External Costs Charge

A policy instrument for climate change mitigation

CE Delft

Committed to the Environment

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CE Delft
Committed to the Environment

Through its independent research and consultancy work CE Delft is helping build a sustainable world. In the fields of energy, transport and resources our expertise is cutting-edge. With our wealth of know-how on technologies, policies and economic issues we support government agencies, NGOs and industries in pursuit of structural change. For 40 years now, the skills and enthusiasm of CE Delft's staff have been devoted to achieving this mission.

Contents

Foreword

The efficiency of some form of 'carbon tax' as a means of tackling the urgent problem of climate change has been widely debated, increasingly so in recent years. While several countries have introduced a limited tax, for example on fossil fuels, an across-the-board tax on the carbon embodied in all market goods and services has until now always met with objections, from government, from industry, or from other stakeholders.
Carbon emissions, climate change, environmental taxes and monetisation of environmental damage are among the issues CE Delft has been working on for several decades.
In this exploratory study we set out the contours of a form of carbon charge that we consider addresses the main objections we encounter. It is our conviction that the External Costs Charge elaborated here can serve as an effective policy instrument for reducing the climate gas emissions.

This report was drawn up by CE Delft with input from Professor Geraldo Vidigal (University of Amsterdam) for the legal aspects (Section 2.2) of the proposed charge.

With this study, published on the occasion of its 40th anniversary, CE Delft hopes to put structural policy mechanisms on the agenda that can help accelerate the so urgently needed transition to a truly sustainable economy.

In previous communication we spoke of a CAT, Carbon Added Tax, but this did not cover the entire potential of the policy instrument. We have therefore switched to the term ECC, External Costs Charge.

The following parties have contributed to the realization of this project financially and/or as a sounding board:
- DCMR
- Engie
- Gasunie
- HVC waste and energy
- LTO Glaskracht
- Nuon Vattenfall
- Port of Moerdijk
- Province of Zuid-Holland
- TenneT
- VNCI.

We thank them all for their contribution.

While this report has benefited from input from many sides, full responsibility for its context lies with CE Delft.

Frans Rooijers, Director

List of abbreviations

Term	Explanation
BTA	Border Tax Adjustment
CAP	Common Agricultural Policy
CAT	Carbon Added Tax
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CFC	Chlorofluorocarbons
CO_2	Carbon dioxide
CO_2 eq.	Carbon dioxide-equivalent
EC	European Commission
ECC	External Costs Charge
ECJ	European Court of Justice
ETS	Emissions Trading Scheme
EU	European Union
FAIR	Future Allowance Import Requirement
GATT	General Agreement on Tariffs and Trade
GHG	Greenhouse gas
GO	Guarantee of Origin
HDPE	High-density polyethylene
HFC	Hydrofluorocarbons
LCA	Life cycle assessment
LDPE	Low-density polyethylene
LULUCF	Land Use, Land Use Change and Forestry
MRV	Monitoring, Reporting and Verification
PP	Polypropylene
SCM	WTO agreement on Subsidies and Countervailing Measures
SPEF	Standard Product Environmental Footprint
TFEU	Treaty on the Functioning of the European Union
Tkm	Tonne-kilometre
VAT	Value Added Tax
WTO	World Trade Organisation

Samenvatting

De vervuiler betaalt! Ja, maar geldt dat ook bij de grootste vervuiling van dit moment, de uitstoot van broeikasgassen? Lang niet altijd…. De Vergoeding Externe Kosten (VEK) legt de lasten waar deze horen: bij de consumenten voor wie de vervuilende artikelen worden gemaakt. Zodat de wetten van de economie in stelling worden gebracht tegen de opwarming van de aarde: wie vervuilt, of wie vervuilende producten koopt, moet daarvoor een prijs betalen. In principe is dat de prijs die nodig is om de toegebrachte schade te voorkomen of te herstellen, zodat vervuilende producten duurder worden en schone producten naar verhouding goedkoper.

De VEK wordt net als BTW geheven bij de verkoop van een product. De VEK belast niet de toegevoegde waarde (zoals bij de BTW), maar de uitstoot van CO_2 en andere broeikas-gassen, en kan in principe ook andere externe kosten belasten. De VEK heeft een vaste waarde per uitgestoten ton CO_2; andere broeikasgassen worden omgerekend naar CO_2.
CE Delft heeft bij haar 40-jarig bestaan dit onderzoek uitgebracht waarin alle praktische vragen rond de VEK worden beantwoord. Zoals: Hoe hoog moet deze vergoeding zijn? Waarop moet hij precies worden geheven? Welke artikelen worden duurder en hoeveel? De VEK is een serieus voorstel voor een grondige aanpak van de broeikasgasemissies.

Maak vervuilende producten duurder

Economen zeggen vaak dat prijzen ‘signalen’ geven aan bedrijven en consumenten, zodat deze worden gestuurd naar de goedkoopste producten. Maar overheden schakelen dit mechanisme bijna nooit in voor het oplossen van maatschappelijke problemen. De VEK gaat daar verandering in brengen. Hiermee worden producten, die hoge externe kosten veroorzaken, duurder gemaakt. De hoogte van de VEK wordt bepaald op basis van een schat aan gegevens die de laatste jaren zijn verzameld over schade aangericht door de uitstoot van broeikasgassen. Dit zijn ‘externe kosten’: kosten veroorzaakt door vervuilende goederen en diensten, waarvoor de consument nu niet betaalt. Kosten, met andere woorden, die worden gedragen door anderen, of door de samenleving als geheel. Denk aan de kosten van dijkverzwaring, van misoogsten, van verwoesting door overstromingen en krachtige orkanen. De VEK gaat deze kosten ‘internaliseren’, tot uitdrukking laten komen in de prijs, zodat ze uiteindelijk worden gedragen door degenen die de schade veroorzaken.

Hoe werkt de VEK?

De VEK werkt als volgt. Bedrijven moeten bijhouden hoeveel broeikasgassen zij toevoegen in hun stap van het productieproces. Aan de hand van een vooraf bepaalde rekenmethode kunnen ze hun VEK precies berekenen. Die methode zal niet eenvoudig zijn omdat de prijs van de toegevoegde koolstof moet worden verdeeld over een veelheid van producten. Bedrijven moeten een vergoeding betalen over die koolstof, en ze kunnen, net als bij de BTW, de VEK aftrekken die ze aan hun leveranciers hebben betaald. Als een speciale administratie te veel werk is, kunnen bedrijven kiezen voor een vastgestelde vergoeding die van tevoren voor elke productgroep is bepaald. In de productieketen voegt elk bedrijf iets toe aan de VEK, en uiteindelijk wordt de volle VEK betaald door degene die het product heeft ‘besteld’, de consument. Het VEK-bedrag is hoog voor producten waarbij veel broeikasgassen zijn uitgestoten om ze te maken (zoals wasmachines: daarin zit veel staal) of die juist bij gebruik veel broeikasgassen uitstoten (zoals aardgas); en het is laag voor producten of diensten met lage uitstoot, zoals bijvoorbeeld een knipbeurt bij de kapper. Prijsverhogingen als gevolg van de VEK kunnen door de overheid worden gecompenseerd in de vorm van verlaging van belastingen of het uitbreiden van subsidies die het klimaat-probleem versneld aanpakken.

Het grote voordeel van de VEK is dat hij de internationale concurrentiepositie niet aantast. Stel dat overal in de Europese Unie een VEK wordt geheven. Maar exportproducten worden gecompenseerd, zodat de VEK de bedrijven niet schaadt in hun exportpositie; en over geïmporteerde producten van buiten de EU moet een VEK worden betaald, gelijk aan het bedrag dat bij productie binnen Europa betaald had moeten worden. Hierdoor wordt een gelijk speelveld geschapen, zodat het voor de afnemer niet meer uitmaakt of staal is gemaakt in Nederland of in Rusland. Op deze manier wordt het verplaatsen van productie naar landen met een minder streng klimaatbeleid ontmoedigd. Europese bedrijven worden niet bevoordeeld (wat overigens niet mag volgens de internationale vrijhandelsverdragen); maar ze worden ook niet benadeeld, zoals nu wel door het Europese handelssysteem voor CO_2-uitstootrechten. We kunnen zelfs hopen dat zo’n systeem nuttig werkt tot ver buiten onze grenzen, doordat bedrijven die naar Europa willen exporteren, een impuls krijgen om schoon te produceren. En de VEK zal ook Europese bedrijven stimuleren om schoner te gaan produceren, omdat zij dan een lagere VEK voor hun eindproducten hoeven te berekenen en daardoor voordeliger zijn dan vervuilendere concurrenten.

Er zijn ook nadelen

De manier van invoeren van een VEK is een verhaal op zich. De vergoeding kan bijvoorbeeld eerst op vrijwillige basis worden ingevoerd, of direct als verplicht systeem. Hij kan worden beperkt tot Nederland of voor alle EU-lidstaten worden ingevoerd. De hoogte ervan moet worden bepaald. Op de korte termijn moet men dan denken aan een hoogte van € 100 per ton CO_2; maar om de uitstoot echt terug te dringen, zodat de aarde niet verder opwarmt dan 1,5°C, is een forsere prijs nodig, misschien € 250 per ton.

Er zijn ook nadelen. Het belangrijkste nadeel is de extra administratie die van bedrijven wordt gevraagd. Ze moeten daarop ook worden gecontroleerd, om fraude te voorkomen. Hoewel: als deze administratie bezwaarlijk is, kunnen bedrijven ook worden belast volgens een standaardtarief voor hun productgroepen. Misschien is het een nadeel dat de vergoeding alleen betrekking heeft op verstoring van het klimaat, en andere belangrijke kwesties buiten beschouwing laat, zoals onttrekking van grondwater of luchtverontreiniging. In principe is het instrument daar ook geschikt voor.

Conclusies

Een VEK heeft significante voordelen ten opzichte van ander klimaatbeleid, zoals EU ETS, een CO_2-heffing of energiebelasting. Er zijn echter ook nadelen aan de VEK verbonden. Toch lijkt de VEK een serieuze optie in de transitie naar een koolstofarme toekomst, die nodig is om 'Parijs' te halen. Het instrument is uniek in de zin dat het CO_2-reductie stimuleert in de gehele productieketen, terwijl het ook de consument aanspoort om producten te kopen met de laagste CO_2-footprint.

Summary

The ‘polluter-pays principle’ is a sound and effective one, but is it being applied to the most urgent form of pollution facing mankind today, greenhouse gas emissions? In most cases the answer is no. The External Costs Charge (ECC) proposed in this report targets the ultimate polluter: the consumer for whom the polluting products are made, so that economic theory is brought to bear on global warming. Those who pollute, or buy polluting products, should pay the proper price. This means a price that includes a charge sufficient to prevent or restore the damage caused by pollution, making polluting products more expensive and greener products relatively cheaper.

Just like VAT, the proposed ECC would be charged at a product’s point of sale.
Unlike VAT, though, the ECC taxes greenhouse gas emissions rather than added value and can in principle be designed to compensate for other external costs, too. The charge would have a fixed value per tonne CO_2 equivalent. To mark the 40th anniversary of its work on the environment, CE Delft is presenting this study, which answers all the practical questions relating to the ECC. What is a suitable charge level? Where exactly should it be levied? What articles will become more expensive and by how much? The ECC is a serious proposal for comprehensively tackling the pressing problem of greenhouse gas emissions.

Make polluting products more expensive

Economists often talk about prices providing ‘signals’ to companies and consumers, steering them towards the cheapest products. Governments rarely employ this mechanism to address society’s problems, however. Introduction of an ECC would change this, making products and services with high external, ‘hidden’ costs more expensive. These so-called external costs – for things like dyke reinforcement, crop failures and the costs associated with extreme weather events like flooding and hurricanes - are not currently paid by the consumer, but by others or by society as a whole. The proposed ECC would ‘internalise’ these costs in the price of the product so they are paid by those ultimately causing the damage. The level of the charge has been calculated using information gathered in recent years on the damage caused by greenhouse gas emissions.

How would the ECC work?

The ECC would work as follows. Companies would have to keep track of the carbon emissions added in their link of the production chain, using a standardised calculation method to calculate the ECC to which they are subject. That method will not be straightforward, because the price of the added carbon will need to be allocated across the range of products the firm produces. Companies would pay a charge on the added carbon, but, as with VAT, they could reclaim any ECC paid to suppliers of inputs. Firms and organisations that consider dedicated ‘carbon accounts’ too much work could opt to pay a standard charge pre-determined for each product group. At each link in the supply chain the firm in question would add their portion of the ECC, with the aggregate sum ultimately paid by the party ‘ordering’ the product: the final consumer. The ECC would be high for products created in a production chain associated with high carbon emissions (like washing machines, containing a lot of steel) or products with high emissions in the use phase (like domestic gas) and low for goods and services with a low carbon footprint (like a visit to the

hairdressers). The government could opt to compensate consumers for these price rises by lowering other taxes or by increasing subsidies on 'decarbonisation' measures.

The great advantage of the ECC is that it leaves international competitiveness unaffected. Imagine the charge were levied in all EU member states. By allowing companies to reclaim the ECC on products exported from the EU and levying the same CEC on products imported to the EU as would have been paid by domestic producers, a level playing field is maintained, leaving competitiveness unchanged. For buyers of steel, for example, it would make no difference whether the steel was produced in the Netherlands or in Russia. Importantly, this means there would be no incentive for firms to transfer production to countries with laxer climate policies. At the same time, European companies would not be given preferential treatment (which is prohibited by international trade agreements), but nor would they be disadvantaged, as they are under the current EU Emissions Trading Scheme. Indeed, we can even hope an ECC would have an impact far beyond Europe's borders, encouraging companies exporting to Europe, or intending to do so, to decarbonise their production processes. An ECC would also incentivise European firms to clean up their act, so they can reduce the charge included in the price of their products and gain an edge over more polluting competitors.

Drawbacks, too

How precisely the ECC would be implemented is an issue in its own right. The charge could initially be introduced on a voluntary basis, for example. Alternatively, it could be immediately implemented as a mandatory measure. It could be rolled out in the Netherlands, or across the EU. The precise level is obviously an issue for discussion. In the short term a charge of € 100 per metric ton CO_2 equivalent would seem realistic. To achieve the robust emission cuts required to keep global warming below 1.5°C a higher level of around € 250 per tonne will be needed, however.

There are also drawbacks, the main one being the additional administrative burden on companies, whose 'carbon accounts' would need to be checked and verified to reduce the scope for fraud. As suggested above, though, firms and organisations deeming this an excessive burden could opt to be charged according to a standardised ECC for their particular product or product group.

