope for growth. But apart from the extreme difficulty of establishing a suitable allocation key for the countries of the world,[7] the reasoning is also only partially valid. In decisions on production capacity, Chinese industry will not calculate with the average costs of emissions abatement but with the marginal (opportunity) costs. As those marginal costs will be uniform under a global emissions trading regime, developing industries in emerging economies will be hardest hit in comparative terms. While it is true that a global emissions trading scheme will entail a considerable transfer of income from wealthier to poorer nations, this does not mean the latter will be in a better position, in the long run, to create the kind of living standards currently enjoyed in the West.

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6 For those noting that our Chinese friend's CO_2 emissions are also lower, it should suffice to state that in relative terms the emissions associated with his consumption package are many times higher because the poor must devote more of their income to material - and energy - related costs, as remarked long ago by Malenbaum (1978).

7 As pointed out above, this difficulty revolves around the question whether this should this be on the basis of equal costs, equal utility, equal per capita emissions or equal contribution to the reinforced greenhouse effect.

Others assert that China and India should adopt a different 'model of progress' to generate their future wealth, a model that differs from the carbon-intensive model that has been pursued to date. The problem, though, is that no other model exists. The entire process of economic growth and accumulation of wealth rests on the bedrock of natural capital being converted to human capital, thus to increase the productivity of labour. Because labour is initially cheap, the cheapest sources of natural resources must first be used to kick-start the required rise in productivity. If human labour is relatively cheaper than using natural resources, as is the case in large parts of Africa, economic development simply never gets going. Assume, for example, that international climate policy leads to a doubling of the costs of coal-burning. For China this would then put a serious brake on national development, for labour would then likewise have to become a factor 2 more expensive before the country can continue down the development path being pursued today.

....the entire process of economic growth and accumulation of wealth rests on the bedrock of natural capital being converted to human capital, thus to increase the productivity of labour....

As these considerations show, the process of designing an international climate agreement is seriously hampered by there being an inevitable trade-off between economic efficiency and social equity. Climate policy is inescapably bound up with issues of equity. But pursuit of the latter is at odds with pursuit of efficiency – i.e. low costs – and vice versa. In political terms this is complicated yet further by the fact that the UN's 'common but differentiated responsibilities' have as yet evaded definition. All of this has major consequences for the feasibility as well as the costs of national climate policy. In short, national climate policies have to take into account that in large areas of the world, CO_2 emissions will have no price which hampers the design of efficient instruments to combat climate change. This can be clearly seen in the design of the European Emission Trading Scheme (EU ETS, see Box 1).

This situation is not unique to the European emissions trading scheme, for any unilateral climate policy adopted while CO_2 prices differ around the world will inevitably lead to the same kind of debates on potential loss of competitiveness. In Japan and the United States discussions on climate action by industry run a very similar course. In the Netherlands, too, in the run-up to the start of climate policy in 1999 there were extensive discussions as to how energy-intensive sectors could be exempted from climate obligations.
As a review of Dutch climate policy from 1999 to 2004 shows, it was the government that footed the bill for virtually all the climate protection measures taken over this period by the entire industrial sector, by way of subsidies, tax-credits for investments in emissions abatement and other such schemes.

Box 1: The politics of the EU ETS
The impact of international competitiveness considerations on the design of climate policy instruments can best be described for the European Emission Trading system. The EU ETS has been up and running since 2005 as a means of regulating the CO_2 emissions of industry and electrical power generators. Over 10,000 installations in the EU must keep track of their CO_2 emissions and hand over emission allowances for every ton CO_2 emitted over the year. Every year, emission allowances are allocated for free according to a distribution key agreed to in prior negotiations. If an industry or generator emits more than their allotted CO_2 equivalent tonnage, they must purchase credits on the European emissions trading market. If they emit less than their allotted share, they can sell their residual credits on the same market. This would set a financial incentive in reducing CO_2 emissions.

The first two phases of the trading scheme, running from 2005 to 2012, can be seen mainly as a test run. Emission allowances were allocated to ETS participants largely free of charge based on national allocation plans. Ex-post analysis has shown that national governments assigned to industry far more credits than warranted on the basis of their emissions and that power generators were the ones buying up the residual credits from industry (Sandbag, 2009).
The reason to exempt industry seemed largely be related to the fear that industry would face a competitive disadvantage if charged for the full carbon costs. Ex-post evaluations have shown that the EU ETS has not led to emission cuts: the main reason being that credits were so generously issued (Ellerman and Buchner, 2008).

As of 2013 all that was supposed to change. First, the allocation of allowances would be centralized at the European level, with the number of credits being reduced each year by 1.74%. This would rule out the habit of over-allocating emission allowances to industry. Moreover, the majority of the emission allowances would no longer be allocated for free, but bought on an auction. Economists have pointed out that in this kind of trading scheme the cost of CO_2 abatement can be substantially reduced if allowances are auctioned rather than issued free of charge (Demailly and Quirion, 2008) and reducing price volatility in the EU ETS market.

However, the issue of whether emission credits should be auctioned to industry or issued free of charge was a major stumbling block in the 2008 negotiations on the third phase of the EU ETS. Unsurprisingly, there was intensive lobbying by industry to ensure their arguments in favour of free issue of credits were heard. Their main argument was that industry would risk losing competitiveness if credits were auctioned, because they would have to pay the full CO_2 costs, which their non-EU competitors would be spared. This might in turn result in increased imports of products from (and decreased exports to) countries unburdened by climate policy. As the EU ETS is a closed system, this kind of shift in international trade would lead to a net rise in global emissions, a phenomenon known as 'carbon leakage'. In addition, industry succeeded in raising the spectre of jobs being lost if it had to pay for their emission credits.

The outcome, presented by then-President Sarkozy in December 2008, is a scheme whereby industries are only allocated emission allowances free of charge if they meet certain criteria with respect to their carbon costs and trade intensity. While this was presented to the press as maintaining the principle of auctioning alive, ex-post analysis has shown that under this rule 95% of emissions (up to the benchmark) would still be issued for free to industrial installations (CE Delft, 2013). Clearly, the wish to protect industry against unilateral carbon costs has been more important than to reduce emissions of CO_2 in the most cost-effective manner.

1.3 The Carbon Added Tax as alternative

The current political crisis in the climate change debate calls for new initiatives to tackle CO_2 emissions. One of the key problems in the current climate arena is that climate policy exerts leverage above all on the production side: the production of electricity, steel, cars and so on is being regulated in climate policies like the EU ETS. Ultimately, though, a transformation to a low-carbon economy will also have to be achieved via the consumption side. It is on the basis of relative prices and individual preferences that consumers decide what to spend their income on.
It is therefore essential that environmental policy targeted at producers is translated to price adjustments at the consumer level.
In a world with a single, uniform carbon price this would indeed be the case. But with non-uniform prices inefficiencies will inevitably occur, which means the translation to consumer prices no longer takes place. Given competition from regions where CO_2 is priced lower or not at all, companies may opt not to pass on the costs of CO_2 abatement in their prices.[8] In addition, over the past two decades – and in all likelihood in the preceding period, too – there has been a gradual shift of material - and energy- intensive production to non-EU countries, often to countries where CO_2 remains unpriced. This implies that a growing portion of our consumption is associated with CO_2 emissions with no price at all.[9] The upshot is that we, as consumers, cannot make the right choices when it comes to purchasing products and services if CO_2 has no price and no information is given on the carbon content of individual products or services.

One way to get around this would be to introduce a carbon tax explicitly at the consumer level. A Carbon Added Tax (CAT) on ‘gross added carbon’ could be designed analogously to today’s VAT and form an instrument that would, with time, even replace it. Although the idea has been proposed before in the literature (see e.g. Courchene (2008), until now it has not been adequately elaborated in detail.

Let us very shortly elaborate on the functioning of a CAT, before we move in the next Chapter with a detailed analysis. With a CAT in place, every company would be obliged to keep ‘carbon accounts’ detailing how much fuel it uses in its operations. This information is already available in corporate accounts; all that needs to be added is an accountant’s verification of the carbon content of the fuels involved – similar to how it is set up at present in the EU ETS monitoring and verification protocol. As an example, imagine that a steel producer sells his steel to a car-part manufacturer. He then charges the latter CAT (€ 40 per tonne CO_2, say), but can in turn deduct this on his tax returns. The net increase in cost price for the steel producer is therefore zero.
The car-part manufacturer uses the steel to make a car door. He sells the door to a car-maker, to whom he charges the steel producer’s CAT plus that on his

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[8] Although this is being questioned both by the economic literature and in empirical work in e.g. CE Delft, 2010.

[9] Again, this critically hinges on the assumption how price formation at the EU markets take place. If producers pass on the prices of CO_2 in their products, importers may adjust to this price level generating additional producer surpluses in their income generation. Prices would then rightly reflect the CO_2 content of production. However, since the importers do not face carbon constraints in their production levels, the EU targets would merely imply ‘carbon leakage’ where emissions under the CO_2 ceiling from the EU would ‘move away’ to countries which have not agreed upon emission ceilings for their CO_2 emissions implying a net increase in global CO_2 emissions. This would be another rationale for installing additional climate policy instruments, such as the carbon added tax, that would tax importers and producers alike.

own added carbon. In this way he is reimbursed by the car-maker for the CAT paid to the steel producer and can deduct his own CAT on his tax returns. He, too, suffers no increase in cost price. The car-maker then produces a car and passes on the CAT of the steel producer, the parts manufacturer and his own added carbon to the final customer. If the vehicle is being bought as a company car, the company can then in turn deduct the CAT. In the end, therefore, it is only private consumers who pay the CAT.

A Carbon Added Tax, as briefly explained above, has three main impacts: it targets both consumers and producers directly while maintaining the level playing field for international business. First, consumers will find that some products have become relatively cheaper (shoe repairs, for example), and others more expensive (like cars). Therefore, they will have an impetus to develop lifestyles according a low-carbon footprint. Since products are then being taxed on their *lifecycle* carbon impacts, the system of CAT assures that not a single production step is being targeted but rather the whole chain of production steps until the product is being sold to final consumers.

Second, producers will have a direct financial impetus to install low-carbon technologies as this would have consequences for their price setting in the market. Suppose that the general CAT-tariff of € 40/tCO_2. Since 1kg of steel would have a general CO_2 footprint of about 1.7 kg CO_2 eq.[10], the CAT tariff would be equivalent to 6.8 cents per kg of steel. With an average price of hot rolled coil steel of 80 cents (the average of the last years), this would yield a total price of 86.8 cents per kg of steel. Now in order to compete in the market and to augment market shares (or to increase profits), the steel manufacturer could invest in low-carbon technologies which would reduce their CO_2 footprint to 1.4 kg CO_2 eq. In this case, he would be able to sell his product at a cheaper rate than the competitors, at 85.6 cents per kilogram. So we see that in this case, the marketing department of the steel manufacturer gets a direct impetus to lower carbon emissions as to avoid the tax rate put on the sales price. This can be a very important driver for transition to a low-carbon economy.

Third, in the present EU ETS, steel companies in the EU face competition from steel importers from countries where no carbon policies apply to steel manufacturers. This may result in a loss of market shares for EU producers leading to so-called 'carbon leakage'. However, the principle of a CAT would apply to importers as well, so they would be charged with a comparable CAT of 6.8 cents per ton of steel. In this case, there is no disadvantage of the EU producer compared to non-EU producers as both face a similar carbon tax regime. This would not only be good news for the competitiveness of EU producers, but also good news for the environment as no emissions of CO_2 would 'leak' out of the EU cap to countries that do not cap their carbon emissions. Ways how the EU could design a system that would tax imports as well, is being described in Chapter 2.4 and 2.5 of this report.

10 Information from Annex D in CE Delft (2008).

1.4 Objective of this study and delineation

The objective of this study is to investigate the design of the carbon added tax as an alternative to the present VAT. We will discuss the design of the CAT and then investigate the impacts. The impacts of the instalment of a CAT on the price level will be quantitatively. In addition, we will qualitatively discuss what kind of impacts such price changes may have on the economic and spatial planning system. The impacts are discussed at the scale of the Netherlands for the years 2030 and 2050 and serve as an illustration of how the CAT may benefit both the economy and the climate. We fully acknowledge that a system of a CAT can only be installed at the European level and not by the Dutch government alone.

1.5 Outline of the rest of the report

The rest of the report will have the following structure. First, in Chapter 2, the design and functioning of the CAT as an instrument in international climate policies will be described and it will be discussed at what level a CAT should function. Then, in Chapter 3 we will investigate what kind of impact can be expected from the CAT on the prices of everyday used products. Chapter 4 concludes.