It might also be considered a disadvantage that the scope of the charge is limited solely to greenhouse gas emissions, ignoring other key issues like freshwater scarcity or local air pollution. In principle, though, an ECC-type instrument could be used to tackle these externalities, too.

Conclusions

The ECC proposed here has significant advantages over other climate policy instruments like the EU ETS, a carbon tax or an energy tax. It has its drawbacks, too, however. On balance, though, the ECC appears to be a serious contender as a policy instrument for leveraging the transition to the low-carbon future necessitated by the goals of the Paris Agreement.
Its defining and unique characteristic is that it incentivises carbon emissions reduction all the way down the production chain, at the same time encouraging consumers to buy products with the lowest carbon footprint.

1 Introduction

1.1 Background

Under the Paris Climate Agreement 179 countries[1] have pledged to limit the global temperature rise due to anthropogenic climate change to 2°C, while aiming for 1.5°C. This agreement poses an enormous challenge to societies around the world to drastically limit their carbon emissions within a short period of time.

In terms of the speed of transformation and the investment challenge, there are few examples in recent history that can rival the efforts needed to comply with the Paris Agreement. The size of these investments, relative to GDP, and the rate at which they need to be made go beyond the sums involved in the cold-war arms race or the investments in flood protection and water management made in the Netherlands since 1953 (CE Delft, 2016). In its magnitude as well as its implications, the transition to a low-carbon world can probably best be compared to the transition of Central and Eastern European countries to a market economy between 1990 and 2010. That transformation implied a drastic technological change in in which 'obsolete' technologies in every field (industrial plant, power generation, transport vehicles, infrastructure) were replaced by 'new', modern counterparts. Likewise, the low-carbon transition implies that the majority of current technologies will have to be labelled 'obsolete' and replaced by up-to-date solutions.

The transformation in Central and Eastern Europe was accompanied by a rapid devaluation of local currencies, contributing to a rapid depreciation of existing assets and establishing attractive business cases for investors to step in. To be successful, the low-carbon transformation will have to develop similar mechanisms to render existing assets unprofitable and create scope for new technologies to take their place. Many years of experience and analysis have convinced us that pricing carbon emissions is the most efficient way to achieve the desired effects on value creation. An explicit or implicit carbon price in every corner of society will reduce the profitability of existing fossil fuel assets and increase the economic value of new low-carbon investments.

Carbon prices will have to increase rapidly to provide sufficient incentives for divestment from fossil fuel assets and make technologies on the right side of the marginal abatement curve attractive (CE Delft, 2016). Given the UNFCCC concept of 'common but differentiated responsibilities', moreover, carbon prices are expected to develop unevenly around the world, differing from region to region.

In a world of uneven carbon prices, high carbon prices tend to have a detrimental impact on industrial competitiveness. The main challenge from an industry perspective is thus how to limit the impact of climate change policy on competitiveness in international markets. One possible solution to this challenge is for the final consumer of the product or service to pay the price rather than industry. This is the route pursued with the proposed External Costs Charge (ECC).

[1] The number of countries that are parties to the agreement through ratification, acceptance, approval or accession as of 23 August, 2018.

The present document considers whether or not an ECC can be feasibly implemented, and if so in what form, taking into account all the considerations that may be brought up by stakeholders.

1.2 External Costs Charge: An Introduction

Climate change has been called the greatest market failure the world has ever seen (Stern, 2006). Economic theory tells us there are numerous ways in which market failures can be corrected. Examples used in climate policy are cap-and-trade systems (e.g. the EU Emissions Trading Scheme (ETS)) and taxation, provided that companies pass on the costs of emission abatement in their prices. With the EU ETS (see Textbox 1) having proved less effective than initially planned or hoped for, owing to amendments to protect European industry, taxation may be a realistic solution. In the environmental context, taxation is a policy targeted at producers that translates to a price adjustment at the consumer level, resulting in potential behavioural change.

Pure economics dictates that the optimal and most efficient solution to market failures can be achieved by taxing the source generating the externality, in this case carbon, making a single, uniform carbon tax a potential solution. However, a worldwide uniform tax on GHG emissions is unfeasible from an equity perspective because of differences in income levels and climate change impacts across the globe. The UNFCCC recognises 'common but differentiated responsibilities', hampering the scope for a uniform global carbon tax. A non-uniform tax has the major drawback, however that it leads to inefficiencies between markets. With a pure carbon tax, then, economic efficiency and social equity are at fundamental odds with one another (CE Delft, 2015) and a simple carbon tax is to be deemed unfeasible.

Textbox 1 - The EU Emissions Trading Scheme

The EU ETS is the cornerstone of the EU's climate policies. At the time of its implementation in 2005, it was the world's first carbon trading scheme. The scheme currently operates in the EU28 as well as Iceland, Liechtenstein and Norway and includes all stationary installations in the EU above a minimum capacity threshold as well as aviation. About 45% of the EU's GHG emissions are covered by the EU ETS. Under the scheme, emissions from the sectors covered are projected to be 21% lower in 2020 than in 2005 and 43% lower in 2030. The EU ETS is divided into trading periods called phases and is currently in its third phase (2013-2020). Each phase has come with significant changes compared to the previous one, such as the inclusion of new sectors, a gradual shift from free allocation to auctioning of permits and a switch from national caps to a single EU-wide cap.

In general, the EU ETS has had both supporters and critics. While supporters hail the emission reductions achieved, critics argue that these reductions have occurred mainly because of the economic crisis and the major expansion of renewable energy due to the Renewable Energy Directive, not as a result of the ETS. They also point at the fact that carbon prices have remained too low to create an incentive for innovative low-carbon technologies. With the start of Phase 4 in 2021, interesting times regarding the development and potential of the ETS to remain the EU's 'silver bullet' in climate policy are approaching.

An ECC may provide a realistic solution, as it leads to the carbon embodied in products being 'offset'. The CEC thus differs from the traditional approach to carbon pricing in the sense that it is not the carbon released during production that is taxed (as in the ETS or traditional carbon taxes in place in the UK or Sweden), but rather the carbon embodied in the products. It was first proposed in the literature as a Carbon Added Tax by Courchene (2008) and a small number of authors (e.g. (CE Delft, 2015)) have since examined it further. The idea has not gained any real traction, however. This study looks at the theoretical implementation and functioning of an ECC in the EU and endeavours to answer the main questions likely to be posed by stakeholders.

The ECC is designed similarly to the Value Added Tax (VAT), but instead of taxing the value (the sum of salaries and profits) the ECC tracks the carbon content of the product. Every company would be required to keep carbon accounts, so the carbon added can be calculated at each step of production. Companies will only end up 'offsetting' the carbon added in their link in the production chain. At the end of the chain, it will be the consumer who pays the full carbon costs of a product over its entire production cycle. At the same time, each manufacturer in the production process will have an incentive to reduce their own carbon emissions. This sets the ECC apart from other climate measures such as subsidies.

Various forms of the ECC can be envisaged, from a full ECC analogous to VAT to an ECC serving mainly as a conveyor of information. In some countries, such as the UK, similar information-based instruments have been in place in the past. For instance, the UK's leading supermarket chain Tesco has footprinted over 1,100 of its own brand products (Tesco, 2012). This in turn triggered leading brands such as PepsiCo to also display a carbon reduction label on certain products showing the amount of CO_2 equivalents (CO_2 eq.) emitted in the growing, packaging and transportation of the food. Tesco started the labelling in 2008, but discontinued it in 2012, claiming the programme was too expensive and time-consuming. The ECC described in this report aims to take such information-based instruments further by actually charging for GHG emissions, making products with a higher CO_2 eq. intensity more expensive than those with a lower CO_2 eq. intensity, ceteris paribus.

It is important to note that the ECC in this form is designed only to solve one of the environmental problems the world currently faces: GHG emissions. There are a range of other environmental problems like local air pollution and freshwater scarcity that may also be amenable to this approach, however. In principle, this policy tool could be designed such that it incorporates *all* the negative externalities originating from production of a particular product or service, being expanded to solve other environmental problems, too. For the time being, though, we focus on the ECC as a climate policy instrument, as this is the most pressing problem facing us today.

1.3 Research method

For a successful transition to a low-carbon future an incentive is needed to reduce carbon emissions all the way down manufacturing and supply chains, as well as an incentive for the final consumer to opt for products with the lowest carbon footprint. The aim of this report is to establish whether or not an ECC could be an instrument that achieves those goals.

This report is an initial scoping document exploring the advantages and disadvantages of an ECC over other instruments and identifying key design features. Specifically, we aim to answer the following questions:
- What are the legal possibilities and limitations of an ECC?
- How can the practical aspects of an ECC best be designed to make the measure as effective as possible? This relates to issues like a monitoring agency, standard product environmental footprints (SPEF) and rules for exported/imported products.
- What impact would an ECC have on the price of selected consumer products and services?
- What are the strengths and weaknesses of an ECC compared with other climate policies?

Our hypothesis is that an ECC is a powerful instrument compared with other climate change policies, one that incentivises reductions in the carbon footprint of products while complying with the polluter-pays principle. This gives the ECC an advantage over many other climate policies like subsidies, which require government funding. The instrument is self-financing and therefore unlikely to meet with much resistance from industry, especially as it is expected to create a level playing field for European industry (and thus limit carbon leakage). This is likely to give an ECC an edge over alternative climate policies.

To answer the questions outlined above we have adopted a broad and varied approach, consisting of an extensive literature review, interviews with industry and government, stakeholder sessions and case study analysis. The resultant answers are reported in the following chapters.

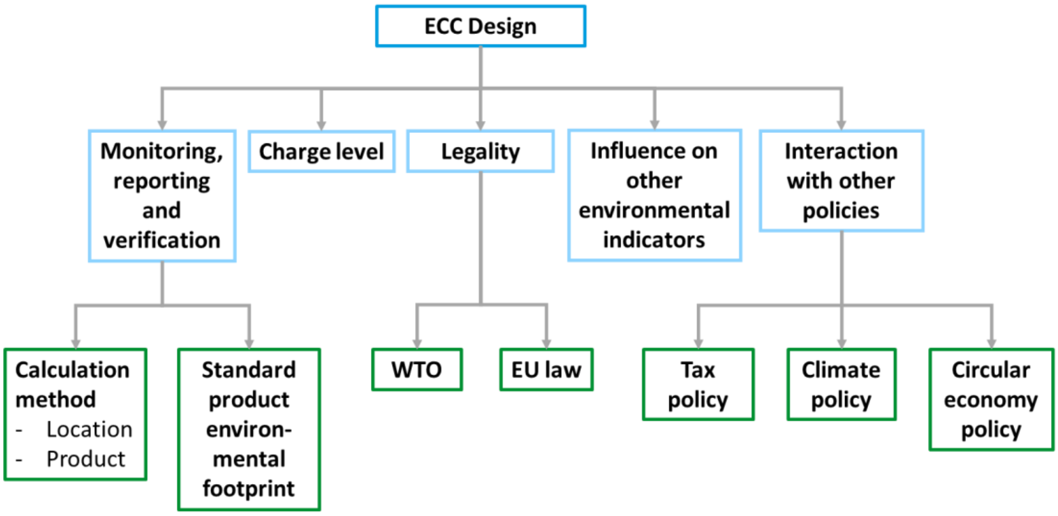
1.4 Reading this discussion document

The remainder of this document is structured as follows. In Chapter 2 we discuss the critical design aspects of an ECC, such as legal compliance with EU law and WTO rules, whether a SPEF per product should be set and, if so, at what level, and the outline of the monitoring, reporting and verification (MRV) process. In Chapter 3 we explore the concrete effects of an ECC on standard consumer products and services with reference to three case studies: a 500 gram pack of tomatoes, a plastic (HDPE) product like a playground slide and a travel ticket from Amsterdam to Berlin. Conclusions and lessons from these case studies about the potential impact of an ECC are also presented in Chapter 3. A detailed comparison of an ECC with other policy instruments is made in Chapter 4, while in Chapter 5 various implementation strategies are considered. Finally, our main conclusions are presented in Chapter 6.

2 Design of an ECC

The practical effectiveness of an External Costs Charge depends on a number of crucial design aspects. For each of these aspects this chapter looks into the various choices available and which of these appear most logical. Before delving into these aspects, first, in Section 2.1, we discuss the different possible ECC variants.

Figure 1 - Crucial design aspects of an ECC



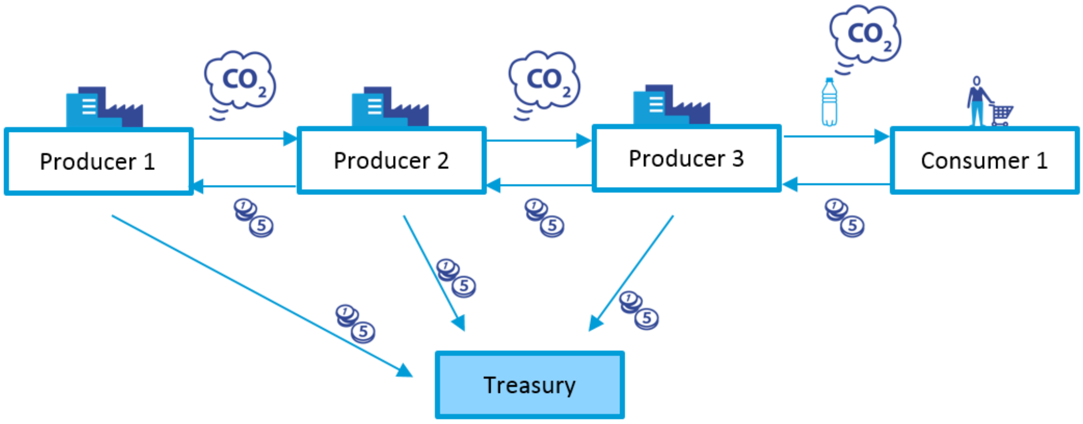
2.1 ECC variants

Multiple variants of the ECC can be envisioned, two of which are considered in detail below.

In the first variant a charge is levied on all the carbon emissions occurring in each respective production stage, which would require every company to keep carbon accounts. This would be largely analogous to today's Value Added Tax (VAT)[2] but rather than being based on the value added (the sum of salaries and profits) at each step of production it would be based on the additional amount of carbon embedded. As the product moves along the production chain, the ECC levied in earlier production stages is rebated, so that only the carbon added at that particular stage is taxed (Courchene, 2008).When the product reaches the final stage – consumer purchase – all the carbon added, i.e. embedded in the product, will therefore have been charged for. This means that each company acts as a charge collector for the Treasury, implying a fairly substantial administrative burden. This variant of the ECC is shown schematically in Figure 2.

[2] The basic functioning of VAT and associated Border Tax Adjustments is explained in Textbox 3.

Figure 2 - Functioning of the ECC with every company acting as a charge collector



In this variant each company is required to keep carbon accounts, so the added carbon can be calculated at each step of production and distribution. In an increasingly globalised world it is important that the ECC also includes the CO_2 emissions associated with transport, whether of raw materials or intermediate products between producers, or to point of sale or home delivery in the case of final consumers. In addition, all the other CO_2 emissions not directly production-related (e.g. emissions from commuter traffic, office electricity and heating) will also need to be included. Companies will only be paying a charge for the carbon added in their particular link in the production chain, with the final consumer paying the full carbon costs of a product over its entire production cycle. At the same time, each manufacturer in the production process will have an incentive to reduce their own carbon emissions. This sets the ECC apart from other climate measures such as subsidies.

Textbox 2 - Worked example of ECC with each company acting as a charge collector

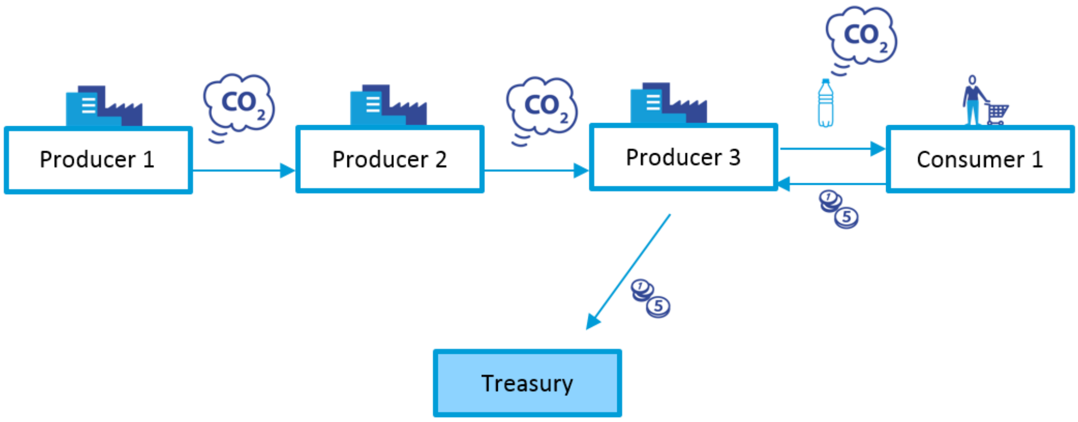
The functioning of the ECC is best explained using a worked example. Consider car manufacture, with a production chain starting with a steel producer selling steel to a car-part manufacturer. The steel producer charges the ECC based on the CO_2 emissions emitted in the steel production process and transport of the steel to the car-part manufacturer. The ECC charged to the car-part manufacturer is therefore based on the carbon footprint of the product up to this stage of production, including transport. The car-part manufacturer then pays the CEC to the steel producer, who passes it on to the government.

The car-part manufacturer then uses the steel to make car doors, for example, which are then sold to the car manufacturer. The car-part manufacturer charges the car manufacturer ECC on the full carbon footprint of the product. This includes the carbon added in his link of the production chain, but also that embedded in previous production stages. Note, however, that he has already paid ECC to the steel manufacturer. It is therefore only the difference between the ECC he charges the car manufacturer and the ECC he paid the steel manufacturer that is passed on to the government.

The car manufacturer then uses the car doors to build the full car and sells the car to the final consumer, who pays the manufacturer ECC on the vehicle's full carbon footprint. As the car manufacturer has already paid ECC on the carbon footprint of his inputs, it is only the ECC on the carbon added in this final step that the car manufacturer pays to the government. If the final customer is a company buying a company car, the company can deduct the ECC paid.

The second variant of the ECC is similar to the first, but with less of an administrative burden on manufacturers and government. In this variant it is only the producer selling to the final consumer who collects the charge, which he then passes on to the government. While all the upstream producers are still required to keep carbon accounts and pass on information on a product's carbon content to the next producer, they no longer act as charge collectors for the Treasury. This variant of the ECC is illustrated schematically in Figure 3.

Figure 3 - Functioning of the ECC with only the final producer acting as a charge collector



As stated, the aim of the ECC is twofold: to encourage consumers to buy less carbon-intensive products and producers to reduce the footprint of their manufacturing process. As corporate procurement departments tend to be significantly more sensitive to prices than consumers, the first of these variants, in which carbon-content data and charges are explicit all the way down the production chain, is likely to be more effective.

2.2 Legal conformity

One key question is obviously whether an ECC can be legally implemented understanding European law as well as in terms of compliance with WTO agreements. The former may affect the geographical scope for implementation (e.g. the Netherlands versus the EU), while the latter may be of influence on the potential for setting SPEFs for specific products and services and applying associated border tax adjustments (BTA). European law is discussed in Section 2.2.1, WTO agreements in Section 2.2.2.

2.2.1 European law

While the EU does not itself impose taxes or charges, Member States are free to adopt their own measures (for e.g. environmental protection), including tax measures, until there is harmonisation at the EU level. However, any taxes or measures introduced by a Member State must be compliant with relevant articles in the Treaty on the Functioning of the EU (TFEU), which specifies that no Member State may use taxation to give preferential treatment to domestic products over products produced by other Member States (Article 110) and set limits on BTAs (Articles 111 and 112). Furthermore, such taxes may not create bureaucratic barriers for the free movement of goods within the EU and must be based on objective criteria that conform to the objectives of the EU, one of which is the sustainable development of Europe.

The European Court of Justice (ECJ) has decreed that taxes designed to incentivise a specific behaviour are permitted. For instance, the ECJ has adjudicated that electricity may be taxed differently depending on how it is produced and the feedstocks used in its generation, as long as the underlying differentiation is (i) based on environmental considerations, and (ii) does not lead to discrimination that prejudices production in other EU Member States. However, a tax measure will be deemed illegitimate if foreign production is subject not to the domestic carbon-based tax but to a flat tax rate that exceeds the lowest rate applied to domestically produced electricity. This implies that foreign producers must be given the same opportunities to prove the carbon content of their products as domestic producers.

In theory, an ECC could be implemented at the level of an individual Member State.
For instance, under Article 104 of the Netherlands' Constitution, taxation is an issue for the Dutch Parliament, which is free to institute new taxes provided other (Dutch and EU) rules are followed. The main consideration when it comes to national roll-out of an ECC, then, is to ensure it does not discriminate against products produced in other Member States.

Similarly, a group of countries within the EU would be free to introduce an ECC as long as it complies with EU and domestic law. What is not permissible is to roll out a charge that results in discrimination against Member States that have not joined in with the effort.

2.2.2 WTO agreements

The legislation underpinning an ECC and its BTAs must comply with WTO rules, specifically the General Agreement on Tariffs and Trade (GATT). Currently, the VAT in place in the EU and many other countries as well as the sales tax in places like the US encompass BTAs. These BTAs have not been deemed to contravene WTO rules. An ECC analogous to current VAT should therefore also be in line with those rules.

The main principle of the WTO is non-discrimination, which can be summarised as follows. if one country rewards another country with a trade benefit, then similar benefits must be awarded to all other Member States (Article I, GATT). Similarly, it may not discriminate between its own and "*like*", i.e. 'equivalent', foreign products (Article III, GATT).
The major exception to this principle is the special and differential treatment of developing countries, which developed countries may treat more favourably than other WTO members, but not less favourably. There is no definition of *like* products, rather 'likeness' must be assessed on a case-by-case basis.

Currently, BTAs are permitted under WTO rules on "indirect" taxes, which are defined as "sales, excise, turnover, value added, franchise, stamp, transfer, inventory and equipment taxes, border taxes and all taxes other than direct taxes and import charges" in the WTO Agreement on Subsidies and Countervailing Measures (SCM). An ECC would fall under" all taxes other than direct taxes and import charges" and seems to be in line with WTO rules on this front. However, the border adjustment on exports may not exceed the amount of tax levied on those goods (Article 3.1, SCM).

In general, an ECC is likely to run up against the special and differential treatment clause that is relevant for developing countries in the WTO, as their production methods tend to be more carbon-intensive (CE Delft, 2015). Furthermore, jurisprudence on *like* products has revealed that a good's production method is insufficient reason to render the good different (CE Delft, 2015). A key example of this was provided by the Tuna-Dolphin GATT case, where the US banned tuna imports from Mexico because the tuna-catching method resulted in excessive dolphin bycatch. The ruling favoured Mexico, supporting the notion that the production process is irrelevant if the product is the same. Unfortunately, the ECC proposed in the present document does precisely this, treating products differently according to their mode of production. It rewards producers using cleaner means to manufacture a product, penalising those employing dirtier technologies. An earlier CE Delft study revealed that sustainably and unsustainably produced wood are classified as *like* products under WTO legislation (CE Delft, 2009). The ECC would imply differential treatment of all products based on the carbon intensity of their production method. Following (CE Delft, 2009) it seems probable that these products would still be classified as *like*, implying that the ECC could only satisfy WTO principles if it can be deemed eligible as an exception to the general GATT rules.

Applying for exception under the GATT rules is particularly relevant if a non-discriminatory tax, accompanied by the BTAs outlined below, can be seen as discriminating *de facto* against imports or functions in such a way as to afford protection. Three issues are relevant in this regard: (i) the costs of complying with the taxation, in terms of the evidence that must be provided, may work to the disadvantage of imported products; (ii) an ECC that applies to the carbon emissions associated with transportation can be characterised as a tax that acts to afford protection to domestic products, given that it is likely to increase the prices of imports more than those of domestic products, and (iii) developing countries may argue that their energy matrix is dirtier than that of developed countries owing to their developing country status, meaning that the CEC discriminates in practice against their products.

Article XX of GATT details ten possible exceptions to the general GATT rules, of which the following are the most relevant for an ECC:
- Article XX (b): "Where they are deemed necessary to protect human, animal or plant life or health."
- Article XX (g): "Relating to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption."

Under the first of these articles, the measure concerned must be deemed necessary, and not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. With respect to the second, there is ample scope for understanding the global climate to be an exhaustible natural resource, which in principle allows WTO members to act to protect it, as long as the measure restricts both foreign and domestic production in equal measure. Arguably, in light of the Paris Agreement, imposing an ECC could be deemed necessary to protect human, animal and plant life, as well as to conserve natural resources, i.e. the earth as we know it. It is therefore well conceivable that such a charge would qualify as an exception to GATT, also because not taking climate action, or a decision to litigate against countries that do so, imposes higher costs (in the form of the impacts of higher global carbon emissions) on countries and producers, which also goes against the grain of GATT. In general, an analysis of WTO cases reveals that it appears that instances where exceptions were classified as relating to human health (e.g. the EC-Asbestos case) are more likely to successfully pass the WTO rules than those relating to animal health or the environment (e.g. US-Tuna I and II, or the US-Shrimp case). The key question to be answered, though, will be whether, and to what extent, an ECC putting imported products at a competitive disadvantage is rationally related to the objective of conserving exhaustible natural resources.

Taking a historical view, there are no 'winners' or 'losers' in a classic sense in cases where Article XX of the GATT has been invoked. It is often the case that a measure is found to be legitimate in its motives but discriminatory in its application. In these cases the 'losing' party must choose between eliminating the discrimination by removing restrictions on previously disadvantaged products, and eliminating it by imposing *more* restrictions on previously favoured products. Therefore, compliance may end up increasing rather than decreasing the extent to which the measure fulfils the objective that justifies it.

There are two Article XX cases that were 'won' by respondents: EC-Asbestos and US-Shrimp. In EC-Asbestos the Appellate Body found that the EU prohibition on asbestos was justified as a means of protecting human health and was applied in a non-discriminatory manner. In US-Shrimp, the US measure to protect turtles during shrimp trawling was initially found to be justifiable in its objective, but applied discriminatorily. The US had (i) failed to negotiate the implementation of the measure with affected WTO Members, and (ii) required shrimp trawlers in other Member nations to essentially adopt the same mechanism for turtle protection as those imposed on US trawlers. To comply, the US (i) engaged in negotiations with affected WTO Members to find a multilateral solution, and (ii) changed the requirement imposed on imported products. Rather than being required to trawl using essentially the same equipment as imposed on US trawlers, foreign producers could catch shrimp using any technique that was "comparable in effectiveness" to the mechanism imposed on US producers in terms of preventing turtle catch. By implementing these two changes, the US measure was found to be compatible with WTO rules.

In any case, it would be wise for WTO members adopting an ECC to pursue cooperative arrangements with exporting WTO members and make efforts to allow their producers to comply with ECC that are of comparable magnitude to the efforts they make to allow domestic producers to comply. Countries adopting an ECC should also take into account the different conditions prevailing in different WTO Member nations, including the fact that producers in developing countries may have reduced access to clean energy while also having greater difficulty complying with bureaucratic and certification requirements than those in developed countries. Lastly, although WTO rules do not prohibit other states raising taxes on events taking place within their own jurisdiction, it runs against the principle of territorial jurisdiction common in international law. To avoid aggravation, the ECC should allow producers from Member countries that have their own carbon payment system that is functionally equivalent to a EU ECC to not pay a second time for the same emissions.

The BTA accompanying the ECC will be crucial in determining whether the ECC can avoid being challenged under the terms of WTO agreements. Under GATT rules, duties can be collected at the border to match duties imposed domestically, as long as the duties are not: (i) in excess of internal taxes or charges applied, directly or indirectly, to like products; or (ii) applied so as to afford protection to domestic production. In short, BTAs can act as equalisation measures, as imported *like* goods should be afforded fair and similar treatment to domestic products. Therefore, imported products should not be taxed in excess of domestic rates, even if they have a larger carbon content (Monjon & Quirion, 2011; Sakai & Barrett, 2016). This implies that the BTA should give imported products both the opportunities enjoyed by domestic products, i.e. a choice between demonstrating the embodied carbon in their product and paying the SPEF laid down for that product. If the BTA meant that all imported products were charged according to the SPEF, this would imply foreign products being treated differently from domestic ones, as they were not offered a choice. Similarly, if the BTA were set higher (lower) than the SPEF in force for domestic producers, this would imply that foreign producers are treated less (more) favourably than domestic ones, which goes against Article III of GATT. Determining the appropriate level of each SPEF, i.e. setting it equivalent to the emissions of the cleanest/dirtiest/average domestic producer, is therefore an extremely important element of any ECC scheme.