2 The Carbon Added Tax explained

2.1 Introduction

There is currently no tax on the consumption of carbon or rather on the carbon footprint of consumed goods and services. However, there does exist a long tradition of consumer taxes. Many countries levy duties on imported goods. Excise taxes on tobacco, alcohol, gasoline and gambling are commonplace and intended to discourage consumption. The best-known examples of consumption taxes are the sales tax in the US and the Value Added Tax (VAT) in the European Union. The sales tax is levied as a fixed percentage of the sales price of consumer goods and services. The VAT is levied as a percentage of the sales price excluding VAT paid on purchases by the producer needed to produce the good or service in question. The VAT as it exists in Europa can serve as a blueprint for the Carbon Added Tax or CAT. We will explain the functioning of the VAT first as this will help us to understand how a CAT could work. We will then show how a CAT scheme would favour clean consumption and clean production as opposed to the current situation under the VAT.

2.2 Value added tax

The first system of value added tax in the world started in France in 1954. In the late 1960s the system was introduced in the EU to replace the existing national sales taxes. Currently VAT systems have been implemented in 156 countries, and seven more are considering implementing a VAT by 2013.[11]

Within the EU, the European Commission has often tried to harmonize tax rates across the member states, but so far only minimum tariffs are agreed upon. The minimum general tariff is 15% with the possibility to use one or two categories of goods with a lower tariff (such as foodstuffs in the Netherlands) albeit with a rate larger than 5%. A few items, such as hospitals, schools and insurances are exempt from the VAT. The VAT in the Netherlands for instance is 21% in general, but goods that are deemed beneficial such as food, books and medicines are taxed at a 6% rate.

The European VAT is a *value-based* tax scheme that is levied by *invoice accounting* and based on the *destination principle*. Text box 2 explains these technical terms.

[11] www.taxanalysts.com/www/freefiles.nsf/Files/LEJEUNE-21.pdf/$file/LEJEUNE-21.pdf, retrieved on 24 July 2013.

Box 2: Technical terms related to the VAT explained
The European VAT is a *value-based* tax scheme that is levied by *invoice accounting* and based on the *destination principle*.

Value-based means that VAT paid by producers on goods and services purchased by them is first subtracted from the sales value before VAT is levied on his good or service. *Value-based* schemes can be opposed to *cascade* schemes in which taxes on purchased goods are added to the sales value. The construction of the VAT ensures that the payment of taxes is pushed on to the final consumers, whereas producers only collect taxes for the government. Producers and consumers share the tax burden in a *cascade* scheme, because the former are eligible for VAT on their purchases.

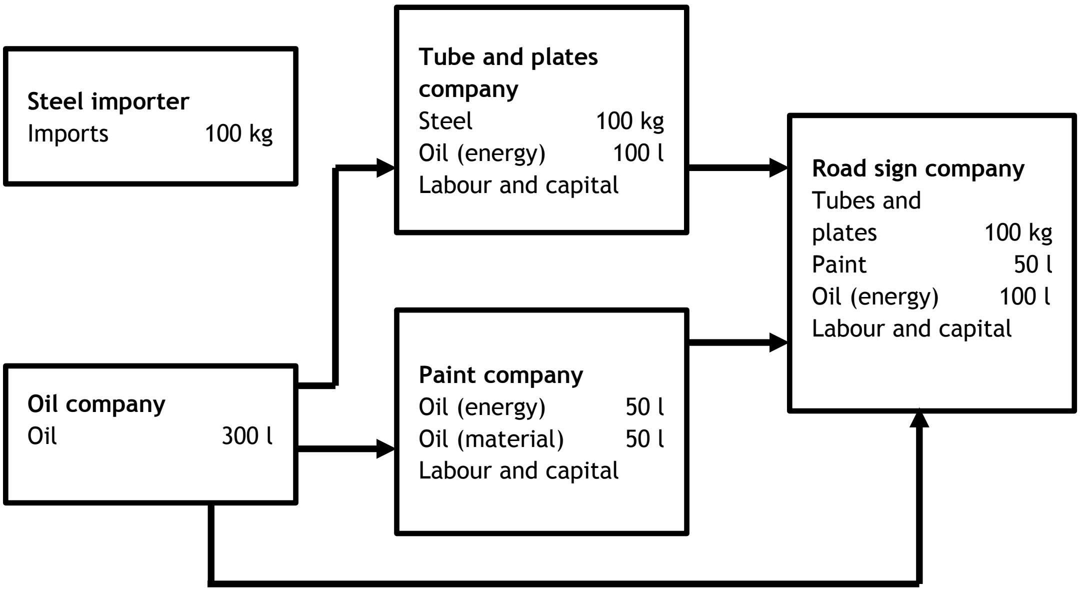
Invoice accounting means that the producer keeps a record of all purchases he makes and VAT paid on them, before he settles the difference between VAT received from consumers and VAT paid by him from suppliers with the government. *Invoice accounting* can be opposed to *subtraction accounting* in which the producer does not have to keep records of the VAT that he pays. He simply subtracts all purchases from sales, applies the VAT rate over this difference and settles with the government. Subtraction accounting, although administratively much cheaper, is only possible in the case of uniform VAT tariffs.

The *destination principle* entails that VAT is levied on imported goods, but that exported goods or services are free from charge. This is done to ensure that foreign producers, or at least those that live in countries where no VAT is levied, do not have a competitive advantage over home-grown producers either in the destination country, where VAT is included in the price of goods and services, or in their own country, where VAT is excluded from the price of goods and services. The *destination principle* can be opposed to the *origin principle*, in which VAT is levied on exported goods, but not on imported goods.

A hypothetical and stylized example, the production of road signs, is used to illustrate the functioning of both a VAT scheme and a CAT schemes in this and the next paragraph. Road signs are products which are being sold on the market to e.g. local governments, final consumers and the governmental body responsible for maintenance of roads. For the production of road signs, the company uses intermediate products from the paint industry (chemical industry) and the steel products industry (tubes and plates company).
The paint company in turn uses intermediate products from refineries for making the paint while the tubes and sheets company uses both inputs from refineries and steel manufacturers.

The production chain can be depicted by Figure 3. We assume here that all companies are within the EU with the exception of the steel company that is outside the EU and exports the steel to the EU market. At the beginning of the production chain 100 kilogrammes of steel are being imported, while 300 litres of oil are produced domestically. Steel tubes and plates are produced by a company that uses all the steel as a material input and one-third of the domestic oil production (i.e. 100 litres) as energy alongside own labour and capital (buildings, machinery, vehicles, etc.). Paint is produced by a company that uses a technology in which 50 litres of oil are used as an energy source and 50 litres as material input for the paint, alongside own labour and capital. The footprint of the tubes and plates company then amounts to 600 kg CO_2, whereas the footprint of the paint company equals 300 kg CO_2. At the end of the production chain a company assembles the road signs using its own labour and capital, the remaining 100 litres of oil as a source of energy, and all the paint, steel tubes and plates as material inputs.

Figure 3 Production chain of steel road signs



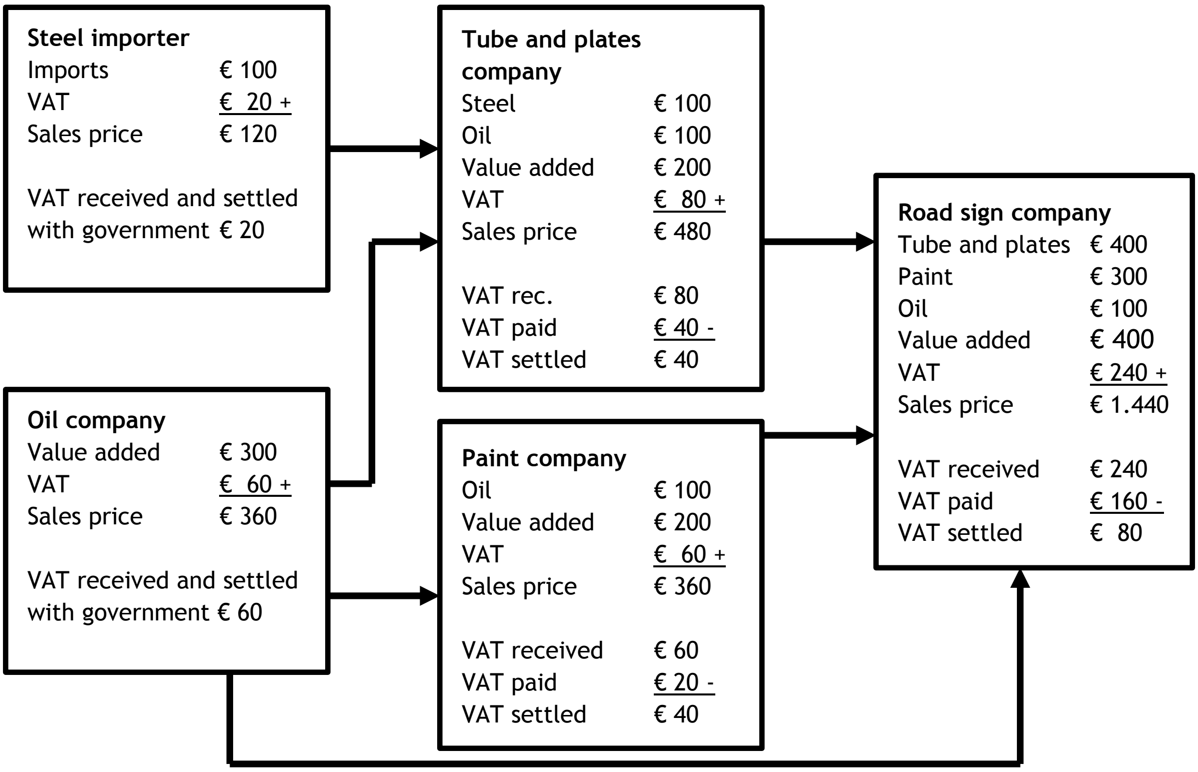
Now a Value Added Tax is introduced into the production chain (see Figure 4). In a VAT scheme, companies levy a fixed VAT tariff on the sales price of their products, but they are allowed to subtract the VAT paid on inputs from the sales price of their products. The VAT tariff is set to 20% in the hypothetical example to ensure rounded-of figures. Now suppose furthermore that the prices are set as follows:

- oil sells at € 1 per litre excluding VAT;
- steel at € 1 per kg excluding VAT.

At the beginning of the production chain, the oil company levies the full amount of tax on all oil it sells (20% of € 300) as it has no inputs to production in this example. This tax can be settled subsequently with the government. Steel imports are taxed in a similar fashion due to *the destination principle*. If imports are made from countries who levy VAT themselves, such as in intra-EU trade, then importing companies would have to settle the VAT with the governments of the exporting countries.

The tubes and plates company must pay € 40 of VAT on its inputs of steel and oil, but it can extract the same amount from the sales price of tubes and plates as it is able to balance this amount with the € 80 of VAT it receives on its products. With € 200 of value added the sales price of tubes and plates amounts to € 480, while the company settles € 40 in VAT with the government. The same calculations can be done for the paint company in the middle of the production chain whose value added equals € 200 and the road sign company whose value added equals € 400 at the end of the production chain.

Figure 4 Production chain of steel road signs with VAT



Two things should be noted from this example:
- Companies do not pay VAT themselves, they only collect taxes for the government. It is the consumer who pays the full amount of € 240 in VAT on the final purchase of road signs.
- The VAT settled with the government equals the VAT on value added, the reward for own labour (gross wages) and capital (depreciation and profits) for all non-importing companies, hence the name Value Added Tax.

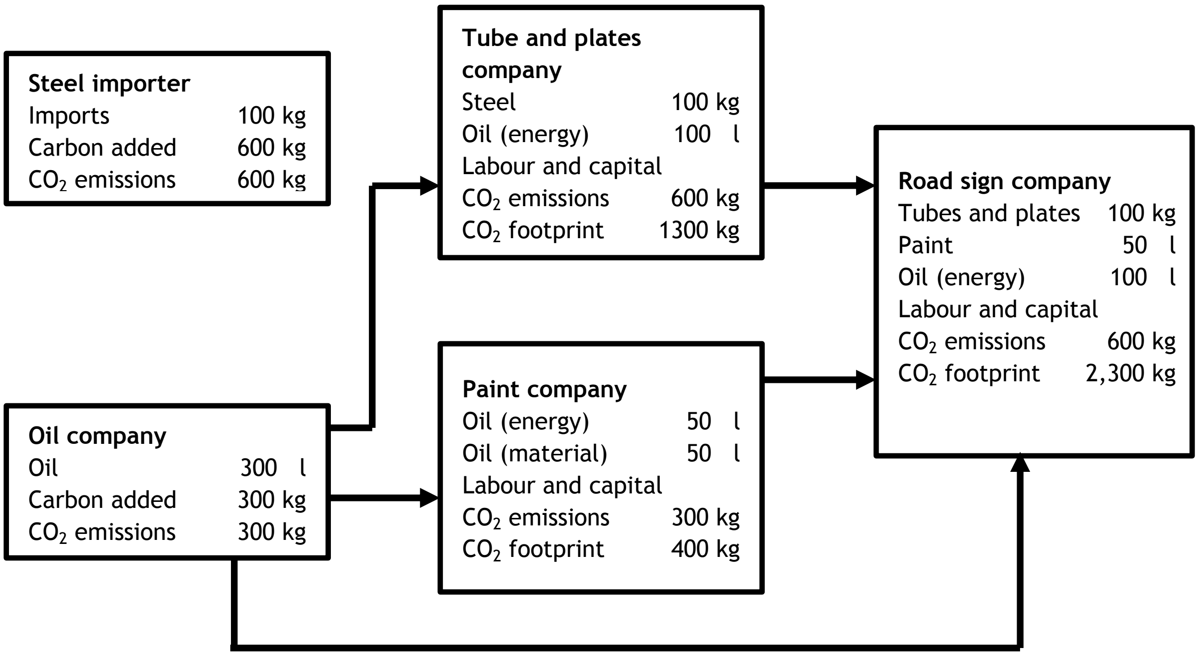
We can also see the *cascading principle* in action: the total amount of VAT is increased in each stage of the production chain, up until the point that the final purchase is made, while producers merely act as middlemen in the collection of VAT.

2.3 Design and operations of a system of CAT

Industry does not only generate value added, but also environmental pressure. We focus in this research on the CO_2 emissions that stem from the production side. In the hypothetical example of a road sign company that uses intermediate inputs from various industries, the CO_2 emissions can be added to each of the production steps. At the beginning of the production chain 100 kilogrammes of steel are being imported, while 300 litres of oil are produced domestically. Suppose that the production and transport of each kg of imported steel leads to 6 kg of CO_2 emissions, so that the carbon footprint of imported steel equals 600 kg. Next suppose the production of 1 litre of oil leads to 1 kg of CO_2 emissions, whereas the burning of 1 litre of oil as a source of energy leads to another 6 kg of CO_2 emissions. The oil company, who only extracts and refines the oil, then has a footprint of 300 kg CO_2.

Steel tubes and plates are produced by a company that uses all the steel as a material input and one-third of the domestic oil production (i.e. 100 litres) as energy alongside own labour and capital (buildings, machinery, vehicles, etc.). The burning of the oil generate an additional CO_2 emissions of 600 kg. Including the previous steps (steel production and oil production), the carbon footprint of this company equals 1,300 kg. Paint is produced by a company that uses a technology in which 50 litres of oil are used as an energy source and 50 litres as material input for the paint, alongside own labour and capital. The CO_2 emissions of the tubes and plates company then amounts to 300 kg CO_2, whereas the footprint of the paint company equals 400 kg CO_2. At the end of the production chain a company assembles the road signs using its own labour and capital, and using 100 litres of oil as a source of energy, and all the paint, steel tubes and plates as material inputs. Its CO_2 emissions, due solely to its energy use, amounts to 600 kg of CO_2. The footprint of the road signs is then equivalent to 2,300 kg CO_2.

Figure 5 Production chain of steel road signs



Traditional environmental policy would be a myriad of companies falling under different rules. The steel importers would not be under any climate policies, while the oil company would fall under the EU ETS. If the tubes and plates and paint companies would be large enough to meet the minimum installation requirement for the EU ETS, it would be subject to the EU ETS. However, a smaller tubes and plates company most likely would fall outside the EU ETS and be part of national legislation (in the Netherlands that would be a mix of subsidies, voluntary agreements and formal requirements). The road sign company most likely would not be subject to the EU ETS but be part of national legislation.

In the end, the impact of these policies on the price of the product would be diffuse and difficult to estimate. The companies that would fall under national legislation do have an impetus to fulfil legal requirements but not an impetus to reduce their emissions beyond their legal requirements.

Now, this myriad of environmental policies could also be replaced by a carbon added tax. The system of the VAT in the EU could work as a blue print for a Carbon Added Tax (CAT). In a VAT system, at every production step, the added value is taxed. Under a CAT system, at every production step, the added carbon released in the atmosphere will be taxed. If well defined, a CAT system should result in consumers paying the full carbon costs of products over the entire production cycle of the product. A CAT system is not likely to replace the current VAT system (see the discussion in Paragraph 2.5). Rather, some amount of CAT could be levied alongside VAT on goods and services.
The introduction of a CAT scheme could either allow for a reduction in the VAT tariff or of other taxes.

For illustrative purposes, below an example is given of a CAT scheme that fully replaces the existing VAT scheme without altering tax revenues.[12]
The CAT system will be based on the carbon added at every production step. Like the EU VAT system, the CAT system needs to be based on *invoice accounting*. S*ubtraction accounting*, though cheaper than Invoice accounting because of a lesser administrative burden, is not feasible for the design of the CAT.
The reason is that different products have different carbon footprints and therefore different tax rates as well. Like the VAT, the CAT needs to be based on the *destination principle* unless it is adopted on a global scale.

In the CAT scheme that replaces the VAT scheme, tariffs are expressed as a fixed amount of money for every kilogram of CO_2 equivalent emitted.
The tariff in this hypothetical example is set at € 100 for each tonne of CO_2 equivalent or € 0.10 kg/CO_2 eq. The full outcome for the CAT scheme is presented in Figure 6. A system of CAT would work both on production and on imports within the EU. The levy on imports necessitates a *benchmark*, as both the steel importer and the government need to know what the proper CAT tariff on steel (and for that matter on other imported goods) is (see also Paragraph 2.4). For imported steel, the benchmark has been set to 1 kg/CO_2 to 1 kg of steel. This would result in a CAT on imported steel of € 60. This money is being transferred to the government. The oil company, who only extracts and refines the oil, has a footprint of 300 kg CO_2 and the CAT levied on the 300 litres of oil production equals then € 30 which is also transferred to the government. Now the tubes and plates company will add another 600 kg of CO_2 to the total footprint. The basis of his taxation is his own CO_2 and the CO_2 embodied in the products he uses. So in total, the CAT will equal his carbon footprint of 1,300 kg. However, he will only pay the CAT on his additional carbon added, as the CAT he paid on his intermediate inputs can be deducted from his CAT transferred to the government.

Companies further down the product chain add CAT on their inputs so that the CAT reflects the carbon footprint of the product, while paying only the CAT on their added carbon. In the end, the road sign company pays € 230 on CAT for the (embodied) carbon content of their final product (road signs) while receiving from the government an amount of € 170 on paid CAT for intermediate inputs.

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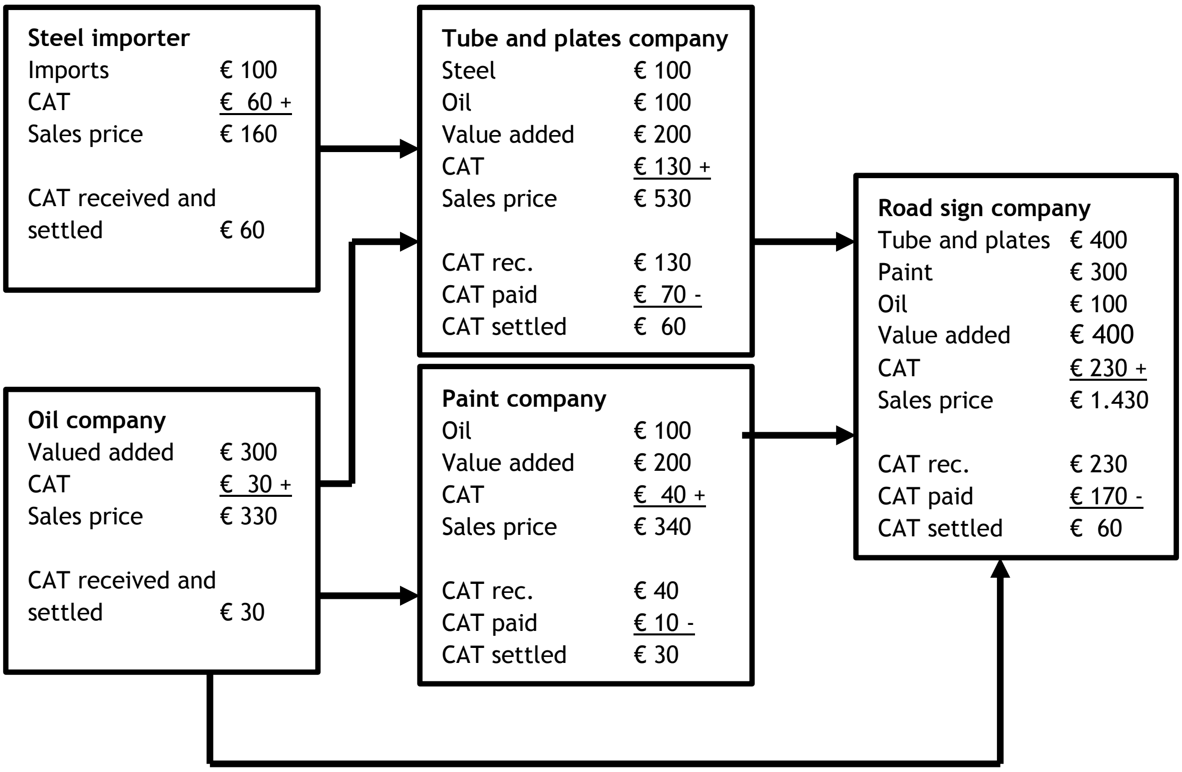
[12] In Paragraph 2.5 we will see that this is actually not possible, a combination of a VAT and a CAT scheme seems to be more likely.

There are two noteworthy differences with the VAT scheme:
- VAT is a tax on value added, CAT on (the embodied carbon-content of) inputs to production. The difference in the accounting method does not invalidate the *cascading principle*: producers still collect CAT, whereas the consumer pays for all the CAT.
- In this hypothetical example, paint has become cheaper compared to steel products. There are three reasons for this: the inputs of the paint company (i.e. oil) are less polluting than the inputs of the tubes and plates company (i.e. steel), the production of paint is less energy-intensive than the production of tubes and plates and paint is a high value added product compared to tubes and plates.

Figure 6 Production chain of steel road signs with CAT



The example given is static, but it is not too difficult to envision what the long run response would be in an economy if CAT were to replace (some) VAT or other taxes. Companies would want to lower their sales price to stay competitive and this can be done by limiting the use of polluting inputs and by increasing the labour- and capital-intensity (the share of value added) in production. A reduction in the use of oil as a fuel is one way to achieve this in the example, but the plates and tubes company could also make material savings by making thinner tubes and plates, or it could shift its production process towards less polluting products with a similar function. If, say durable plastic tubes and plates can be produced under a similar technology as that of the paint company (50% of oil used as energy and the other 50% as a material input), then the sales price of plastic tubes and plates would be lower with a CAT scheme than with a VAT scheme. Since the tubes and plates company and the company assembling the road-signs compete in the market with other companies, there is a strong impetus at various stages in the production chain to lower the CAT and hence the carbon footprint of products to the maximum extent.

A CAT scheme would thus enable a long-run transformation towards a low-carbon economy. It would create an impetus for more material-efficiency and energy-efficiency in the production of existing goods and services, it would increase the demand for less polluting goods and services and it would benefit products with a higher value added (such as services and mineral extraction), which are implicitly taxed in a VAT scheme. The main rationale for a CAT scheme is to internalise the 'hidden' costs of emissions in the prices of services and goods. As a side-effect, the revenues from the CAT can be used to reduce more distortionary taxes, such as the income tax and corporate tax. This shift in the tax base is believed by many economists to be welfare-increasing, although this argument in favour of a Carbon Added Tax proves more complex than it seems at first sight.[13]

2.4 Practical design issues

2.4.1 Bookkeeping system

The CAT would have to be augmented with a monitoring, reporting and verification (MRV) scheme at the level of individual companies. Each company must keep track of the CAT it pays on its inputs, the amount of carbon that it releases during production and the CAT that it charges on its products ands services. CAT invoices have to be collected from suppliers and given out to clients.

This scheme will consist of two components:
1. A monitoring, reporting and verification scheme of the flows of CAT received and paid.
2. A monitoring, reporting and verification scheme of the CO_2 emissions that are being added to the production process.

In practice, both monitoring, reporting and verification schemes already do exist. In the present VAT scheme, there exists a monitoring, reporting and verification scheme for the VAT paid on inputs, while under the EU ETS scheme there exists a monitoring, reporting and verification scheme of the CO_2 emissions that are being released into the atmosphere. However, there are two major challenges ahead. First, both monitoring schemes must be integrated with each other, which means that for companies different departments must be integrated with each other. Second, the height of the CAT would be adjusted if the firm succeeds in taking low-carbon investments to reduce the carbon emissions. This also would require an authority that agrees with companies what there CAT rates would be for their products and when they are allowed to adjust their CAT rates because they have lowered their CO_2 emissions.