2.3 Geographical and sectoral scope

If an ECC is indeed legally feasible, the question of scope remains. The second issue we look into is therefore the different choices that can be made with regard to the scope of an ECC, differentiating between geographical scope and the sectors/industries to which it applies. For each, we set out the arguments for and against the various options.

Geographical scope

Based on Section 2.2.1 we conclude that an ECC, if suitably designed, could be implemented in compliance with EU law as well as under Dutch national law. Because the Dutch market is much smaller than the EU market, and given that the aim is to trigger the greatest impact, the scope chosen to illustrate the ECC in this document is implementation across the EU. This does not mean the policy instrument could not be implemented at a national level, though, and the instrument could be initially tested on a smaller scale.

Sectoral scope

An ECC could be simultaneously implemented for all industries, it could be implemented first in just a few, with comprehensive roll-out later, or it could be structurally restricted to specific industries or sectors, similarly to the EU ETS.

Although ideally it would be preferable to include all carbon-emitting activities in an ECC, this may not always be the possible because of existing exemptions. Such is the case for aviation, for instance. Currently, the kerosene used on international flights is exempt from taxes and excise duty. In the EU this was determined in the Energy Taxation Directive, although countries may agree bilaterally to cancel this exemption. For flights to and from non-EEA member states, the tax and excise duty exemption for kerosene is determined in their bilateral air service agreements. Taxing aviation CO_2 emissions is complicated, because of an old ruling from the European Court of Justice stating that as there is a direct link between CO_2 and kerosene, a tax on carbon is in essence a tax on kerosene. As kerosene is exempted from taxes and excise duties under the Energy Taxation Directive, it would at present be unfeasible for an ECC to encompass aviation emissions. These considerations do not apply to the EU Emissions Trading Scheme, since this is not a tax, so the tax exemptions holding for kerosene do not apply.

Besides aviation, there appear to be no other sectors that could, on principle, not be included in the ECC. In this document we shall therefore refer largely to the broadest scope possible, which means including all sectors/industries apart from aviation.

2.4 Standard product environmental footprint

Firms and organisations that prefer not to introduce their own carbon accounts for the purposes of Monitoring, Reporting and Verification (MRV) would be allowed to book their carbon emissions using a standard product environmental footprint (SPEF). Foreign companies manufacturing outside the EU but marketing their products within it will automatically be subject to an ECC as defined by the SPEF. However, to avoid unfair competition (see Section 2.2.2), the possibility of conforming to the terms of the ECC using a dedicated MRV system would have to be opened up to foreign producers as well. For alignment with WTO agreements, the same choice between the SPEF and MRV route would have to be available to EU- and foreign-based companies alike.

When it comes to the SPEF itself, there are two main aspects on which choices need to be made:
- How many SPEFs should be developed, i.e. to what level of detail?
- What should the SPEFs be based on: EU production with a low, medium or high carbon footprint?

For both aspects we consider the options in more detail.

Level of detail of SPEFs

Setting SPEFs for all the products on the market will be a laborious task for the ECC authority. One option is to base them on the benchmarking system established for the EU ETS. Alternatively, life cycle assessment (LCA) data can be used to extend the list of SPEFs to rather more products. The amount of work to be put into these efforts depends on the desired level of detail. The SPEFs would then be multiplied by a standard factor to yield the ECC to which the product or product group is subject. Companies with an MRV scheme in place would be eligible for a lower ECC, if the emission intensity of their product was demonstrably lower than specified by the SPEF.

As the legal analysis of Section 2.2.2 reveals, for the ECC to be permissible under WTO rules one and the same SPEF must hold for foreign and domestic producers alike. In this respect, the value of the SPEF (see next paragraph) does not matter, as long as the charge calculated from it does not constitute an *arbitrary* or *unjustifiable* discrimination.
A benchmark level agreed to through political or economic haggling is not a criterion against which the measure needs to be judged. In the WTO context the sole criterion is that it has no discriminatory effects that cannot be justified on the basis of its rationale and must not constitute a disguised restriction on international trade. Nonetheless, in drawing up a list of SPEFs due care needs to be taken that they in no way only affect foreign producers.

Basis for SPEFs

There are three main options for setting SPEFs for individual products. They can be based on the emissions level of the average producer, the dirtiest producer or the cleanest producer.

If the SPEF, and consequently ECC, were based on the **cleanest production** mode, virtually every company would be at a competitive disadvantage compared to the cleanest if they had a dedicated MRV system in place, and almost no company would be incentivised to do so. Furthermore, government revenue from the ECC would be very low if the cleanest mode of production were adopted for the SPEF.

If the SPEF were set at the emission level of the **average** production mode it can be argued that the dirtier producers would have no incentive to clean up their production methods, unless this reduces their emissions to below the SPEF level, in which case they would want to set up an MRV system. Companies already manufacturing their products in a cleaner fashion than the SPEF would already be incentivised to have their own MRV system in place to demonstrate this and be subject to a lower ECC. Companies with relatively carbon-intensive production methods are at a competitive disadvantage compared with cleaner producers, as is indeed intended.

If the SPEF were set at the level of the **most-carbon intensive production**, the vast majority of companies will be induced to set up their own MRV system so they are eligible for a lower ECC on their product. Compared with the dirtiest producers, just about every company will then have a competitive advantage. As non-EU producers may be using dirtier technologies than those within the EU, it can be argued that setting the SPEF at the level of the dirtiest producers discriminates against foreign producers.

Table 1 summarises the arguments for and against the three different ways of setting SPEFs.

Table 1 - SPEF options

Basis for SPEF	Arguments for	Arguments against
Lowest carbon footprint	– Low administrative burden	– No incentive for own MRV system – Low tax revenue from ECC
Average carbon footprint	– Incentive for cleaner companies to adopt own MRV system	– No incentive for dirtier producers to adopt own MRV system
Highest carbon footprint	– High incentive for own MRV system – Maximum tax revenue from ECC	– High administrative burden

In this exploratory study we have opted to base SPEFs on the dirtiest 10% of EU producers. This choice was motivated by there being no legislation determining what level is legally permissible and this low level being unlikely to discriminate against foreign producers. At the same time, acting on this level is likely to achieve maximum behavioural change at the company level and comply with an MRV scheme.

2.5 Monitoring, reporting and verification

Without a secure MRV procedure in place, an ECC is doomed to fail. Such procedures, instated at the individual company level, must have two main components, which will need to be integrated if the first ECC variant is chosen (modelled after VAT) (CE Delft, 2015):
1. MRV of ECC flows received from product sales and ECC paid to suppliers of inputs in the case of an ECC analogous to VAT.
2. MRV of direct CO_2 emissions added to the overall production process, including emissions from fuel use and other direct emissions. These carbon accounts will be used to calculate the total CO_2 eq. emissions per product.

To some extent, both these components already exist. In the first place, every enterprise is currently required to maintain an accounting system for VAT flows, which could be readily supplemented by a parallel system for flows of ECC. In addition, all companies currently falling under the EU ETS are required to monitor, report and verify their direct CO_2 emissions, which means it is only companies presently excluded from the ETS that will need to start doing so. At most companies these two MRV components are usually the responsibility of different departments. With introduction of an ECC these will need to be integrated.

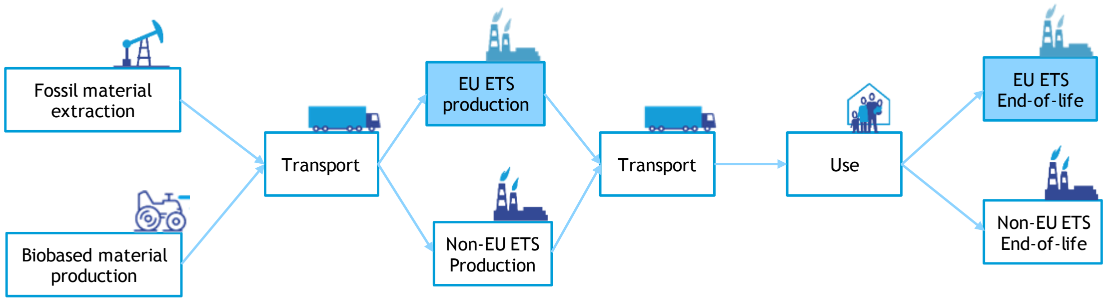
Below we describe the various options available for the three component elements of monitoring (Section 2.5.1), reporting (Section 2.5.2) and verifying and settling the charge (Section 2.5.3).

2.5.1 Monitoring: Calculation method

Two aspects will need monitoring: (a) flows of ECC received from product sales and ECC paid to suppliers of inputs or the CO_2 eq. of these inputs, and (b) the CO_2 eq. emissions added by the own company to the overall production process. The first element is essentially an addition to existing VAT accounts and therefore requires no further discussion. The second is completely new, however, and deserves further explanation.

A robust emission calculation method will need to be developed that consists, first, of **emission calculation** and, second, of **allocation of those emissions over different products/services**. It will need to be developed in such a way that companies can calculate their emissions for their entire operations, since not all emissions are covered by the EU ETS. The following figure shows which life cycle steps are included under the ETS (highlighted in blue) and for which additional calculation methods will need to be developed.

Figure 4 - Life cycle steps falling under EU ETS calculation rules (blue) and other steps (white)



Emissions from non-ETS production can be covered in the same way as those from ETS production. The main calculation method is reasonably straightforward and will need to consist of calculations based on Scope 1 emissions as defined in the GHG protocol. This means both direct emissions from fuel use (which can be calculated from fuel input) and process emissions (relevant, for example, in the cement industry). These need no further discussion. The main issue here is how the emissions are to be allocated across different products/services, which can be broken down into two parts:

1. Allocation of carbon added in the production process and ECC on inputs.
2. Allocation of carbon embedded in infrastructure and machinery.

Delving deeper into the calculation method, we further consider the following aspects:
1. Biobased materials production: direct emissions and LULUCF emissions.
2. Taxation of carbon content of fossil feedstocks (as extracted) versus end-of-life carbon emissions (whether emitted under EU ETS or other end-of-life).
3. Taxation of use-phase emissions.
4. Tracking renewable and fossil-based energy throughout the supply chain.
5. Tracking biobased and fossil-based content throughout the supply chain.
6. Carbon capture and utilisation: CCS, CCU and biological carbon sequestration.

Aspect 1. Allocation of carbon added in the production process and ECC on inputs

The ECC paid on production inputs and the carbon emissions added during the production process will need to be allocated across the various items produced. There are two possibilities: economic allocation and physical allocation, which are now briefly described.

With **economic allocation,** emissions are allocated according to the revenue generated by the different products/services sold. This means that if 95% of a steel manufacturer's revenue is from sales of steel and 5% from sales of bottom ash for use in cement production, the carbon footprint is divided accordingly.

With this allocation method it is important to note the following:
- It is especially useful for industries where the relative revenue per product group does not differ significantly from year to year. If this does differ significantly, allocation will likewise fluctuate annually.
- It would pan out most fairly if product differentiation were 'high-resolution'. For companies marketing a multitude of products this will be a laborious process, however.

In the case of **physical allocation,** emissions are allocated based on weight or another physical relationship such as MJ energy delivered. This means that if 75% of the weight of the products from a wheat mill are flour, 75% of the carbon footprint will likewise be allocated to this product.

This allocation method is especially suited to industries where the relative value of the various products sold fluctuates significantly from year to year.

This means there are three basic options: economic allocation for all industries, physical allocation for all industries, or a different allocation method per industry depending on its specific characteristics.

Aspect 2. Allocation of carbon embedded in machinery and infrastructure

The carbon emissions embedded in machinery and infrastructure also need to be incorporated in the ECC. Whenever a company invests in machinery or infrastructure, therefore, the embedded carbon should be treated in the same way as the financial investment, i.e. spread out over a certain depreciation period. The carbon allocated to each year can then be deduced. Based on the number or value of the products manufactured that year, the carbon can then be allocated as described under Aspect 1.

Aspect 3. Biobased materials production: direct emissions and LULUCF emissions

Land use and land use change and forestry (LULUCF) emissions are atmospheric carbon emissions associated with human land use, which are particularly relevant when it comes to production of biobased materials. Of course it is also possible to remove carbon from the atmosphere by increasing carbon retention in soils or through afforestation. This kind of carbon capture is covered under Aspect 8.

Besides direct emissions, then, these LULUCF emissions will also need to be incorporated in the calculation method, in particular:
- emissions from natural fertiliser application (e.g. manure, digestate)
- emissions from ruminants
- emissions from manure storage
- emissions from soil due to increased or reduced water content (e.g. in drained peat soils)
- reduction of carbon content in soil
- reduction of carbon storage in forest.

In the case of land use change it should be possible to allocate the reduction in the carbon content of soil and forest over the number of years a plot of land is used.

Aspect 4. Taxation of feedstock carbon content versus end-of-life carbon emissions

Waste management is very often not paid for by consumers, and if it is there is no differentiation among products. When considering the life cycle of a given product this means the ECC may be paid by two different parties: the consumer of the product and the consumer of the waste treatment service. More often than not, the latter is the municipality in which the consumer lives.

This means the decision to tax the carbon in a product at the feedstock stage or to tax the CO_2 equivalent emitted at end of life will impact the behaviour of two actors.
The respective incentives created at these two leverage points are summarised in Table 2.

Table 2 - Incentives due to charge leverage point

Leverage point	Incentives for consumer product	Incentives for consumer waste treatment
Feedstock	– Incentive for recycled materials – Incentive for biobased materials – Incentive for lifespan extension – No incentive for recyclability	– Indirect incentive for materials recycling
Waste treatment	– No incentive for biobased material – No incentive for recyclability – No incentive for lifespan extension – Indirect incentive for recycled materials	– Incentive for product recycling – Incentive for lifespan expansion (if less energy needed than for recycling)
Double taxation	– Incentive for recycled materials – Incentive for biobased materials – Incentive for lifespan expansion – No incentive for recyclability	– Incentive for product recycling – Incentive for lifespan expansion

Incentives with a charge on feedstocks

If the charge is levied on feedstocks, it becomes more attractive to buy products made from either recycled or biobased materials. Consumers will also be incentivised to extend the lifespan of the products they use.