Administrative design

The administrative duties involved are not excessive for companies, as purchases of energy products (electricity, gas and oil for heating, oil products for transport and water) enter the profit and loss account as normal expenses. Standard calculations can be applied for the carbon released during trips of employees through the aid of indicators such as kg of CO_2 per kilometre for different travel modes.

[13] See Bovenberg and Goulder (1996) and Goulder (2000) for a full discussion on this subject.

The difference between CAT collected and CAT paid in each year would have to be forwarded to the tax authority. The initial verification process could be a standard bookkeeping procedure carried out by accountants. Given the large number of companies involved, tax authorities would have to conduct samples to verify that companies do not overstate CAT paid or underreport CAT received by checking on their invoices. They are aided in this through the ability to compare CAT receipts with those of 'like' companies (i.e. same sector and size). Furthermore, they can check on the energy and water expenses of suspect companies, which are known to them as VAT is charged on the delivery of electricity, gas and water. The government would thus have to incur some administrative costs, but these need not be excessive as mechanisms for verification are already in existence. Nevertheless, fraud with CAT remains a possibility. The standard assumption is that 10% of VAT revenues in the European Union is lost through fraud (EC, 2004), and the figure for a CAT scheme could be of the same order of magnitude.

Setting the tax rates

The biggest challenge posed by the Monitoring, Reporting and Verification (MRV) system of the CAT is the way in which the amount of carbon released during production is transformed into tax rates on products and services. These tax rates must allow for yearly changes to reflect efforts from companies to reduce their carbon emissions. Each company should at the end of each year report their CO_2 emissions in a report verified by accountants. Based on this report, the government will issue a CAT rate for these companies to be used in the next year.

Like in the EU ETS MRV, the verification report can contain pre-defined rate for different energy carriers and for kilometres travelled by mode.
This calculation is simple for highly standardised products such as tickets on buses and for service-related industries. The amount of petrol used times the pre-defined carbon cost of a litre of petrol divided by passenger-kilometres in the previous year yields the CAT rate per kilometre that the bus company must charge in the next year. Several commercial tools are in existence which aid companies in keeping track of the carbon footprint of their production process. Service-related companies can then multiply the various components of their carbon footprint with the carbon cost for each energy carrier and divide this amount by their turnover in the previous year to obtain a fixed rate on services provided.

This calculation becomes more complicated for companies with many establishments, that sell heterogeneous products or conduct many activities as well as for innovations. Each product's footprint could be based on the energy use of the installation or overhead per establishment involved in its production or assigned to different activities based on their respective turnover.
Such calculations would increase the administrative duties of both companies and government. It might therefore be advisable to allow for standard CAT rates for small businesses based on for instance the average carbon footprint of the sector, and to allow for rebates if companies can prove that their calculated CAT rate is lower than this average. The implementation of the CAT would in any case provide new opportunities for businesses that provide carbon footprinting as these tools would have to be augmented by a monetary valuation and possibly a separate calculation for each product line.

Potential alternatives

The above sketched bottom-up approach in which every company would have to monitor, report and settle the tax rates with the government may be perceived as relatively complex. However, the system could be made less complicated by prefixing a larger number of categories with respect to the tax that is being paid. This could be determined on the basis of a LCA of these products or services. For large energy consumers, the tax would then be based on the bookkeeping in a way that similarly only large energy consumers are currently part of the EU ETS. In this way there would be a dual system:

1. Companies that apply a CAT based on their reported and verified emissions.
2. Companies that apply a CAT rate based on their estimated carbon footprints by using a pre-fixed rate.

The first regime would typically apply to large energy consumers, such as producers of products that currently fall under the EU ETS. The second category would then be for services and products from SMEs, such as the graphical industry.

Companies that use pre-fixed tax rates would have an opt-in of applying under the first category. This could for example be for forerunners in their specific domain that feel that they would benefit from lowering their CAT rate by evidencing their low-carbon profile from their bookkeeping.

Another alternative would be to base the entire system of CAT for domestic producers upstream exclusively on the fossil fuel input. Companies that use fossil fuel must then themselves calculate the appropriate CAT rate and their CAT paid and received must be settled with the government. In this way, the fossil fuel would be taxed at the CO_2 content it would release into the atmosphere by burning it or discarding it as waste. The problem, however, would be that for the imports still benchmarks need to be developed. Under that scheme a dual system would exist for domestic and foreign producers, which has not a high chance of passing the international trade organisations and most likely would face fierce resistance. Therefore, such a system is only imaginable globally.

2.4.2 Treatment of import and export flows

As a destination-based tax scheme, the CAT exempts exports from carbon taxation and impose a countervailing duty on imported goods. Imported products would fall under a ‘benchmark’ where the average carbon intensity of e.g. a kg of steel is being determined. The CAT for domestic producers therefore necessarily goes together with a system in which imports are being brought under the same taxation regime. If the products from the company fall under a ‘benchmark’ (see above), the benchmark would apply equally to EU producers and importers. If the EU producer would use a MRV system to determine their own CAT rates, there would be a difference between how domestic and foreign producers would be taxed. However, by opening the MRV requirements to foreign producers as well, in which they can base their CAT rates on the basis of their MRV system, this discrimination would be avoided.

Under this border-tax adjustment (BTA), producers in countries without a CAT scheme would not gain a competitive advantage or disadvantage over producers in countries that participate in the same scheme, as they would face the same taxation basis for their products in each country. This is similar as present-day VAT which is nowhere disputed as being a discriminatory tax.

However, sales prices of like products would off course be higher in the country with the CAT – in a similar way that sales prices currently are more expensive in countries with a high VAT rate.

The CAT creates thus a level playing field between domestic and foreign producers. However, the system may have unintended side-effects. At home, consumption will be lowered of carbon-intensive products. Domestic producers of these products may see lowering capacity rates, which gives them a stimulus to export a larger share of their production to countries where no CAT applies. The same would apply for producers in countries without a CAT that export to the EU market. Due to a loss in demand from the EU market, prices of these polluting products outside the EU market may fall.
Concerns raised against the CAT and the associated BTA can therefore never be based on economical or environmental arguments, only on political or legalistic arguments (McLure, 2011).

Potential legal problems can be depicted as follows: BTAs have to comply with regulation and rulings by the European Union and the General Agreement on Trade and Tariffs (GATT) within the framework of the World Trade Organization (WTO). The CAT has no difficulty in complying with EU standards; the introduction of the CAT and BTA maintains a level playing field between producers inside the EU and is intended to combat Climate Change, a key objective of the European Commission. The current political discussion in Europe mainly centres around the question how to reduce trade advantages of producers in countries that fall outside of the scope of the EU ETS (i.e. how to reduce carbon leakage) and how Developing Countries can be exempt from or rebated for countervailing measures (Medina and Lazo, 2011).
As the CAT reduces trade advantages, the EU may welcome such a system. Matters are more complex concerning compliance to GATT regulations.

The GATT is an agreement among the 159 member states of the WTO.
Its main purpose is to promote free trade by abolishing export subsidies, import duties and other 'unfair' subsidization of domestic produce, but in recent times it has become more involved with issues such as intellectual property rights, labour standards and environmental protection. The GATT acts on the *Most favoured nation* principle. This means that if one country rewards another with a trade benefit, than similar benefits must be awarded to all other member states. An exception to this general principle is the *Special and differential treatment* of Developing Countries. Developing Countries are for instance allowed more time to adjust to GATT regulation than Developed Countries. Members can litigate against other members by bringing their case before the Dispute Settlement Body, if they feel that the most favoured nation principle has been breached. Decisions by the Dispute Settlement Body can be overturned or confirmed by the highest body of appeal: the Appelate body.

Discussion on the legality BTAs under the GATT centres on a number of contradictory principles. The GATT however, does not interfere with domestic tax (and other) policies as long as the most favoured nation principle and level playing field between domestic and foreign producers are maintained. The BTA in the VAT scheme for instance is compliant with GATT regulation. The GATT allows for differentiation in the BTA as long as import duties are based solely on product characteristics; like products must be treated in the same way (Horn and Mavroidis, 2011).

GATT explicitly forbids differential treatment of products based on the means of production. In other words, different import duties can be levied on grades of steel (provided that similar taxes are levied on domestic steel products), but not on the same grade of steel cast by furnaces powered by gas or more polluting coal. As such, the BTA rates in the example of Paragraph 2.3, where CAT rates were based on the type and amount of energy used in production, would be in violation of GATT if they are based on the same calculation method. Furthermore, BTAs in the CAT scheme would run counter the special and differential treatment principle as Developing Countries tend to have more carbon-intense modes of production.

On the other hand, the WTO recognizes in article 20 of the GATT that environmental protection is a valid reason for undertaking trade actions. Jurisprudence on this matter is referred to by some authors as the reason why the WTO would also allow for BTAs in the CAT scheme (Horn and Mavroidis, 2011). The decision to not undertake any climate action, or the decision to litigate against countries that do so, would impose externalities (i.e. higher worldwide carbon emissions) on the latter countries and their producers, which also runs against the grain of the GATT. The WTO would in any case be careful to decide against BTAs as such a decision encroaches upon domestic policies to combat climate change (Horn and Mavroidis, 2008).

The view that GATT allows for BTAs in a CAT scheme however, seems premature as long as no jurisdiction on that subject exists. WTO jurisdiction is less than clear on the question what Article 20 entails. Furthermore, the decision to litigate under the WTO framework is driven by political forces and not always by legalistic or economic arguments. As such, countries may decide to not challenge the BTA even if it doesn't comply with GATT legislation. Although no clear picture emerges from the jurisprudence or the literature, some elements in the design of the BTA would definitely help to improve its compliance with the GATT.

Box 3: WTO jurisdiction

Article 20 of the GATT states that: "A country invoking an exception (*on the other GATT articles sic.*) has to establish the following elements; that the policy in respect of the measures for which the provision was invoked fell within the range of policies designed to protect human, animal or plant life or health, and that the inconsistent measures for which the exception was being invoked were necessary to fulfil the policy objectives."

The WTO judicial bodies have referred to Article 20 in two prominent cases. The first case was forwarded by Mexico against the U.S., which felt that the by-catch of Dolphins allowed for an import ban on Mexican tuna. The Dispute Settlement Body decided that no country can impose its domestic environmental policies on others and that other courses of action should have been considered first by the U.S. before the import ban was introduced, despite that country's appeal on Article 20.

India, Malaysia, Pakistan and Thailand brought a similar case against the U.S. for the banning of shrimp imports with sea tortoises as a by-catch. The initial decision against the U.S. by the Dispute Settlement Body on similar grounds as in the Tuna case was not overturned by the Appellate Body, but the motivation given did change. The Appellate Body stated that less distortionary actions than an import ban should have been considered first by the U.S., yet it accepted its appeal on Article 20 as a viable motive (CE Delft, 2008). The Appellate Body did however, not elucidate which type of action should have been considered first and when distortionary actions such as an import ban or a BTA are deemed necessary to comply with Article 20.

First, the BTA should apply to products only and not to the way in which they are produced (McLure, 2011). Differentiation in CAT rates and import duties entails a trade-off between many tariffs for different types of goods (and as such more administrative duties) which maximizes the incentives for less carbon-intense consumption and production, or a cheaper and simpler tariff structure, which lessens the impact on emissions to some extent.

Second, the size of the import duty on a product should be calculated from domestic production methods and not from foreign ones. The CAT rate could either be based on the 'cleanest' mode of production or on the average mode of production in the home country (McLure, 2011). The first calculation method would not discriminate against foreign producers and is therefore fully compliant with the GATT. This comes at the expense of a competitive disadvantage for all but the 'cleanest' of domestic producers. The latter consideration would favour the calculation method based on an average benchmark for products.

Third, some foreign producers could be eligible for rebates (McLure, 2011). Exporters who are willing to join the MRV from the CAT system and prove that their production method releases less carbon than the average benchmark for the product group, may have the same opportunity to opt-in for a company-based CAT rates based on their MRV efforts, similar as domestic EU producers are eligible to do this. In this way, the system will have a higher chance of being non-discriminatory under the GATT rules.

2.5 Target setting and price levels of a CAT

The CAT will be put in place as the primary instrument to reach the climate targets of the EU in the future. The primary goal of the EU is in line with the goal of the UNFCC as outlined in Objective 2 of the UNFCC treaty in 1992.