With economic allocation, increased demand for recycled materials will mean the carbon footprint of the energy used for recycling is allocated more to production of recycled materials than to waste management. Since the carbon allocated to waste management will never become zero, though, there will always remain an ECC on product recycling. This is in contrast to end-of-life product incineration, on which no ECC will be charged, since the carbon emitted during incineration was already taxed at the feedstock stage. The consumer of the waste treatment, i.e. a municipality, is therefore not encouraged to opt for waste recycling instead of incineration. However, since the market price of recycled material is likely to rise (from the consumer perspective), end-of-life product recycling will also become more attractive.

A downside of levying the charge on the feedstock is that end-of-life biogenic emissions are ignored, since only fossil emissions are taxed at the feedstock stage. This means, for example, that methane emissions from landfill are not taxed, as biogenic methane is not a short-cycle greenhouse gas. If feedstocks are adopted as the leverage point, then, additional policy will be required for landfill emissions.

Incentives with a charge on waste treatment

If waste treatment is adopted as the leverage point, end-of-life product recycling is directly incentivised and landfill methane can be taxed. Consumers will have no incentive, however, for choosing products made from biobased rather than fossil feedstocks, nor for extending product use, as is the case of the feedstock is taxed.

Double taxation

If the charge is levied on both feedstock and waste treatment, there is an incentive to reduce carbon footprints down the entire supply chain. However, this does mean that the carbon embedded in products (i.e. not the carbon emissions of energy use) will be doubly taxed.

None of the options discussed create an incentive for product recyclability (eco-design). This issue is discussed in Section 2.8.3.

Aspect 5. Taxation of use-phase emissions

Emissions may also occur during product use, as is the case with transportation (e.g. exhausts) or refrigerator use (refrigerant leakage). If the ECC is levied on feedstocks rather than waste treatment, as discussed under Aspect 4, all potential use-phase emissions can be included. This means a charge based not only on physical carbon content (in plastics and in in natural-gas methane, for example) but also on the carbon content of (precursors of) greenhouse gases like SF_6 in switch gear, N_2O and refrigerants (chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs)).

If the ECC is charged on waste treatment, on the other hand, a separate methodology will need to be developed for use-phase emissions. Such a methodology would be complicated and would need to differentiate among a wide range of products and is therefore not recommended.

Aspect 6. Tracking renewable and fossil-based energy throughout the supply chain

The guarantees of origin (GOs) for renewable energy set out in the Renewable Energy Directive could, in principle, be very suitable for tracking purposes in the context of an ECC. This system is not currently working as hoped for, however, making it less attractive for use in monitoring.

The GO system, illustrated in Figure 5, separates physical delivery of electricity, indicated by blue arrows, from the guarantee of origin, in green. With physical delivery it is impossible to distinguish between electricity originating from different sources.[3] To guarantee the origin of electricity from renewable sources, a GO is produced for every megawatt hour (MWh) produced using renewables, detailing the source of the electricity and the country of origin. These GOs, issued to the producer of the renewable electricity, can then be freely bought and sold to third parties separately from electricity. These parties can then claim they use renewable electricity, even though the physical electricity delivered to them may not be.

[3] Except in the case of private solar panels, for example.

Figure 5 - Illustration of a guarantee of origin

In the Netherlands, GOs can be bought at relatively low cost from renewable energy producers in other countries. In Scandinavia, for example, the claim that electricity is renewable may be valued less than in the Netherlands (as a relatively large percentage of electricity is already renewably generated), making GOs a cheap option to 'use' renewable electricity. As long as the EU market for them continues to function imperfectly, it is hard to justify their use providing any guarantee of zero carbon emissions per MWh. As this is a politically charged issue, however, the case studies considered in Chapter 3 assume that electricity use backed up by a GO can be counted as having zero carbon emissions per MWh. If and when an ECC is concretely elaborated, this is an issue requiring further attention.

Aspect 7. Tracking biobased and fossil-based content throughout the supply chain

The issue of tracking biobased and fossil-based content throughout the supply chain is very similar to the previous point. A case in point is production of a biobased plastic equivalent in composition to a fossil-based counterpart. In the production process these two feedstocks may often be mixed and there are two options for tracking their respective content:
- establishing the physical content of products based on carbon-14 measurement
- using a certification system similar to that for renewable energy, in line with the ISO chain-of-custody standard, for example.

Aspect 8. Carbon capture and utilisation: CCS, CCU and biological carbon sequestration

Under the EU ETS there is no procedure for dealing with carbon capture and storage (CCS) or utilisation (CCU), nor for whether or not the carbon involved is of biological origin. In the context of a possible future ECC this is therefore an issue that will need to be adequately delineated, making choices on at least the following topics:
- Since embodied carbon is likely to be taxed on feedstocks, a choice needs to be made as to whether or not sequestered carbon (i.e. avoided emission of the CO_2 embodied in fossil fuels) can be deducted from the carbon added in the process step.
- If CCU is applied, it needs to be decided whether the carbon captured for utilisation is seen as a product (meaning that its impact can be economically allocated to the product in question; see Aspect 7) or is dealt with in the same way as CCS.

Under the EU ETS, CCU does not qualify as reduced carbon emissions except in the production of precipitated calcium carbonate. There is currently debate on whether this is to be extended to a wider range of products.

2.5.2 Reporting

For the ECC to become an efficient instrument, clear rules on reporting will need to be established. To an extent, these could be based on current regulations for reporting under the EU ETS. Reporting will need to be done on an annual basis to some kind of authority that then determines the charge rate for the following year. Quality standards with which reporting must comply will also be needed, in the form of both internal company checks and independent external verification of the reporting process by an accredited auditor. In practice this will mean the competent authority receiving from each company an emissions report accompanied by an auditor's certificate.

2.5.3 Verifying and settling the charge

Apart from the MRV requirements at the company level, there is also a need for an independent authority to verify the reported CO_2 emissions. This is particularly relevant when a firm invests in low-carbon technologies or practices in a given year, making them eligible for reduced charges the following year. The authority will therefore need to verify the firm's previous-year carbon accounts and settle the charge for the current year (CE Delft, 2015). Depending on the ECC variant adopted, verification will either need to be carried out along the entire production chain or only at the level of the final producer. The competent authority can carry out such verification checks similarly to how they are currently conducted for companies falling under the EU ETS, with random checks of companies' on-site emissions being made against the reported emissions.

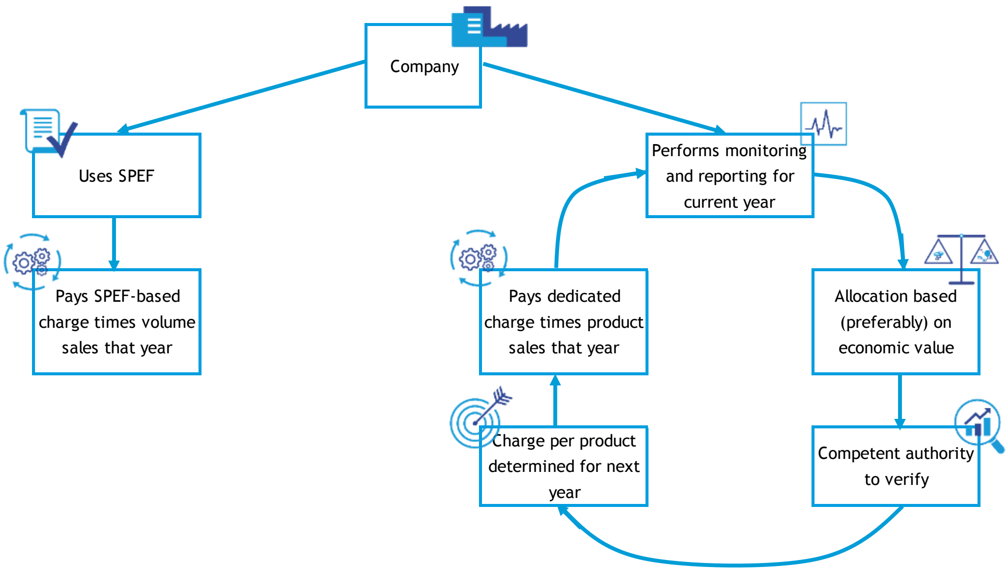
2.5.4 Strategic choices for companies

As outlined in Section 2.4, domestic as well as foreign companies would have a choice as to how they wish to administer the ECC. One option is not to monitor and report their specific emissions, but to have the standard product environmental footprint (SPEF) of their products established by the authority. They would then pay the SPEF-based charge per product multiplied by volume sales that year for each of the products they market.

The alternative option is for the company to monitor the added carbon of its own activities, allocate this across its products (preferably based on economic value; see 2.5.1) and report these data to the competent authority once yearly. The authority then verifies the reported emissions and their allocation to products and, in doing so, determines the ECC per product for that company for the following year. The company will then pay the calculated ECC per product times volume sales for each of the products marketed. The cycle then starts anew, with the company monitoring and reporting its carbon emissions for the current year.

The overall process is schematically summarised in Figure 6, distinguishing between the two options available to companies and organisations.

Figure 6 - Overall ECC process for individual companies



2.6 Border tax adjustments

Taxes based on the destination principle, i.e. on where the product was consumed rather than where it is manufactured, imply a need for some form of Border Tax Adjustment (BTA) to relieve exported products of tax charged in the exporting country. The imported products sold on the home market are then charged a tax identical to domestically produced products. These BTAs are needed to even out potentially unfair competition between countries in the form of double taxation or no taxation at all.

By basing the ECC on the BTAs currently in place for VAT, goods that are exported are exempted from any ECC payments. Goods that are imported are charged ECC for the full carbon content of their product at that stage. This means producers making goods in countries without a ECC but exporting them to countries that do have one are not disadvantaged compared with domestic producers. Similarly, domestic producers creating goods for export to regions without a ECC are not disadvantaged compared with those in regions without a ECC.

Textbox 3 - BTAs under a VAT

All countries in the EU have a Value Added Tax in place on goods and services that are bought and sold for use or consumption. The member states are responsible for adopting a VAT that complies with the EU VAT code outlined in Directive 2006/112/EC on the common system of VAT. The VAT rates are therefore not harmonised across member states, as the code only specifies a minimum standard VAT rate (at least 15%) and reduced VAT rate (at least 5%). The standard VAT rate ranges from 17% in Luxembourg to 27% in Hungary, for example, while some countries have different reduced rates for certain goods and services. Collection of VAT is not carried out at EU level but rather by the member state.

The VAT currently in place in Europe is a value-based tax, implying that VAT paid by producers on the goods and services they make is first subtracted from the sales value before VAT is levied on their good or service. Each (intermediate) producer thus only pays the tax rate over the value added (sum of salaries and profits) in their production step. This feature of VAT means producers act as a tax collectors for the government, while actual VAT payment is shouldered by the final consumer. Producers are obliged to keep a record of all VAT paid on purchases made and VAT received on products sold, settling the difference with the government.

To avoid unfair competition, all imported goods and services are taxed when they first enter the EU, at the point of entry, subject to the rate applicable in that member state. Without this adjustment, non-EU producers would be at an advantage over domestic EU producers, as the market price of their products would be lower because of the tax exemption. Goods and services manufactured outside the EU are therefore subject to the VAT on its sales price at point of entry, putting them on par with goods manufactured inside the EU. Similarly, goods produced in the EU for export or services sold to customers abroad are not subject to VAT.

If the goods were subject to VAT, products manufactured in the EU would be relatively more expensive in markets abroad, compared with goods produced in foreign countries. To avoid unfair competition, imports to the EU are therefore subject to VAT, whereas goods and services produced for export are not, with producers receiving a VAT rebate[4].

Domestically produced goods will either be subject to the SPEF carbon content of their product, or the company needs to have an MRV scheme in place to prove the carbon emissions of their product are lower than the SPEF. This SPEF will also apply to all goods being imported. If the same product produced by a foreign and domestic company are both charged the SPEF ECC rate, there is thus no unfair competition. However, if the domestic company follows the MRV procedure to determine the ECC to be paid on their product and the foreign company does not have that option and is taxed at the SPEF ECC, this implies domestic and foreign producers are taxed differently. In order to prevent unfair competition the optional MRV scheme should therefore be opened up to foreign producers as well. Like domestic producers, foreign producers should have the choice of paying the SPEF ECC or having an MRV scheme in place. Under this BTA, producers in countries without an ECC would not be at a competitive (dis)advantage compared with producers in countries with an ECC, as they would face the same taxation basis for their products in both countries (CE Delft, 2015). Referring back to Section 2.2, although a measure may be designed in a non-discriminatory manner, it may still discriminate *de facto* against developing countries, for example. This may be particularly true when monitoring and reporting requirements are extensive, as producers in developing countries are likely to have more difficulty complying with bureaucratic certification requirements than those in developed countries.

As argued in Section 2.2.2, BTAs will need to be set at the same level as the SPEF to satisfy WTO rules. Although a number of carbon-related border adjustments have featured in policy proposals or draft laws in the EU, these have never been adopted. They all base their calculations on average EU product emissions (Mehling et al., 2017). For instance, the Future Allowance Import Requirement (2007) aimed to calculate border adjustments based on the average carbon intensity of EU goods. Similarly, the Carbon Inclusion Mechanism (2009) based border adjustments on the average direct emissions of a European producer, whilst the Border Adjustment Proposal for the Cement Sector (2016) based border adjustments on the average emissions of EU production (or less, if lower emissions can be proven). Although these draft legislations were in the end not adopted, they may suggest reasonable basis for setting SPEFs and BTAs at the level of the average domestic producer.

4 A second underlying reason for the VAT on imports and VAT rebate on exports is that it avoids situations involving double or zero taxation of goods produced and traded between two countries, one with a sales tax system and one with a VAT system.

Although other draft legislation has used the average EU producer as a SPEF or border adjustment, setting the ECC BTA (and SPEF) at the level of the average EU producer may lead to certain problems. This might be the case if domestically produced products are associated with lower carbon emissions than products produced abroad, even before the ECC was introduced. If this were the case, the ECC would go against the WTO's principle of non-discrimination. This was observed in the EC-Hormones case, when a European ban on meat treated with growth hormones discriminated *de facto* against US meat. This was concluded because not only during but also prior to the ban the percentage of animals treated with such hormones was significantly higher in the US than in the European Community.

To comply with EU law and WTO rules, in this report we have taken a BTA equal to the SPEF. This implies the BTA is based on the carbon footprint of products produced by the dirtiest 10% of producers in Europe (see Section 2.4).

2.7 Charge level

A key issue is obviously the charge level of the ECC, i.e. the fixed sum to be paid over every kilogram of CO_2-equivalent emitted in producing the product concerned. The charge needs be set at a level reflecting the 'price tag' to be put on emitting one kilogram of CO_2 eq. into the atmosphere. Because the effects of climate change are global and long-term and have risk patterns that are hard to anticipate, establishing that price is far from straightforward, however.

Damage costs versus avoidance costs

Economic theory tells us that to avoid market failure, products should be priced at their marginal social cost, that is, the product's price including all the external costs it generates. The level of the ECC should therefore be set equal to the external cost of 1 kg CO_2 eq. There are two main ways in which the cost of CO_2 eq. emissions can be monetised: using damage costs or avoidance costs (CE Delft, 2018a). The damage cost approach evaluates the marginal cost of climate change under the assumption that no efforts are made to reduce emissions. The avoidance cost approach estimates the marginal cost of avoiding the effects of climate change up to a desired point, represented by a certain policy target like that specified in the Paris Agreement. Provided this policy target is an accurate representation of society's preference regarding the level of environmental quality, the avoidance cost approach is a more pragmatic, albeit theoretically second-best, approach to establishing the costs of climate change.

The damage cost approach is theoretically preferable because it gives an indication of consumers' willingness to pay to prevent damage. Provided all impacts and costs can be accurately identified (admittedly an almost impossible task), the damage cost approach yields an accurate figure for the price of carbon emissions. Given the serious caveats associated with estimating and monetising potential damage costs (regarding issues like biodiversity loss, climate-induced migration, political instability and violent conflicts), an accurate figure is in practice very hard to determine, however. On top of this, the Paris Agreement has demonstrated that the collective will to limit global warming to a concrete target is stronger than ever before. If the Paris target can be regarded as an expression of the world's preference to avoid dangerous climate change, this would imply that the avoidance costs equal the damage costs. Because of the uncertainties associated with damage costs and the increased political will to take action on climate change, most recent studies on the external costs of CO_2 emissions recommend adopting the avoidance cost approach (see e.g. (CE Delft, 2018a; Ricardo-AEA, TRT, DIW Econ & CAU, 2014).

The ECC charge rate should therefore be set according to the avoidance cost approach. A central estimate for the short and medium term is € 100 per tonne CO_2 eq., increasing to € 270 in the long term (Table 3). These are the prices suggested in academic literature. However, it is important to note that an ECC would also be a political issue and that rates would be determined in negotiations. While these may to some extent be based on the literature, it is unlikely that the precise values suggested there will be adopted as ECC rates.

Table 3 – CO_2 eq. prices based on avoidance costs

	Low	Central	High
Short and medium term	€ 60	€ 100	€ 189
Long term	€ 160	€ 270	€ 500

2.8 Interactions with other policies and legislation

Given the numerous policies and articles of legislation in place in the EU, when designing the ECC these must clearly be duly considered to avoid negative interactions, including double taxation. Four areas of policy and legislation can be distinguished in this context: climate change, taxation, circular economy and agriculture. These are briefly examined in turn below, though it is not feasible here to provide a comprehensive review.

2.8.1 Climate change policy

There are essentially four types of policy instrument: taxation, subsidies, standards and information policies (as well as their combinations). All these come into play in the climate policy arena. We briefly discuss how each of these could interact with an ECC.

Taxation/carbon tax

Several European countries have some form of carbon tax in place. Sweden, for example, levies a tax between € 110 and € 120 (depending on current exchange rates) per tonne CO_2 eq. on the use of fossil fuels. If products produced in Sweden were also to be taxed with an ECC, there would be double taxation, putting Swedish producers at a competitive disadvantage compared with producers elsewhere.[5] This may not only be the case with trade between EU member states but may also hold for products imported into the EU. If, for example, a product is produced in California and a CO_2 tax has already been levied there it would be advisable for the pre-set BTA to be amended.

We therefore make the following two recommendations:
- Apply BTAs based not only on carbon footprints but also on any carbon tax that may have been paid outside the scope of the ECC, unless of course this tax is not levied on the exports concerned.
- Amend national climate policy in such a way that carbon is no longer directly taxed unless a product/service is not covered by the ECC.

[5] It should be noted that Swedish companies falling under the EU ETS are exempt from this tax.

Other types of taxation, such as a landfill tax, could also interfere with an ECC. It is therefore advisable to inventory which kinds of taxation do so.

Subsidies

From a theoretical point of view, for an ECC to work as efficiently as possible all other financial incentives aimed at addressing climate change should be removed. This means, for example, that if the Netherlands' SDE+ subsidies were maintained renewable energy would be incentivised twice. When designing an ECC it is therefore recommended to inventory all other subsidies that are in place.

Standards/information

Since neither standards nor information are monetary policy instruments, they will affect the workings of an ECC less than is the case for taxation and subsidies. Of course it is still important to ensure that standards and information have no adverse impacts on climate change.

2.8.2 Taxation policy

Another issue is whether the ECC would replace VAT or complement it. CE Delft (2015) has investigated this issue and concluded that the ECC cannot replace VAT entirely in the long term. This is because VAT income is a major element of government finance. If a full switch from VAT to ECC were to be made, accompanied by a transition to a greener economy, this would remove one of the main components of government revenue.

This means that combining ECC with VAT provides the best basis for a relatively sustainable revenue, as this gives the most predictable cash flow. VAT rates could be lowered to compensate low-income households for increased product prices or, alternatively, the revenues could be used for other purposes, e.g. as compensation for environmental damage resulting from global warming. The issue of recycling of revenues is beyond the scope of the present project, however.

2.8.3 Circular economy

Circular economy policy at the EU level aims to increase maintenance, re-use and refurbishment of products as well as boost recycling and reduce landfilling of materials considered as waste. The 2018 Circular Economy Package therefore includes new legislation on waste as well as the EU Action Plan for the Circular Economy.

As described in Section 2.5, the proposed ECC creates incentives for many aspects of the circular economy, such as recycling and life-span extension. It does not stimulate design for recyclability (eco-design), however. This is also missing in the current EU legislation and the European Commission therefore intends to include it in the future Ecodesign directive (European Commission, 2015).

2.8.4 Agricultural policy

Under the Common Agricultural Policy (CAP) farmers receive subsidies to keep rural areas and economies alive and ensure stable supplies of affordable food. In June 2018 the European Commission published a proposal to amend the CAP that is scheduled to come into effect at the beginning of 2021. The proposal states that CAP payments to Member States under the regulation should contribute to the EU's climate-related objectives.

These CAP payments can therefore be regarded partly as climate change policy subsidies, as described in Section 2.8.1. This means that in the case of the CAP, too, certain interventions may be incentivised twice if both the renewed CAP and an ECC were simultaneously in place.

2.9 Influence on other environmental indicators

The ultimate goal of the ECC is to reduce the carbon footprint of products and encourage consumers to make the more sustainable choice when faced with two otherwise identical products.

It is important to note, though, that there may be a trade-off between reducing carbon emissions and impacts on other environmental indicators. A case in point is vehicle engine technology. Although diesel engines have lower CO_2 emissions, their NO_x emissions are higher. Pricing CO_2 alone while ignoring other environmental indicators would therefore lead to a rise in sales of diesel vehicles, with increased air pollution as a result. Another example is freshwater scarcity in connection with agricultural produce. While imported produce may have a smaller carbon footprint than that grown domestically in greenhouses, the products concerned may be grown in areas where there is freshwater scarcity.

It is important to note that this problem is not unique to the ECC. Any other policy involving the pricing of CO_2 emissions will suffer the same problem in the absence of standards or prices relating to other environmental indicators. This is because companies will seek to reduce their CO_2 emissions at lowest possible cost, even if this means increased emissions of other pollutants. The only way to avoid this is to price or regulate other environmental externalities under an ECC-type scheme.

In summary, then, while the ECC instrument described here is tailored to reducing carbon emissions, it is technically feasible to use it to internalise other environmental issues, too, and such a design indeed seems preferable.

3 Case studies

To illustrate the functioning of the charge we examine three case studies, on products or services that will be subject to the ECC, as defined in Section 3.1. Section 3.2 demonstrates the effects of an ECC on tomatoes, a standard supermarket product grown using different production methods and in a variety of locations. Section 3.3 calculates the effect of an ECC on a playground slide, as an example of a plastic product that can be manufactured from biobased or fossil-based plastic and using recycled or virgin materials. Section 3.4 considers the effects of an ECC on a service, taking the example of a trip to Berlin.
Two different modes of transport are explored: train and plane. The main lessons learned from these case studies are presented in Section 3.5.

3.1 ECC design in the case studies

As described in the previous chapter, a number of design choices need to be made before an ECC is introduced. To test the effects of the charge in the series of case studies, the following design assumptions were made:

- **Scope**: European Union.
- **SPEF** and **BTAs**: An SPEF representing production with the 10% highest carbon footprints in the EU has been taken. This SPEF is applied to European companies not wishing to opt in to the MRV scheme as well as to foreign companies selling their products on the European market (via a BTA). The BTA is rebated for products and services exported to regions outside the EU, which will not be subject to the ECC.
- **Charge level**: Three different ECC charge levels are considered: € 25, € 100 and € 250 per metric ton CO_2 eq. The first is a price deemed reasonable under EU ETS at present, € 100 is a realistic short and medium-term avoidance cost price, while € 250 is a realistic long-term (2050) avoidance cost price.
- **Interaction with other polices and legislation:** The ECC is implemented in addition to VAT, but charged prior to it.
- **Allocation of carbon footprint:** Economic allocation.
- **Feedstock:** The carbon content of feedstocks is charged, implying that end-of-life carbon emissions are not counted.

For simplicity's sake, none of the case studies take infrastructure into consideration.
In practice, however, this aspect will need to be taken on board if an ECC is rolled out.

3.2 Case study 1: Tomatoes

3.2.1 Introduction to case study

In this case study we look into the production and packaging of 500 grams of tomatoes for sale in a Dutch supermarket, considering three alternative production methods/locations:
1. Tomatoes grown in a Dutch greenhouse heated using geothermal energy.
2. Tomatoes grown in a Dutch greenhouse heated using natural gas.
3. Tomatoes grown outdoors in Spain in plastic tunnels heated by the sun.[6]

The packaging of most conventional (non-organic) tomatoes available in Dutch supermarkets consists of a plastic tray and a plastic film cover. We assume a PP tray and an LDPE foil cover. The weights of the respective components are given in Table 4.

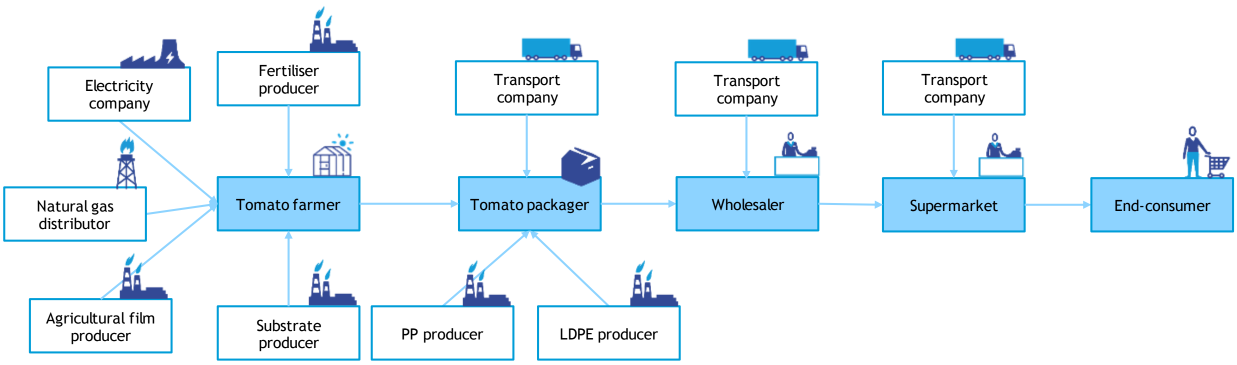
Table 4 - Product components, Tomatoes case study

Product component	Weight
Tomatoes	500 gram
PP tray	7 gram
LDPE film	2 gram

ECC transactions for tomato production

Figure 7 shows the main players in the tomato production supply chain. The figure is a simplification: depending on the specifics there may be additional players (e.g. an extra packaging step), but this shows the principal players of relevance for ECC transactions.

Figure 7 - Main players in ECC transactions for 500 g tomatoes



6 Approximately 5% of Spanish tomatoes are grown in heated tunnels (Blonk Consultants, 2018), but we have assumed here that they are grown without external heating.

3.2.2 Data used

Carbon footprint data

The carbon footprint has been calculated based on the average annual production cycle, as the ECC will also be charged on annual emissions. We note that there may be differences depending on growing season (e.g. summer vs. winter), but this is beyond the scope of the present study.

In the case of tomatoes produced in the Netherlands in a gas-heated greenhouse, there are two products: tomatoes and electricity. We assume that 96% of the income is generated by tomatoes and 4% by electricity[7]. 96% of the carbon footprint of the tomato grower's inputs is therefore economically allocated to the tomatoes.

Table 5 reports the precise data used for the three different types of tomato production.

Table 5 - Data used for tomato case study

Data point | Growing method	NL, geothermal	NL, natural gas	ES, sun
Tomato farmer			
Tomato production (Blonk Consultants, 2018)	50.3 kg/m^2	50.3 kg/m^2	8.4 kg/m^2
Natural gas use	None	57 m^3/m^2 (Blonk Consultants, 2018)	None
Electricity use (Ecoinvent, 2018)	0.14 kWh/500 gram [8]	0.109 kWh/500 gram	0.014 kWh/500 gram
Substrate use (Ecoinvent, 2018)	0.005 kg/500 gram	0.005 kg/500 gram	0.0191 kg/500 gram
Agricultural film use (Ecoinvent, 2018)	None	None	0.0020 kg
Fertiliser use (Ecoinvent, 2018)	Per 500 gram: 0.0008 kg (as N) 0.0003 kg (as K_2O)	Per 500 gram: 0.0008 kg (as N) 0.0003 kg (as K_2O)	Per 500 gram: 0.0013 kg (as N) 0.0005 kg (as P_2O_5) 0.0031 kg (as K_2O)
Pesticide use (Ecoinvent, 2018)	< 0.0001 kg / 500 gram	< 0.0001 kg/500 gram	0.0001 kg/500 gram
Emissions from fertiliser use (Ecoinvent, 2018)	0.006 kg CO_2 eq./ 500 gram	0.006 kg CO_2 eq./ 500 gram	0.013 kg CO_2 eq./ 500 gram
Tomato seedling (Ecoinvent, 2018)	0.0290 piece/500 gram	0.0290 piece/500 gram	0.0848 piece/500 gram
Allocation to tomato production	100%	96%	100%

7 In 2016, income per m^2 horticulture was € 56.20 (Wageningen University & Research, 2017), while income for electricity was slightly over € 2/m^2 (van der Velden & Smit, 2017).