"The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would *prevent dangerous anthropogenic interference with the climate system*. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

Limiting the average global surface temperature increase of 2 degrees Celsius over the pre-industrial average has, since the 1990s, been commonly regarded as an adequate means of avoiding dangerous climate change, in science and policy making – although recently many observers have indicated that even a temperature rise of 2 degrees Celsius may have severe impacts on biodiversity, poverty and economics. According to IPPC (2007) the greenhouse gas emission concentrations must be kept between 445 and 495 ppm CO_2 equivalent in order to have a probability of 50% of avoiding more than 2 degrees Celsius global warming. This would mean that global GHG emissions should decline by 50 to 80% in 2050 compared to 2005 levels (EEA, 2009). This shows already the ambition of the 2 degrees Celsius target – more ambitious targets would be highly unlikely in such a short transition period.

EU leaders have adhered themselves to the 2 degrees Celsius target. The EU has set itself targets for reducing its greenhouse gas emissions progressively up to 2050 and is working successfully towards meeting them. With its: Roadmap for moving to a competitive low-carbon economy in 2050 (COM/2011/0112), the EC has suggested that, by 2050, the EU should cut its emissions to 80% below 1990 levels through domestic reductions alone. The Roadmap set out milestones which form a cost-effective pathway to this goal - reductions of the order of 40% by 2030 and 60% by 2040. Although these interim targets still have to be agreed upon politically, we will use them as a basis for establishing a target for the CAT that will be capable of achieving these targets.
As indicative targets we will set the following targets for these years and years in between.

Table 1 **Indicative EU targets for reduction of GHG compared to 1990 levels**

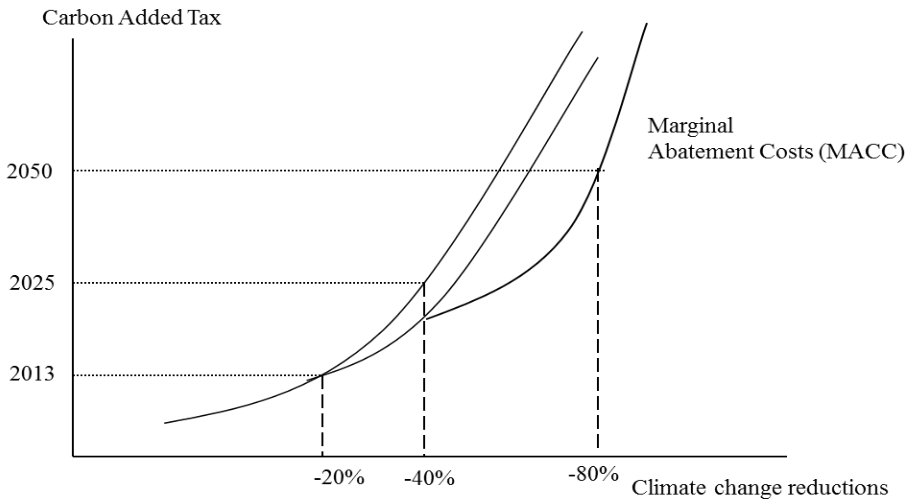
2020	2025	2030	2040	2050
-20%	-30%	-40%	-60%	-80%

If a CAT is to be implemented, it must give a right price signal to assure that these targets will be reached. It is clear that a higher CAT will reduce more CO_2 emissions. But what will be a good level of the CAT to reach these targets?

Standard economic theory (Pigou, 1952) tells us that in order to attain a policy goal the price of a tax must be set at the marginal costs of reaching the target: in other words, the costs of the most expensive measure that must be taken in order to reach the policy target must be used as a tax rate. This price is also called the shadow price of the policy goal. While the tax rate recommended by Pigou applies in principle to producers and production output, it could apply to the CAT as well.[14] So in the stylized world of economics, a CAT set at the shadow price of that policy target would be just sufficient to reach this target. Because the targets become more ambitious over time, also the shadow price will not be constant. Figure 7 shows a marginal abatement cost curves for climate emissions. We see here that these curves are falling downwards over time due to technological progress and innovation. In other words, the costs of moving to a -80% target are quite different in 2050 than it would have been if we would have to implement this today. This delivers three different shadow prices, one for 2013, one for 2030 and one for 2050.

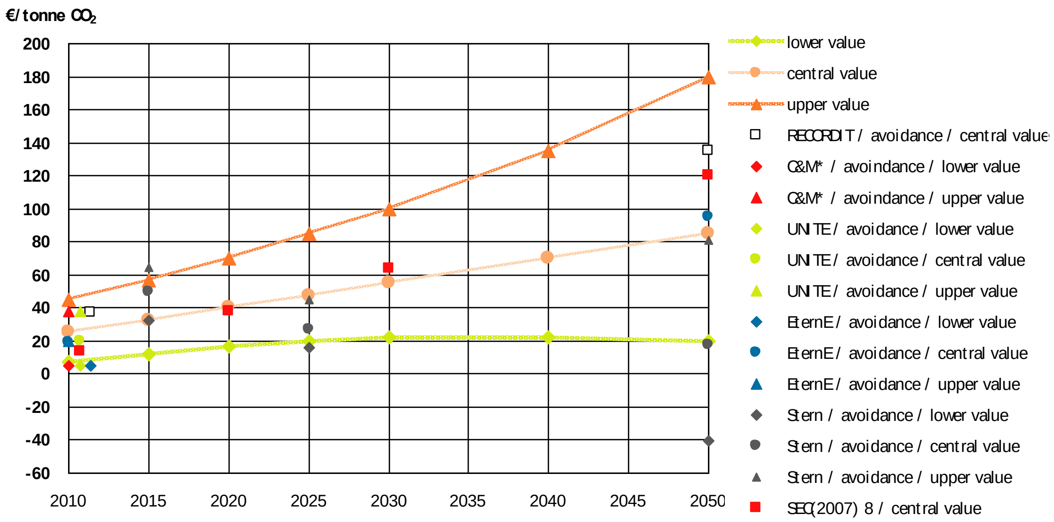
[14] We abstain here from more complex issues such as tax incidence, incomplete information, second-best aspects and other factors that may cause a divergence between a consumption tax and a production tax. It goes beyond the present purposes to highlight these differences but should be elaborated in future work.

Figure 7 Three shadow prices for climate change emissions



The question is now how high this price must be so that the targets will be reached. In other words, we are looking at the literature that has estimated cost-curves for mitigation. An overview of avoidance cost estimates is presented in the IMPACT study (CE Delft/INFRAS/ISI, 2008a). The main results of the literature review performed in this study are presented in Figure 8. The values along the shaded lines correspond to the values recommended by CE Delft/INFRAS/ISI, 2008a.

Figure 8 External climate change costs (avoidance costs)



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Overview of the CO_2 avoidance costs (in €/tonne CO_2) as presented by CE Delft/INFRAS/ISI, 2008a.

The variance in the cost values presented in Figure 8 is quite large, especially for the long-term. This is largely due to the fact that the study does not. The Stern Review even presents negative avoidance costs for 2050, which are the result of large economies of scale and learning effects (Stern, 2006). However, these low avoidance costs are criticised by various other studies (e.g. Tol and Yohe, 2006; Weyant, 2008) and judged to be too optimistic.

For Stern (2006) and ExternE (2005) it should be noticed that the (emission based) targets which have been taken into account are less ambitious than the current estimations of the targets needed to reach the 2 degrees Celsius objective. The ExternE (2005) estimate for CO_2 avoidance costs is based on a target of 4.5 Wm^2, which according to Kuik *et al.* (2009) corresponds to a temperature increase of about 3.6 degrees Celsius. Stern (2006) considers a target of 500-550 ppm CO_2 eq., which according to Kuik *et al.* (2009) corresponds to about 2.5 degrees Celsius. The lower targets used by these studies could have a significant reducing effect on the avoidance costs estimated. For example, Stern (2006) states that the cost of stabilising emissions at 500–550 ppm CO_2 eq. would be around a third of doing so at 450-500 ppm CO_2 eq.

A recent study into the costs of greenhouse gas mitigation policies that aim at the long-term stabilisation of these gases in the atmosphere was carried out by Kuik *et al.* (2009). Based on a meta-analysis of 62 studies they estimated the avoidance costs as functions of target implemented (ranging from 450 to 650 ppm CO_2 eq.) for both 2030 and 2050 (see Figure 8). Both the value of and the uncertainty in the avoidance costs figures increase when the reduction targets are tightened. With regard to a long-term target of 450 ppm CO_2 eq. (corresponding to a temperature increase of about 2 degrees Celsius) the avoidance cost in 2030 is estimated to be equal to € 129, with a bandwidth of € 69-241. For 2050 the central estimate is € 225, with a bandwidth of € 128-396 per tonne CO_2 eq. These values are in 2005 constant euros. Because of inflation, these figures should be increased by 13.2% to arrive constant figures for 2012 euros.[15] .

We will use these values for our purposes here. Table 2 gives the values for the CAT of policy targets in 2030 and 2050.

Table 2 CAT in €/tCO_2 eq. for

	2030	2050
CO_2 eq. reduction target	-30%	-80%
CAT (€/tCO_2 eq.)	146	255

Values in 2012 constant euros.

One should notice that CO_2 prices of € 146 and € 255/tCO_2 are much higher than the anticipated EU ETS price in 2020 from the 2007 Impact Assessment by the European Commission (EC, 2007), which was estimated to be around € 30/tCO_2. And they are a factor 35-60 higher than the current price at the emission trading markets. So the instalment of a CAT that is to reach the policy targets results in substantially higher CO_2 prices. However, unlike the EU ETS, this will not affect the competitiveness of European business. It is most likely even enhancing employment as we will argue in the next chapter.

[15] CPI from the Netherlands, derived from Statline on 24 July 2013.

3 Impacts of a CAT

3.1 Introduction

In this chapter we will investigate what impact the CAT will have on the prices of products and the governmental revenues. We will argue here that although the price changes are in the order of -20 to +70% (which is less than the fluctuations in the oil prices over the last two decades), the impacts can be substantial.

We will work out the impacts for the Netherlands, although the impacts will be similar in other European countries – and as argued in Paragraph 3.6, the impacts can be even felt worldwide (even if countries do not adhere to the concept of CAT).

3.2 Can the CAT replace the VAT? An issue on governmental revenues

As argued in Chapter 2, the CAT will be set at price levels that present the best possible estimate of the future marginal costs of carbon mitigation measures to reduce emissions to -80% in 2050. We will use in our quantification also an intermediate target of -30% in 2030. For these two years, we have taken associated price levels from the literature, as can be found in Chapter 2.

For every kg carbon added, a consumer (whether it is a final consumer or a company that consumes certain goods) has to pay € 0,146 in 2030. This amount will steadily increase to € 0,255 in 2050. Although not entirely correct we have presented here the tariff in Table 3 as a percentage, to achieve similarity with the concept of VAT.

The question now is: how much revenues will be generated by the CAT? To answer that question we have to look at the CO_2 intensity of Dutch consumption. There are two ways to investigate this: bottom-up and top-down. The top-down approach uses information from the environmental national accounts in the Netherlands. PBL has estimated that in 2009, the total emissions caused by Dutch consumption were equivalent to 228 Mt CO_2 eq. Because of emission reduction targets this figure will have to decrease to 160 MtCO_2 eq. in 2030 and 46 Mt CO_2 eq. in 2050.[16] So while the CO_2 price increases in 2050 compared to 2030, the total revenue base will become much smaller due to the reduction in CO_2. In Table 3 the total revenues have been calculated as being equivalent to € 23 billions in 2030 and almost € 12 billions in 2050. These form the revenues from the CAT.

[16] We would assume here emission reductions in line with the proposals of the European Commission (EC, 2014) with 41% reduction in 2030 and 80% reduction in 2050 compared to 1990 levels. When compared to 2009 levels, this would be more or less equivalent.

Table 3 **Revenues from an optimal CAT: total economy**

	2009	2030	2050
CAT level €/kg CO_2 eq.	-	14.6%	25.5%
Carbon equivalent GHG emissions due to consumption (Mton)*	228	159.6	57.0
CAT revenues (billions€)		23.3	14.5

* The carbon equivalent emissions due to consumption in 2030 and 2050 has been calculating by comparing the EU targets set in EC (2014) to 1990 levels in the EU with the 2009 actual GHG emission of the EU. No specific Dutch targets have been assumed here.

The bottom-up approach uses the analysis from Vringer *et al.* (2010) of the embodied carbon intensity of over 300 Dutch consumer goods in the year 2000. Using a variety of approaches they calculate that the most likely embodied carbon intensity equals around 27t GHG emissions (CO_2 equivalent) per household through private consumption.[17] They would sum up to a total of 184Mt GHG emissions as a carbon footprint from household consumption.
If we compare this 184Mt from the bottom-up approach with the 228 Mt from the top-down approach, one would be tempted to assume that households would be responsible for over 80% of the embodied carbon emissions from the Dutch economy. However, from the national accounts, it appears that households consumption itself only makes up about 55% of GDP in the year 2000.[18]

Therefore, either the carbon intensity of Dutch household consumption is much larger than those for investments and consumption, or the method of calculation embodied carbon bottom-up and top-down is not congruent.
In CBS (2012) different methods for calculating the carbon footprint have been calculated and it is concluded that the various methods may show results that differentiate by almost a factor 2. The above mentioned result of 228 Mt GHG emissions (of which 187Mt CO_2) is indeed on the low-end of the spectrum.