8 As the LCA database gives no data on tomato production in a geothermally heated greenhouse, we assume 0.03 kWh power consumption for the geothermal pumps per MJ greenhouse heat. Approximately 4.5 MJ heat is used per 500 gram tomatoes.

Data point | Growing method	NL, geothermal	NL, natural gas	ES, sun
Tomato packager			
PP producer	7 gram/500 gram	7 gram/500 gram	7 gram/500 gram
LDPE producer	2 gram/500 gram	2 gram/500 gram	2 gram/500 gram
Electricity for cooling	0.0005 kWh/500 gram	0.0005 kWh/500 gram	0.0005 kWh/500 gram
Wholesaler			
Electricity for cooling	0.0005 kWh/500 gram	0.0005 kWh/500 gram	0.0005 kWh/500 gram
Supermarket			
Electricity for cooling	0.0005 kWh/500 gram	0.0005 kWh/500 gram	0.0005 kWh/500 gram
Transportation			
Tomato farmer to Tomato packager	50 km	50 km	2,300 km
Tomato packager to Wholesaler	20 km	20 km	20 km
Wholesaler to Supermarket	20 km	20 km	20 km

Note: Data for which no source is specified are based on assumptions.

For the carbon footprint of inputs the following CO_2 eq. values were taken:

- For electricity we took the carbon footprint of fossil-based electricity, which in the Netherlands is 0.649 kg CO_2 eq. per kWh (CO2-emissiefactoren, 2017), of which 0.572 kg CO_2 eq. are direct emissions at the power plant, with the rest due to resource extraction. The carbon footprint of Spanish electricity was assumed equal to the Dutch figure. Although most electricity currently produced in the Netherlands is classified as 'green', based on its guarantee of origin, this has not been taken into consideration here because of the difficulties surrounding these 'guarantees' (see Aspect 6 in Section 2.5.1).
- For the carbon footprint of transport we took our data from STREAM Freight (CE Delft, 2017), assuming that all transport is by container on a tractor-semitrailer and that the freight carried is medium-weight, such that the vehicle has a load capacity of 2 tonnes. We took a well-to-wheel emission factor of 102 g CO_2 eq. per tkm.
- For all other inputs we used the data reported in the Ecoinvent v3.4 LCA database.

Based on these data the carbon footprint was determined using the methodology 'IPCC 2013 GWP 100a v1.03', as available in the SimaPro software.

Table 6 - Carbon footprint of the three alternative routes for 500 g tomato production (annual average)

Production stage | Growing method	NL, geothermal	NL, natural gas	ES, sun
Electricity producer	0.156 kg CO_2 eq.	0.065 kg CO_2 eq.	0.003 kg CO_2 eq.
Natural gas distributor	None	0.054 kg CO_2 eq.	None
Fertiliser producer	0.001 kg CO_2 eq.	0.001 kg CO_2 eq.	0.028 kg CO_2 eq.
Substrate producer	0.006 kg CO_2 eq.	0.006 kg CO_2 eq.	0.028 kg CO_2 eq.
Agricultural film producer	None	None	0.006 kg CO_2 eq.
Tomato farmer	0.006 kg CO_2 eq.	0.985 kg CO_2 eq.	0.013 kg CO_2 eq.
Transport company *Tomato farmer to Tomato packager*	0.003 kg CO_2 eq.	0.003 kg CO_2 eq.	0.117 g CO_2 eq.
PP producer	0.014 kg CO_2 eq.	0.014 kg CO_2 eq.	0.014 kg CO_2 eq.
LDPE producer	0.004 kg CO_2 eq.	0.004 kg CO_2 eq.	0.004 kg CO_2 eq.
Tomato packager	< 0.001 kg CO_2 eq.	< 0.001 kg CO_2 eq.	< 0.001 kg CO_2 eq.
Transport company *Tomato packager to Wholesaler*	0.001 kg CO_2 eq.	0.001 kg CO_2 eq.	0.001 kg CO_2 eq.

Production stage | Growing method	NL, geothermal	NL, natural gas	ES, sun
Wholesaler	< 0.001 kg CO_2 eq.	< 0.001 kg CO_2 eq.	< 0.001 kg CO_2 eq.
Transport company *Tomato packager to Supermarket*	0.001 kg CO_2 eq.	0.001 kg CO_2 eq.	0.001 kg CO_2 eq.
Supermarket	< 0.001 kg CO_2 eq.	< 0.001 kg CO_2 eq.	< 0.001 kg CO_2 eq.
Total	**~ 0.192**	**~ 1.134**	**0.222**

Note: Rounded to three decimals.

Price data

For a tray of tomatoes in a Dutch supermarket we assume a retail price of € 1.50 including 6% VAT, giving a net retail price of € 1.42.

3.2.3 Results

The price change for the final consumer per 500 g of tomatoes is shown in Table 7.
Several observations can be made:
- The product price will increase by a maximum of 20% in the case of tomatoes grown in a Dutch greenhouse heated with natural gas if the ECC is € 250/t CO_2 eq.
- If the greenhouse operates below the ETS threshold, this price change will not be achieved under the current EU ETS, as most of it is due to direct emissions from transport fuel and natural gas consumption.
- The ECC will make tomatoes grown in a gas-heated greenhouse approximately 16% more expensive than the two other types of tomatoes if the ECC is € 250/t CO_2 eq.

Table 7 - Consumer price change for 500 g tomatoes

ECC | Alternative	NL, geothermal	NL, natural gas	ES, sun
€ 25/t CO_2 eq.	€ 0.005 + € 1.42 = € 1.42	€ 0.028 + € 1.42 = € 1.45	€ 0.006 + € 1.42 = € 1.43
€ 100/t CO_2 eq.	€ 0.019 + € 1.42 = € 1.44	€ 0.113 + € 1.42 = € 1.53	€ 0.022 + € 1.42 = € 1.44
€ 250/t CO_2 eq.	€ 0.048 + € 1.42 = € 1.47	€ 0.284 + € 1.42 = € 1.70	€ 0.056 + € 1.42 = € 1.48

Note: Carbon price rounded to three decimals.

A closer look at the carbon emissions per production step (see Table 6) reveals that the following aspects contribute most to the ECC paid by the final consumer:
- direct emissions from natural gas use (for the gas-heated greenhouse)
- indirect emissions from electricity production
- direct and indirect emissions from inputs of plastics, fertilisers and substrate production
- transport to the Netherlands (for Spanish tomatoes).

This means the calculation rules will need to incorporate all these aspects, describing in particular how to account for direct emissions from fossil fuel use and how to calculate the footprint of the electricity used. Furthermore, SPEFs will need to be developed for use when a producer opts out of the MRV scheme. At a minimum, SPEFs will need to be developed for all the main plastics and fertilisers, as these will be used for all fruit and vegetables available in supermarkets.

The main challenge is likely to be the calculation rule for direct emissions from fertiliser use and substrate production, since these emissions from agriculture are not currently included under the EU ETS. Though not playing any significant role in greenhouse crop production, a similar issue is the climate change impact of land use and land use change.

Classic examples are the emissions from soil due to cropping practices and carbon stock reduction due to deforestation.

3.3 Case study 2: Plastic playground slide

3.3.1 Introduction to case study

In this case study we look into manufacture of an HDPE slide produced in the Netherlands for sale at Dutch garden centres. We consider four alternative production :

1. A slide made of conventional fossil-based HDPE.
2. A slide made of recycled fossil-based HDPE.
3. A slide made of biobased HDPE.
4. A slide made of recycled biobased HDPE.

The weight of the product is given in Table 8.

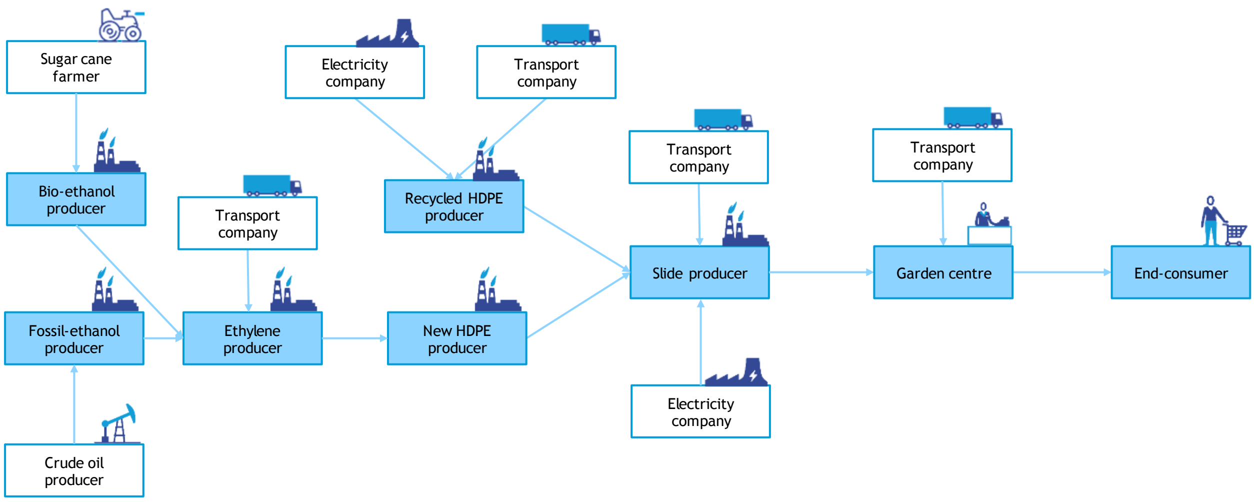
Table 8 - Product components, HDPE slide case study

Product component	Weight
HDPE	14 kg

ECC transactions for slide production

Figure 8 shows the main players in the slide production supply chain, from the ethanol producer to the final consumer, which are thus also important in the ECC transactions.

Figure 8 - Main players in ECC transactions for an HDPE slide



3.3.2 Data used

Carbon footprint data

The carbon footprint was calculated based on the average annual production cycle, as the ECC will also be charged on annual emissions. As there is no data available on economic allocation with respect to fossil HDPE production, data from Plastics Europe was used (Plastics Europe, 2014). Table 9 shows the exact data used for the four types of HDPE slide production.

It should be noted that biobased HDPE is not (yet) produced on a large scale and that the carbon footprint of such HDPE production may therefore possibly become lower in the future as production is scaled up.

Table 9 - Data used for HDPE slide case study

Data point | Type of HDPE	Fossil HDPE	Recycled fossil HDPE	Bio-HDPE	Recycled bio-HDPE
Raw material producer				
Feedstock fossil carbon content	0.857 kg C/kg HDPE	None	None	None
Sugarcane farmer	None	None	0.5 kg CO_2 eq./kg ethanol[9] (Tsiropoulos, et al., 2014)	None
Crude oil producer	0.39 kg CO_2 eq./kg HDPE[10]	None	None	None
Naphtha/ethanol producer				
Raw material	Unknown	None	2.5 kg ethanol/kg HDPE[11]	None
Direct emissions	0.94 kg CO_2 eq./kg HDPE[10]	None	0.25 kg CO_2 eq./kg HDPE (Tsiropoulos, et al., 2015)	None
Ethylene producer				
Direct emissions	0.17 kg CO_2 eq./kg HDPE[10]	none	0.5 kg CO_2 eq./kg HDPE (Tsiropoulos, et al., 2015)	None
HDPE producer				
Direct emissions	0.24 kg CO_2 eq./kg HDPE (Plastics Europe, 2014)	None	0.24 kg CO_2 eq./kg HDPE (Plastics Europe, 2014)	None
Electricity use	0.06 kg CO_2 eq./kg HDPE (Plastics Europe, 2014)	1.28 kWh/kg HDPE (CE Delft, 2017a)	0.06 kg CO_2 eq./kg HDPE (Plastics Europe, 2014)	1.28 kWh/kg HDPE (CE Delft, 2017a)
Slide producer				
It is assumed that 14 kg HDPE is blow moulded for slide production				

9 This includes direct land use change, but not indirect land use change, which is estimated by Tsiropoulos, et al. (2015) at 0.08 kg CO_2 eq./kg ethanol.

10 The 1.5 kg CO_2 eq. per kg HDPE from monomer production as indicated in Plastics Europe (2014) has been allocated across the three production steps: crude oil production, naphtha production and ethylene production based on data received from Plastic Europe Netherlands.

11 Calculated based on Tsiropoulos, et al. (2014) and Tsiropoulos, et al. 2015).

Data point | Type of HDPE	Fossil HDPE	Recycled fossil HDPE	Bio-HDPE	Recycled bio-HDPE
Gardening centre				
None				
Transportation				
Bio-ethanol to ethylene producer	None	None	9,700 km	None
Naphtha to ethylene producer	50 km	None	None	None
Ethylene producer to plastic producer	50 km	None	50 km	None
End-of-life HDPE to plastic producer	None	50 km	None	50 km
Plastic producer to slide producer	50 km	50 km	50 km	50 km
Slide producer to gardening centre	50 km	50 km	50 km	50 km

Note: Data for which no source is specified are based on assumptions.

For the carbon footprint of inputs the following CO_2 eq. values were taken:
- For electricity we took the carbon footprint of fossil-based electricity, which in the Netherlands is 0.649 kg CO_2 eq. per kWh (CO2-emissiefactoren, 2017), of which 0.572 kg CO_2 eq. are direct emissions at the power plant, with the rest due to resource extraction.
- For transport we used the carbon footprint data from STREAM Freight (CE Delft, 2017). Transportation in involved in various links in the supply chain:
  - Transport of bio-ethanol to the ethylene producer: We assume this transport is by Handymax-sized bulk carrier with a load capacity of 52,222 tonnes.
    The corresponding well-to-wheel emission factor is 8 g CO_2 eq. per tkm (CE Delft, 2017).
  - Transport of naphtha to the ethylene producer and from the ethylene producer to the HDPE producer: For this transport, carried out within Europe, we assumed a distance of 50 km by bulk truck with a load capacity of 15.7 tonnes and an emission factor of 172 g CO_2 eq. per tkm (CE Delft, 2017).
  - All other transport: The product needs to be transported by truck over 50 km.
    The container truck has a load capacity of 2 tonnes and an emission factor of 102 g CO_2 eq. per tkm (CE Delft, 2017).
- For all other inputs we used the data reported in the Ecoinvent v3.4 LCA database.

Based on these data the carbon footprint was determined using the methodology 'IPCC 2013 GWP 100a v1.03', as available in the SimaPro software.