If we would have more confidentiality at the bottom-up estimations by Vringer *et al.* (2010), the following calculations can be made at the level of individual households:[19]

Table 4 **Influence of a CAT at the level of individual households**

	2000	2030	2050
Household expenditure ($€_{2000}$/yr)	24,073		
ow VAT paid	2,878		
GHG embodied (kg_{CO2eq}/yr)	27,180	19,026	6,795
CAT paid ($€_{2000}$/yr)		2,778	1,731

While, at the level of the individual household, the CAT paid in 2030 seems to be similar to the presently installed VAT, in 2050 a shortage in taxes paid can be expected due to the 80% reduction in GHG emissions compared to 1990.

17 Vringer *et al.* (2010) use bottom-up data on expenditures from households. An average household would spend € 24,703. For 93% of these expenditures, a CO_2 footprint of 27t CO_2 was calculated by the researchers including embodied carbon.

18 The other 45% can be explained by governmental consumption and investments by companies, governments and households.

19 Here we have extended on the Vringer data set by including the VAT paid for each category.

From this analysis we would conclude that it is unlikely that the CAT can fully replace the VAT and attain a similar level of income for the state. Certainly in the long-run an additional regime of taxation seems to be required to keep governmental budgets intact.
Therefore, in the next sections we will elaborate on the impacts of a CAT/VAT system with the following rates:

Table 5 Rates of CAT/VAT tax schemes used for calculation

	2013	2030	2050
CAT rates (€/tCO_2 eq. added)	0	146	255
High VAT rates %	21%	4%	8%
Low VAT rates %	6%	1%	2%

Pending on whether one believes that the top-down or bottom-up perspective is better in calculating embodied GHG emissions, this would result in lower or higher tax incomes for the government.

3.3 Impact of the CAT on technologies and composition of expenditures

A system of CAT will have two important influences:
1. On the technologies used for production
2. On the composition of consumption expenditures.

The system of CAT, as described in Section 2.3 and 2.4, can be an important leverage for realizing low-carbon investments improving the **technologies used for production**. Producers will want to minimize their carbon emissions so to cut down the carbon costs of the products they deliver so that they can establish a lower CAT tariff for the next year. By producing below the benchmarks they can realize cost-savings compared to non-EU competitors and create a competitive edge compared to imported products. Low-carbon investments thus have a direct return in lowering sales prices and increasing market share.

At present, innovation in low-carbon technologies is stagnant and governmental support has become the largest source of technology development in e.g. renewable energy (UNEP 2013). Introduction of a CAT would imply that corporate capital will be attracted stemmed for improving the competitive position of industry and stimulate investments in this area. The extent to which this will reduce CO_2 emissions depends, among others, on the pace of technological development and costs of measures to reduce emissions.

A second impact will be that the relative price of various products will change. Products with substantial carbon content will become more expensive and low-carbon products will become cheaper from the lower VAT rates. This will stimulate shifts in the **composition of household expenditures** towards cleaner products and may result in changes in lifestyles, etc.

It is very clear that these forces will be intertwined and for each product category differently. If producers fail to move to low-carbon technologies, consumers will consume less of these products because of the higher additional costs. The possibilities to reduce carbon emissions will be different for every product category, and the changes in consumption patterns will be dependent on price- and income elasticities for the various goods. Future work should reveal these impacts. For the present study, illustrating the functioning of the CAT and its potential impacts, we will use the heroic assumption that due to the CAT half of the required emission reductions will be obtained from cleaner technologies, and half of the emission reductions from changes in lifestyles. Effectively this implies that we assume that for each of the products, 2030 carbon emissions will be 15% lower than the present values, and 2050 emissions 35% lower.

3.4 Impact of CAT on household expenditures and consumer goods

The quantitative impacts of a CAT can be assessed both from a top-down and a bottom-up approach. The top-down approach uses the overview by Vringer *et al.* (2010) that established for the entire household expenditures of Dutch households an estimation of the CO_2 footprint per spend household euro. This gives an indication of the CO_2 footprint for about 350 product categories. The impact of the CAT has been calculated for these product categories taking the assumption that half of the reductions are realized through technological improvements. The CAT tariffs per € product and the biggest changes compared to the household budgets in the year 2013, are given in Table 6.[20]

First there are product categories that become considerably more expensive. Table 6 gives a list of products that become considerably more expensive under a system where the dominant form of taxation becomes a CAT.

Table 6 Top categories that become more expensive due to the instalment of a CAT

	CAT tariffs per € product		Price increase *		€ per hh in 2000
	2030	2050	2030	2050	2,114
Matches and candles	159%	212%	142%	199%	13
Butter	68%	91%	63%	87%	16
Natural gas	77%	103%	60%	90%	407
Salad oil	66%	88%	61%	84%	8
Rice	63%	84%	58%	80%	11
Solid and liquid fuels	72%	96%	55%	83%	2
Electricity	70%	93%	53%	80%	351
Eggs	47%	63%	42%	59%	23
Other meat products	46%	61%	41%	57%	12
Minced meat, fresh	43%	58%	38%	54%	83
Beef, fresh	42%	56%	37%	52%	59
Cream	42%	56%	37%	52%	5
Nuts and peanuts	41%	55%	36%	51%	28
Fish, fresh	41%	55%	36%	51%	24
Offal	38%	51%	33%	47%	24
Herring	38%	51%	33%	47%	7
Preserved fish	38%	51%	33%	47%	5
Other fish	38%	51%	33%	47%	2
Fruit and vegetable juices	37%	50%	32%	46%	59
Meat and meat products, frozen	37%	50%	32%	46%	25

[20] For this analysis we calculated first the amount of VAT spend for each product categories and then applied the VAT/CAT system based on CO_2 footprint from consumption using the tariffs from Table 5.

	CAT tariffs per € product		Price increase *		€ per hh in 2000
	2030	2050	2030	2050	2,114
Cheese	37%	50%	32%	46%	181
Petrol, oil for cars and motor cycles	46%	61%	29%	48%	723
Other oils and fats	36%	48%	31%	44%	24
Fats for frying and deep frying	36%	48%	31%	44%	14
Fish, frozen	35%	46%	30%	42%	8

Note: Own calculations using data from Vringer *et al.*, 2010. CAT and VAT rates as in Table 5.

* Price increases are real prices (excluding inflation) using prices with base year 2000 and tax rates 2013. Price increases assuming a 15% reduction in GHG intensity in 2030 and 35% in 2050.

From the Vringer data, the most carbon-intensive categories can be found in the energy sector and the food sectors. In relative terms, matches and candles will show the largest price increase, but expenditures on these items are very small. Much more important categories for household consumption are natural gas, electricity and petrol used for cars and motorcycles. Natural gas will more than double in price in 2050 – and the same would apply for electricity. Furthermore it is apparent that most of the food products that are from animals become considerable more expensive.

In addition to products that become much more expensive, there are also products that are becoming cheaper – especially in 2030 when the CAT more fully replaces the VAT. Table 7 gives the overview.

Table 7 Categories that become more cheap in 2030 due to the instalment of a CAT using existing technologies of production (excluding technological progress)

	CAT tariffs per € product		Price increase *		Expenses/ household in EUR
	2030	2050	2030	2050	3,756
Other tobacco articles	6%	8%	-11%	-5%	65
Repair and maintenance household appliances	5%	7%	-12%	-6%	8
Hire/repairs audio/video equipment	5%	7%	-12%	-6%	21
Costs tending pets	5%	7%	-12%	-6%	138
Cigarettes	5%	7%	-12%	-6%	120
Telephone	5%	7%	-12%	-6%	507
Spirits and liquors	4%	5%	-13%	-8%	64
Rental value	4%	5%	-13%	-8%	2383
Service costs for rental	4%	5%	-13%	-8%	98
Hire and charge for making clothes	4%	5%	-13%	-8%	4
Hire of footwear	4%	5%	-13%	-8%	2
Repairs to finery	4%	5%	-13%	-8%	7
Laundry, dry cleaning, dye works	4%	5%	-13%	-8%	14
Chiropodist, manicurist, beauty salon	4%	5%	-13%	-8%	28
Hire and maintenance camping equipment	4%	5%	-13%	-8%	16
Hire and repairs of musical instruments	4%	5%	-13%	-8%	12
Services provided by clubs	4%	5%	-13%	-8%	2
Lincenses and taxes relaxation	4%	5%	-13%	-8%	5
Repair mopeds, motor cycles and scooters	4%	5%	-13%	-8%	13
Driving lessons	4%	5%	-13%	-8%	40

	CAT tariffs per € product		Price increase *		Expenses/ household in EUR
	2030	2050	2030	2050	3,756
Other educational costs	2%	3%	-15%	-10%	21
Car/motor cycle storage	2%	3%	-15%	-10%	29
Bicycle/moped storage	2%	3%	-15%	-10%	2
Postal expenses	2%	3%	-15%	-10%	22
Wages for domestic staff/servants	1%	2%	-16%	-11%	132

Note: Own calculations using data from Vringer *et al.*, 2010.

* Price increases are real prices (excluding inflation) with base year 2000. Price increases assuming a 15% reduction in GHG intensity in 2030 and 35% in 2050.Rates of CAT/VAT as in Table 5.

Low CAT tariffs per unit of euro spend can especially be found in products and services from the service sectors. Storage, repair, postal services, lending out equipment, making telephone calls: it is expected to become more cheap in 2030 due to the instalment of a CAT. These products and services contain in their cost price large amounts of labour costs which are heavily taxed under a VAT system as labour constitutes the largest of share of *value added*.
The CAT system, however, does not tax labour intensive products but only carbon-intensive products.

3.5 Impact of the CAT on building materials

Building materials pose an important burden of embodied carbon intensity. Currently these carbon costs are not factured in the price of buildings, so designers, architects and construction workers do not take the carbon content into account in their decisions. A CAT will change that. But to what extent?

For our analysis of building materials we took results from a variety of recent sources: CE Delft (2013); Ecoinvent database (version 2.2) and SBK (2012) to come up with a most recent estimate for the Netherlands. We added prices from a variety of sources to these LCA data and made calculations on the impacts of the CAT.

Currently, building materials fall under a VAT of 21%. However, for a number of materials the CAT would be lower than 21%, implying that they would become cheaper. This especially applies to sawn wood, sand and gravel. Table 8 gives the CAT rates for a selection of building materials. The CAT rates for aluminium are by far the highest, implying a level of taxation that would more than double the price of aluminium in 2050. CAT rates lower than the current tariff for VAT (21%) can be found for many materials.

Table 8 CAT rates as percentage of pre-taxed sales for building materials

	2030	2050
Concrete (mortel)	6%	9%
Bricks	13%	17%
Limestone (brick)	10%	13%
Cellular concrete	21%	28%
Sand	2%	3%
Gravel	0%	0%
Asphalt	5%	7%

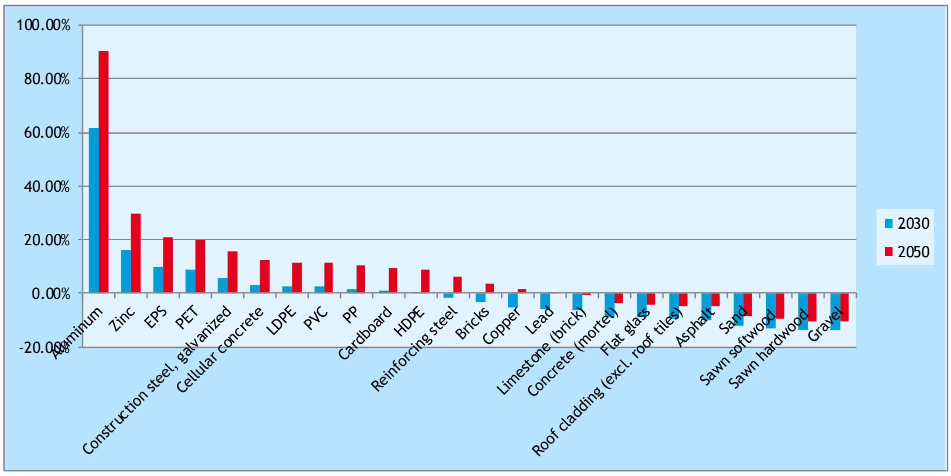
	2030	2050
Roof cladding (excl. roof tiles)	5%	7%
Reinforcing steel	15%	20%
Construction steel, galvanized	24%	32%
Aluminum	92%	122%
Copper	11%	15%
Lead	10%	14%
Zinc	37%	49%
Flat glass	6%	8%
HDPE	18%	24%
LDPE	20%	27%
PP	19%	25%
PET	28%	37%
PVC	20%	27%
EPS	29%	38%
Sawn hardwood	0%	1%
Sawn softwood	1%	2%
Cardboard	18%	24%

Note: Own calculations. CAT tariffs assume a 15% reduction in GHG intensity in 2030 and 35% in 2050 per building material. Rates of CAT/VAT as in Table 5.

Note: CAT rates assuming a 15% reduction in GHG intensity in 2030 and 35% in 2050.

When we look at the price increases and allocate also the lowered VAT tariffs from Table 5 in Paragraph 3.2, we see that aluminium will increase in price by 60% in 2030 and 90% in 2050. Various materials actually become cheaper, such as gravel, wood and sand.

Figure 9 Total price increase in a system of CAT and lowered VAT tariffs in % compared to prices 2013



Note: Own calculations. Price increases are real prices (excluding inflation) with base year 2012. Price increases assuming a 15% reduction in GHG intensity in 2030 and 35% in 2050. Used rates of CAT/VAT, see Table 5.

In the end, in an efficiently operating market, the choice of building materials will also be influenced by thermal properties of the materials as thermal insulation will become more important due to the increase in the price of natural gas for heating purposes. This impact has not been quantified here.

3.6 Food

Food is an important item in the lifestyles of consumers. However, food also creates huge environmental impacts. Van der Voet *et al*. (2004) were among the first studies that have highlighted the enormous environmental impact from food production. Moreover, many of these environmental impacts are happening in poorer economies where nature and biodiversity are not very well protected.

The question is now: what impact will the CAT have on the price development of food consumption. We will investigate this from two perspectives. First, the general perspective on the price development for over 100 food categories can be found in the data from Vringer *et al*. (2010).

The categories with the highest CAT rates are given in Table 9.

From Table 9 it becomes apparent that per unit of pre-tax sales, the tariffs will be highest for butter and salad oil followed by eggs and various meat products.[21] It is remarkable that from these data also fish will become much more expensive under the regime of the CAT. The first vegetable on this list are potatoes and tomatoes which will have a CAT tariff of 35% in 2030 and over 60% in 2050 if technologies of production do not alter. However, the CAT for tomatoes grown in Spain will be much lower.

Table 9 CAT as % in pre-taxed sales for various products ranked to highest CAT %

	2030	2050
Butter	68%	91%
Salad oil	66%	88%
Rice	63%	84%
Eggs	47%	63%
Other meat products	46%	61%
Minced meat, fresh	43%	58%
Beef, fresh	42%	56%
Cream	42%	56%
Nuts and peanuts	41%	55%
Fish, fresh	41%	55%
Offal (meat)	38%	51%
Herring	38%	51%
Preserved fish	38%	51%
Other fish	38%	51%
Fruit and vegetable juices	37%	50%
Meat and meat products, frozen	37%	50%
Cheese	37%	50%
Other oils and fats	36%	48%
Fats for frying and deep frying	36%	48%
Fish, frozen	35%	46%
Other dairy products not specified	34%	45%
Fried minced meat	32%	43%
Other meat and meat products not specified	31%	41%
Potatoes	30%	40%

21 One should bear in mind that this does not imply that these categories have the highest carbon footprint per kg of material: it rather implies that these categories have the highest carbon footprint per € of pre-taxed sales.

	2030	2050
Tomatoes	30%	40%
Other confectionary	30%	40%
Sausages and meat products	30%	40%
Fried fish	30%	40%
Milk	30%	40%
Other cabbages	29%	38%

We can compare this with the list of food items that have the lowest CAT. Table 10 gives this overview. Alcoholic drinks have the lowest CAT per € value – a fact that solely relates to the excise duties on alcoholic beverages. Because the VAT also applies to excise duties, the sheer amount of VAT paid is high in the case of demerit goods (tobacco, alcohol). As the CAT rate for excise duties is zero, the total tax paid will decrease.

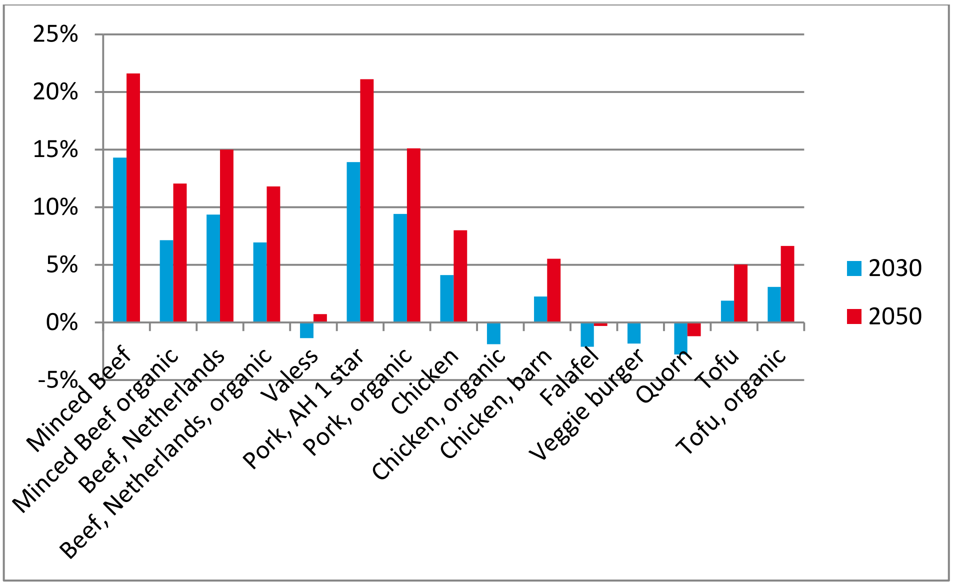
Next to alcoholic beverages, meals and drinks in bars and restaurants tend to be the food items with the lowest CAT. However, total taxes may increase given current low VAT tariff of 6%.

Table 10 CAT as % in pre-taxed sales for various products ranked to lowest CAT %

	2030	2050
Spirits and liquors	4%	5%
Wine	7%	10%
Coffee and tea, beverages in restaurant, etc.	9%	12%
Meals, in restaurant	9%	12%
Meals, delivered and take-away	9%	12%
Candy, not at home	9%	12%
Ice cream, not at home	9%	12%
Beer	10%	13%
Beverages not specified	11%	15%
Water	11%	15%
Non-alcoholic beer and wine	12%	17%
Mineral and soda water	14%	18%
Deer	16%	22%
Honey	19%	25%
Coffee	19%	25%
Tea	19%	25%
Other non-alcoholic beverages	20%	26%
Bread with raisins	21%	28%
Other (leafy) vegetables	21%	28%
Cauliflower	21%	28%
Sauerkraut	21%	28%
Fruit in juice	21%	28%
Ice cream	21%	28%
Spirits and liquors	4%	5%

It is also interesting to investigate how the need for proteins by humans will be influenced by a CAT. Here we investigate two types of meat (regular and organic) with non-meat alternatives (e.g. soya-based meat replacements). Figure 10 presents this analysis for the growth of prices compared to the present prices, in 2030 and 2050 if a system of CAT and VAT rates (as indicated in Table 5) would apply. This analysis is based on a more recent comparison using data that have been used in the SuperWijzer (CE Delft, 2011a) – a popular app comparing environmental and climate impact of various meat related products.[22] The following figure shows the price increase in 2030 and 2050 if the CAT would be introduced.

Figure 10 **Price developments of meat and meat replacements in €/kg due to CAT and VAT tariffs in 2030 and 2050**



Note: Own calculations based on CE Delft (2011a). There are differences between these data from Ecoinvent and the Vringer database that relate to the way GHG emissions from non-EU sources have been estimated. Price increases are real prices (excluding inflation) with base year 2012. Price increases assuming a 15% reduction in GHG intensity in 2030 and 35% in 2050. Used rates of CAT/VAT, see Table 5.
That has been used above. Within the time-frame of this project it was not possible to reveal these differences. The outcomes should only be indicative of the general trend.

All meat-based protein suppliers will see increased prices. However, prices of meat replacements remain at the same level or are even likely to fall – especially up to 2030. All traditional meat products face considerable increase in prices of 5-over 20%. The instalment of a CAT will also have a small impact on the choice between organic meat and traditional meat since organic meat, in general, tends to have a lower CO_2 footprint (mainly through the feedstock).

3.7 Transport

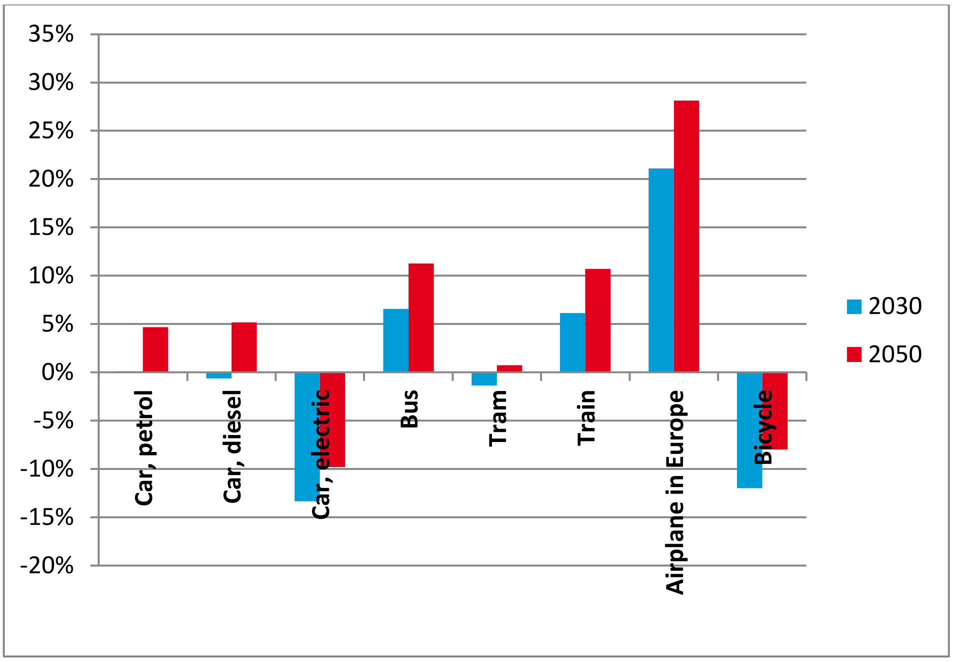
Transport is an important sector for modern economies. Modern economies have an urgent need for decline of transportation costs. It is not without reasons that biggest population growth rates are clustered in areas were overall transport costs are cheapest, like in Deltas and metropoles.

22 The 'SuperWijzer' is a website and smartphone app providing consumer advice on meat and dairy products. It is based on CE Delft (2011a), a study to calculate the climate and environmental impact of numerous types of meat and meat replacements.

Since all transport is relatively carbon-intensive, the total demand for transport is likely to fall if a CAT is introduced. However, since there will be more distinct price differentials between the various modes of transport, there will be at the same time a modal-shift towards cleaner modes of transport.

Using a variety of databases from RWS and Ecoinvent we calculated the following impacts from a CAT.

Figure 11 Price changes due to the CAT for different transport modes: passenger transport



Note: Own calculations. Price increases are real prices (excluding inflation) with base year 2012. Price increases assuming a 15% reduction in GHG intensity in 2030 and 35% in 2050. Used rates of CAT/VAT, see Table 5.

The CAT has substantial impacts on the price of medium-distance aviation transport. This is primarily because at present aviation is not paying VAT. We assumed here that under the new regime aviation does have to pay the CAT but not the VAT part. This will imply that aviation will have to raise its prices substantially.[23]

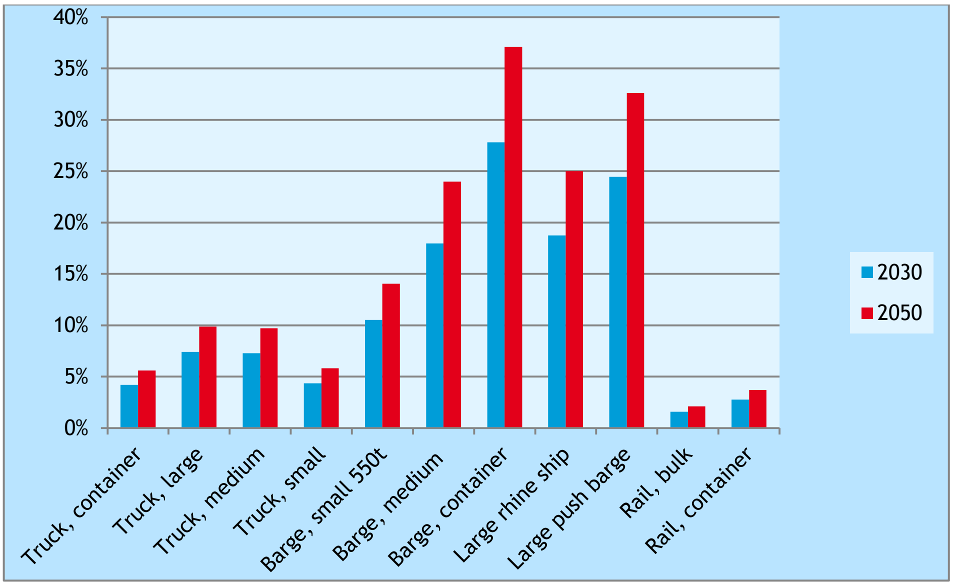
The impacts on cars from this analysis are relatively moderate, with some price increases at around 5% in 2050. However, electrical cars will become much more cheap, probably neutralizing the current (post-tax) price differential between electrical cars and conventional automotive. Travelling by bus and train will also become relatively more expensive. The reason is that these transport-modes are currently under a low VAT tariff, while we assume

[23] Currently there is no VAT on any aspect of air travel, not on airline tickets, nor on purchase of aircraft, fuels or on-board meals. The reason is that VAT tariffs differ between countries and it is unclear which VAT tariffs would apply on a flight between countries – the tariff of the country of departure or the country of arrival. A CAT could be levied probably more easily in a similar fashion to the current rules under the EU ETS where the CAT would be levied for the part of fuel attributed to flight movements in the EU. However, the experience of the EU ETS would learn that this is not straightforward and may be heavily contested by non-EU airlines.

they will be under the full CAT tariff. Travelling by tram will hardly be affected, while travelling by bicycle will become cheaper (although this mode of transport is by far the cheapest already so the impacts will be minimal).

Freight transport is also currently under VAT tariffs, although the issue is highly complex and depending on the goods transported, type and location of customer and type and location of service provider. It is beyond the scope of the present study to give a full account of the VAT rates that would apply to freight transport. However, if the CAT would apply a potentially more simple system would be in place that would tax the carbon content of the fuel. Figure 12 shows the potential cost price increases of various mode of transport within the EU.

Figure 12 Price changes due to the CAT for different transport modes: freight transport in t/km excluding lowering of the VAT rates



Note: Own calculations based on STREAM model (CE Delft, 2011b) and assuming average current VAT rate of 20% in the EU. Price increases are real prices (excluding inflation) with base year 2012. Price increases assuming a 15% reduction in GHG intensity in 2030 and 35% in 2050. Used rates of CAT/VAT, see Table 5.

Surprisingly, the CAT would result in a larger increase in shipping rates of inland waterways than road transport. This is because the CO_2 per unit of revenue is higher in inland waterways than for road transport. Freight transport over rail would most likely become more cheap.

3.8 Conclusions and wider economic impacts.

The CAT will change the relative prices of products. For the construction sector, the CAT implies that traditional materials gain more importance: wood, sand, glass. Plastics, aluminium, construction steel and zinc would become quite more expensive. Price impacts on bricks and concrete would be quite minimal. However, the largest impacts probably come from the increase of the costs of heating: buildings would inherently have to be more energy-efficient. Moreover, an integration of buildings with ways to generate energy (solar PV, geothermal, wind energy) is likely since the costs of electricity and heat will rise quite substantially. Standard buildings would be equipped with solar roof tops or even solar panels on walls because this will be more attractive. Small windmills may find their way in the city landscapes.

In general, food will become more expensive due to a CAT – especially for meat products and food for sale in supermarkets. Since food cooked at home may increase a factor 1.5 in price, people are more likely to eat outdoors. Restaurants tend to profit from the CAT by being able to sell their services at lower prices. A larger share of vegetables will be shown on the plate than today. Meat replacements will be more used than today implying economies of scale and cheaper costs of production. The opposite applies to meat production: lower volumes would imply larger costs of production. Meat may become an exclusive material served in smaller portions than today.

In transport there will be a continuing drive for lower CO_2 techniques and modes of transport. Electrical vehicles will become considerably more cheap relative to conventional automotive. Also public transport may become a more dominant form of transport.

The above examples have in general shown that due to the CAT, carbon-intensive products will become more expansive and labour intensive products tend to become more cheap. At the level of national economies, this may be perceived as a merely distributional impact. However, this may have important dynamic consequences for companies which may impact the economic structure as well.

First, at the firm level the CAT will impose a continuous search for ways to reduce emissions as to lower the costs of carbon gaining competitive advantages vis-à-vis the major competitors. This will stimulate employment in so-called green sectors (e.g. renewable energy manufacturers, energy saving technologies). This is the first attractive feature of the CAT.

Second, this strive for lower carbon emissions will not be jeopardized by adverse competitive impacts from products produced in countries that do not adhere to climate policies. Since all imports will be taxed at a benchmark CO_2 level (unless the client adheres to the bookkeeping principles underlying the CAT), there will be no distortive competitive impacts from investing in clean technologies. Therefore, the CAT is a mechanism where stringent climate policies can be combined with a sound competitive industrial structure. Third, consumers themselves will be forced to adopt less carbon-intensive lifestyles. A greater use of services, low-carbon leisure activities and different types of foods will imply that the total CO_2 emissions will start to decline through changes in lifestyles. It is difficult to predict how these changes actually will take place – but the impact can be substantial.

All of these impacts imply that in general the labour intensity of the economy will increase. We saw from the examples that activities that are relatively labour intensive will show less price increases than activities that are highly dependent on energy-inputs. Therefore the CAT is likely to provide a positive stimulus to employment.

4 Carbon Added Tax: conclusions

4.1 Cause for a Carbon Added Tax

The earth climate is a collective good for which every country in the world, every individual, must deliver efforts in order to reduce the current CO_2 emissions and carbon footprints. However, progress in the international design of climate policies have been frustrating and slow at best.

Chapter 1 argues that there is not much room to expect considerable improvement in this area for four distinct reasons:
1. The countries that suffer most from climate change are the countries that emit the lowest CO_2 emissions while the countries that emit most of the CO_2 emissions are hardly hit by climate change (or can even benefit from it in economic terms). Therefore, climate change regimes are intertwined with social issues such as poverty alleviation and the world has shown not a great track-record in alleviating poverty in the last 50 years.
2. Current estimates of the costs to reduce CO_2 emissions below levels where the risk of detrimental climate change is considered to be acceptable are overly optimistic and negate the fact that governments so far tended to fail to regulate CO_2 emissions in a cost-effective manner. Ex-post experience show considerable inefficiencies in climate policies.
3. Given the high costs individual countries have a benefit by not signing international climate treaties so as to reduce costs for their industry and enhancing their export position. They would act as ‘free-riders’: profiting from the global reduction of risks of detrimental climate change and not to pay for it.
4. In the design of economic instruments for global climate policies, a single price for CO_2 worldwide would have adverse impacts on the poorer countries and in conflict with social justice. However, a differentiated price would be economically not efficient. Because of the conflict between social justice and economic efficiency, the design of international climate policies is becoming very difficult.

A Carbon Added Tax would address these issues effectively, especially the second and third. Since a Carbon Added Tax would not tax production, but rather consumption of products, and since domestically produced products and imported products are taxed alike, there is no discrimination in the taxation level with respect to the country of origin. Therefore, there is no benefit for countries not to sign climate treaties – the benefit of being a free-rider is severely diminished. Moreover, a carbon added tax would reduce costs significantly since companies will be seeking a continuous drive for lower CO_2 emissions as this will lower the price of their products. This may run down prices of complying to CO_2 limits and speed up innovation in cost-effective low-carbon technologies. Finally, the CAT would be more acceptable from a social-justice perspective in which the poorer countries can decide to stay exempt from the CAT. This effectively would imply that while their export to EU countries still falls under a regime of climate pricing, the domestic consumption does not. However, they would have an impetus to sign into the system as well in order to advance their competitiveness on global markets.

4.2 Design

The VAT system in place in the EU could serve as a blueprint for a CAT. Under the VAT scheme, the value added in each production step is taxed. Under a CAT scheme, the carbon additionally released to the atmosphere in each production step would be taxed. If well-defined, a CAT system should result in consumers paying the full carbon costs of a product over its entire production cycle. Under today's VAT system, every company basically operates as a tax-warehouse, not paying VAT themselves, but merely collecting taxes for the government. The VAT settled with the government equals the VAT on value added, the reward for own labour (gross wages) and capital (depreciation and profits) for all non-importing companies, hence the name Value Added Tax.

In a CAT scheme, envisaged as replacing today's VAT scheme, tariffs are expressed as a fixed sum of money for every kilogram of CO_2 equivalent emitted. The tax would be levied both on domestically produced and imported products in the EU. The CAT (and especially the levy on imports) necessitates a *benchmark*, defining for each product the benchmark CAT rate that would apply. Companies further down the product chain would add CAT on their own inputs, ensuring the CAT reflects the ongoing carbon footprint of the product, while paying only the CAT on their own added carbon.

The CAT would work more effectively if it were augmented with a monitoring, reporting and verification (MRV) scheme at the individual company level. Each company would then be obliged to keep track of the CAT it pays on its inputs, the amount of carbon it releases during production or processing, and the CAT charged on its products and/or services. CAT invoices would be collected from suppliers and given to customers and clients. The MRV scheme would have two components:
1. MRV of the flows of CAT received and paid.
2. MRV of the CO_2 emissions added to the overall production process.

In practice, both these monitoring, reporting and verification schemes already exist. Under the present VAT scheme, there is MRV of the VAT paid on inputs, while under the EU ETS there is MRV of atmospheric CO_2 emissions .There are two major challenges ahead, though. First, the two monitoring schemes need to be integrated, implying departmental integration at companies. Second, the level of the CAT would be adjusted if a firm manages to reduce its carbon emissions by investing in low-carbon technologies and practices. This would also mean a need for an authority to verify companies' previous-year bookkeeping and settle the tax rate for the current year.

For imports as well as for companies not wishing to adhere to an MRV system, product benchmarks would have to be set up defining the benchmark CAT rate for each particular product (made of flat glass versus hollow glass, etc.). Under the current EU ETS, such benchmarks have been defined for over 50 products. EU companies with an MRV system in place could apply for a lower CAT rate than the benchmark.

4.3 Impacts of a CAT

Introducing a Carbon Added Tax to partly or entirely replace today's VAT would drastically change price patterns, even in the short run. Based on an analysis of effective carbon tax rates from the literature, we propose a CAT rate of € 146/tCO_2 in 2025, increasing to € 255/tCO_2 in 2050. This would be in line with efforts to stay below the threshold of 2 degrees warming that is deemed an acceptable risk. Such high CO_2 prices, over 30 times higher than current ETS prices, would initially result in major price changes for consumer products. They would imply cost increases of 40-80% for various carbon-intensive consumer products such as meat, petrol and animal fats. However, the government revenue generated would be such that the high VAT rate could be reduced from the current 21 to 4% in 2030. Price changes may be less pronounced in the long run, moreover, because a CAT scheme would induce major carbon cuts, implying that by 2050 the CAT would have to be accompanied with a larger share of VAT in order to safeguard governmental tax revenues.

Relative prices of products would change drastically. In general, energy items (electricity, heating) and food tend to become more expensive. Products with substantial labour cost components (or products with high excise duties) tend to become more cheap. Food served in restaurants and hotel stays will become more cheap than today. For the construction sector, a CAT implies that traditional materials gain in importance: wood, sand, glass. Plastics, aluminum, construction steel and zinc would, in contrast, become rather more expensive. Price impacts on bricks and concrete would be fairly minimal. In transport, there will be a continuing drive towards low-carbon technologies and modes of transport. Electric vehicles will become considerably cheaper than conventional cars, while public transport may become a more popular form of transport.

If designed with an MRV option for individual companies, a CAT scheme can become a major driver of low-carbon technologies and practices. In the long run, companies would seek to lower their sales price to remain competitive, achieved by limiting polluting inputs and increasing the labour- and capital-intensity (the share of value added) of production. A CAT scheme would thus facilitate and drive a long-term transformation to a low-carbon economy. It would create an impetus for greater material and energy efficiency in the production of current goods and services, increase demand for less polluting alternatives and benefit products with greater value added (e.g. products with greater knowledge intensity and services) which in a VAT scheme are implicitly taxed. The main rationale for a CAT scheme is to internalise the 'hidden' costs of emissions in the price of goods and services. As a side-effect, CAT revenues could be used to reduce more distortionary taxes, such as income tax and corporate tax.

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