Table 10 - Carbon footprint of the four alternative routes for HDPE slide production

Production stage | Type of HDPE	Fossil HDPE	Recycled fossil HDPE	Bio-HDPE	Recycled bio-HDPE
Feedstock fossil carbon content	44 kg CO_2 eq.	0 kg CO_2 eq.	0 kg CO_2 eq.	0 kg CO_2 eq.
Sugarcane farmer	Not applicable	Not applicable	18 kg CO_2 eq.	Not applicable
Crude oil producer	5 kg CO_2 eq.	Not applicable	Not applicable	Not applicable
Naphtha / Ethanol producer	13 kg CO_2 eq.	Not applicable	4 kg CO_2 eq.	Not applicable
Transport company *Ethanol producer to ethylene producer*	< 1 kg CO_2 eq.	Not applicable	2 kg CO_2 eq.	Not applicable
Ethylene producer	2 kg CO_2 eq.	Not applicable	7 kg CO_2 eq.	Not applicable
Transport company *Ethylene producer to plastic producer*	< 1 kg CO_2 eq.	Not applicable	< 1 kg CO_2 eq.	Not applicable
Transport company *End-of-life HDPE to plastic producer*	Not applicable	< 1 kg CO_2 eq.	Not applicable	< 1 kg CO_2 eq.
Electricity producer	1 kg CO_2 eq.	12 kg CO_2 eq.	1 kg CO_2 eq.	12 kg CO_2 eq.
HDPE producer	3 kg CO_2 eq.	0 kg CO_2 eq.	3 kg CO_2 eq.	0 kg CO_2 eq.
Transport company *Plastic producer to slide producer*	< 1 kg CO_2 eq.	< 1 kg CO_2 eq.	< 1 kg CO_2 eq.	< 1 kg CO_2 eq.
Electricity producer	15 kg CO_2 eq.	15 kg CO_2 eq.	15 kg CO_2 eq.	15 kg CO_2 eq.
Slide producer	< 1 kg CO_2 eq.	< 1 kg CO_2 eq.	< 1 kg CO_2 eq.	< 1 kg CO_2 eq.
Transport company *Slide producer to gardening centre*	< 1 kg CO_2 eq.	< 1 kg CO_2 eq.	< 1 kg CO_2 eq.	< 1 kg CO_2 eq.
Gardening centre	< 1 CO_2 eq.	< 1 CO_2 eq.	< 1 CO_2 eq.	< 1 CO_2 eq.
Total	**~ 85**	**~ 27**	**~ 50**	**~ 27**

Note: Rounded to whole numbers.

Price data

For a slide sold at a gardening centre we assume a price of € 121 including 21% VAT, giving a net price of € 100.

3.3.3 Results

The price change per slide for the final consumer is shown in Table 13. Several observations can be made:

- The product price will increase by a maximum of 21% in the case of the slide made of fossil HDPE with an ECC of € 250/t CO_2 eq.
- This price increase cannot be achieved under the EU ETS because the manufacturing industry does not fall under the current EU ETS.
- The ECC will make a slide made of fossil HDPE approximately 13% more expensive than a slide made of recycled plastic (whether biobased or fossil-based).

Table 11 - Consumer price change for an HDPE slide

ECC | Alternative	Fossil HDPE	Recycled fossil HDPE	Bio-HDPE	Recycled bio-HDPE
€ 25/t CO_2 eq.	€ 2.12 + € 100 = € 102.12	€ 0.69 + € 100 = € 100.69	€ 1.24 + € 100 = € 101.24	€ 0.69 + € 100 = € 100.69
€ 100/t CO_2 eq.	€ 8.46 + € 100 = € 108.46	€ 2.74 + € 100 = € 102.74	€ 4.96 + € 100 = € 104.96	€ 2.74 + € 100 = € 102.74
€ 250/t CO_2 eq.	€ 21.16 + € 100 = € 121.16	€ 6.86 + € 100 = € 106.86	€ 11.41 + € 100 = € 111.41	€ 6.86 + € 100 = € 106.86

Note: Carbon price rounded to two decimals.

A closer look at the carbon emissions per production step (see Table 10) reveals that the following aspects contribute most to the ECC paid by the end-consumer:
- the fossil carbon in the feedstock (only if primary material is used)
- biobased feedstock production (sugarcane production)
- indirect emissions from electricity production.

This means that the choice made with regard to allocation of the fossil carbon (allocation to the feedstock vs. waste management) has a major impact on results. Furthermore, this case study echoes the finding from the first one that it is important that robust calculation rules are established for direct emissions from fertiliser use and for land use and land use change.

It is also important that, if biobased and fossil-based products are both produced in the same installation and are combined in products, the 'advantage' of biobased material is allocated once only. This issue is described in more detail in Section 2.5.1.

3.4 Case study 3: Return trip Amsterdam-Berlin

3.4.1 Introduction to case study

This case study concerns a return trip from Amsterdam to Berlin, via the fastest route. We consider two alternatives:
- a return trip Amsterdam Centraal – Berlin Hauptbahnhof by train
- a return trip Amsterdam Centraal – Berlin Hauptbahnhof by plane (flight Schiphol-Tegel, including transport to and from airports).

It is important to note that this case study does not take into account the infrastructure needed to provide these travel services. This implies that the carbon embedded in trains, rails, train stations, airplanes, airports, etc. is ignored, with only the well-to-wheel emissions of the fuel and electricity involved in the actual services being taken into consideration.

Nonetheless, the concept and treatment of embedded carbon in the infrastructure underlying these services is important, since such carbon could in principle also be incorporated in an ECC. When a company invests in machinery or infrastructure, the embedded carbon should, for example, be treated the same as the financial investment, i.e. spread out over a certain depreciation period. The carbon allocated to each year could then be deduced. Based on the number and value of products manufactured that year, allocation could then be made to the product level.

3.4.2 Data used

Carbon footprint data

The carbon footprint of the trip was calculated using (EcoPassenger, 2018). For the carbon intensity of the electricity used by the railways we factored in their electricity mix.
For the rail trips we assumed that guarantees of origin indeed count as green certificates and that such electricity has a carbon footprint of zero (see discussion in Section 2.8.1).
In calculating the climate impact of the air trip, it should be noted that the radiative forcing associated with high-altitude emissions has also been taken into account (see also Section 3.4.3).

Table 12 reports the precise data used for the two variants.

Table 12 - Carbon footprint of the two variants for the Amsterdam-Berlin trip

	Train	Airplane
Outward bound trip Amsterdam - Berlin	21.3 kg CO_2 eq.	169.1 kg CO_2 eq.
Transport to and from airport	n/a	0.8 kg CO_2 eq.
Inward bound trip Berlin - Amsterdam	21.3 kg CO_2 eq.	169.1 kg CO_2 eq.
Transport to and from airport	n/a	0.8 kg CO_2 eq.
Total	**42.6**	**339.8**

Note: Rounded to one decimal.

Price data

For a return train ticket to Berlin booked a month in advance we took a price of € 150 (NS, 2018). On the Dutch leg of the trip VAT is charged at 6%, on the German leg at 19%. As it is unclear how the ticket price is split between the Dutch and German railways, we took an average VAT rate of 14%. Excluding this VAT, the net price of the train ticket is € 141.51. The price of a return air ticket to Berlin booked a month in advance is € 100 (Skyscanner, 2018), to which no VAT is added, as air tickets are exempt from VAT.

3.4.3 Results

The price change for the final consumer of a return trip to Berlin is shown in Table 13. Several observations can be made:
- The product price will increase by 8% for the train trip and by 85% for the air trip.
- This higher price for air travel could theoretically be achieved under the EU ETS, as intra-EU flights are within its scope. However, it is unlikely that prices of € 100 or € 250/t CO_2 eq. will be attained under the EU ETS.
  The original price advantage of air over rail without the ECC is upheld with ECC rates of € 25 and € 100/t CO_2 eq. With an ECC rate of € 250 per tonne, train tickets become cheaper.

Table 13 - Consumer price change for return trip Amsterdam-Berlin

ECC | Alternative	Rail	Air
€ 25/t CO_2 eq.	€ 1.09 + € 141.51 = € 142.60	€ 8.50 + € 100 = € 108.50
€ 100/t CO_2 eq.	€ 4.34 + € 141.51 = € 145.85	€ 33.98 + € 100 = € 133.98
€ 250/t CO_2 eq.	€ 10.85 + € 141.51 = € 152.36	€ 84.95 + € 100 = € 184.95

Note: Carbon price rounded to two decimals.

For accurate setting of the ECC it is important that the full climate impact of aviation is taken into account. Aviation emissions are more harmful as they are emitted at high altitude; ignoring the associated radiative forcing yields a carbon footprint roughly 28% lower than the figure reported in Table 12. If this radiative forcing is ignored, the ECC of the air trip would therefore also be 28% lower.

For the rail trip, assuming guarantees of origin to be true green certificates yields a carbon footprint roughly 19% lower than if the country's national electricity production mix were taken. How these guarantees of origin are judged and counted is therefore a key debating issue in setting an ECC, as Dutch railways, for example, use these certificates to verify their claim of using 100% renewable energy.

Although it is interesting to note the effects of an ECC on trip prices, it is important to note that it will likely be difficult to tax the carbon emissions of aviation, as discussed in Section 2.3.

3.5 Lessons learned from the case studies

From the three case studies we can conclude that:
- An ECC charge rate of € 250/t CO_2 eq. will lead to a price rise ranging from 20% (tomatoes) to 85% (air ticket) compared with the price of the product without the ECC.
- This price rise cannot be achieved under the current EU ETS, since most agriculture and certain types of manufacturing plant are excluded from this emissions trading scheme. Although rail journeys are outside the scope of the EU ETS, commercial intra-EEA flights are. This implies that the price increase for air travel is theoretically possible under the EU ETS, though it should be noted that the price rises resulting from a carbon price of € 100 of € 250/t CO_2 eq. are highly unlikely.

The calculation rules will need to specify how to deal with the following aspects.

Direct emissions from agriculture

The agricultural sector does not currently fall under the EU ETS. For an ECC to function fairly for both fossil-based and biobased materials this sector will need to be included, not in the least because direct emissions from agriculture are responsible for roughly 10% of all GHG emissions in the EU. This figure works out higher if the emissions from agricultural energy consumption and the climate change impact of land use and land use change and forestry (LULUCF) are included.

Since the agricultural sector is not included in the EU ETS there is currently no method available for calculating emissions at the individual farm level. Such a method will therefore need to be developed if an ECC is rolled out.

Land use, land use change and forestry (LULUCF)

For an ECC to work effectively for both fossil-based and biobased materials the climate change impact of LULUCF will need to be included. This implies that the impact of deforestation needs to be charged under the ECC and will therefore be visible in the final product available on supermarket shelves (particularly relevant for beef and soy products, for example). For this aspect too, therefore, a calculation method will need to be developed.

Taxation of feedstock carbon content of versus end-of-life carbon emissions

As already discussed in Section 2.5.1, the decision on whether the fossil carbon embedded in products is to be allocated to the feedstock or to waste management will have a major impact on the workings of the ECC.

4 ECC compared with other policy instruments

The External Costs Charge outlined in this study has a number of benefits compared with alternative policy instruments. At the same time, though, it presents several challenges to which no adequate answer has yet been found. In this chapter we discuss both the advantages and the drawbacks of an ECC by comparing it with four other policies, both current or feasible in the future:

- EU ETS+ (Section 4.2): the EU ETS extended to cover all sectors, without BTAs
- subsidies supporting a switch to low-carbon technologies, covering all sectors (Section 4.2.2)
- a carbon tax (Section 4.2.3) covering all sectors, without BTAs
- an energy tax (Section 4.2.4) covering all types of energy use.

In Section 4.1 we start by reviewing the pros and cons of an ECC compared with these four alternatives.

4.1 Overall review

The advantages and drawbacks of an ECC over the alternative policy instruments are summarised in Table 14, in which:

+ indicates a relative advantage of an ECC
+/- indicates approximate similarity
- indicates a relative disadvantage of an ECC

Table 14 – Advantages of CEC compared to other policy instruments

Aspect	EU ETS+	Subsidies	Carbon tax	Energy tax
Level playing field for European industry	+	-	+	+
Cost-efficient emission reduction	+	+	+	+
Impact beyond European borders	+	+	+	+
Information function: insight into product's carbon footprint	+ *1	+ *1	+ *1	+ *1
Polluter-pays principle	+	+	+	+
Scope: All emissions can be included	+/-	+/-	+/-	+

*1: Depending on the exact variant of an ECC.

In theory, all emissions occurring within the EU can be included under an EU ETS+, subsidies and a carbon tax. This is not the case for an energy tax, though. The disadvantages of an ECC compared with the first three policy instruments, with the same scope, are shown in Table 15. The energy tax is omitted since it cannot be used for the same purpose.

Table 15 - Disadvantages of an ECC compared with the other policy instruments

Aspect	EU ETS+	Subsidies	Carbon tax
Target-setting	-	+/-	+/-
Implementation time	-	-	-
Continuous costs for governments	-	-	-
Continuous costs for companies	-	-	-
Risk of retaliation	-	-	-
Risk of fraud	+/-	+/-	-

Note: An energy tax is not included in the comparison since it cannot cover all EU carbon emissions.

The pros and cons of an ECC relative to the other policy instruments are described in Sections 4.1.1 and 4.1.2, respectively.

4.1.1 Advantages

An ECC has numerous advantages over the other four climate policy instruments. Six of these are briefly described below, based on an earlier report by CE Delft (CE Delft, 2018b):
- an ECC creates a level playing field for EU industry, preventing carbon leakage
- an ECC leads to cost-efficient carbon emissions reduction over the entire product lifecycle
- an ECC has an impact going beyond EU borders and is likely to result in emission cuts in non-EU countries as well
- an ECC fulfils an informative function by giving insight into products' carbon footprint
- an ECC is in line with the polluter-pays principle
- an ECC can encompass all EU carbon emissions.

Level playing field for European industry

Under the EU ETS, a carbon tax or an energy tax, GHG emissions are only priced (whether directly or indirectly) if these emissions occur within the EU. Emissions embodied in imported products are not priced, putting EU industry at a competitive disadvantage. Implementing an ECC in combination with a BTA would ensure a level playing field between EU and non-EU industry in terms of carbon emissions.

Based on the available legal information, it appears that WTO agreements preclude a border tax adjustment being introduced under the current EU ETS, a carbon tax or an energy tax as described in this chapter. This is because none of these instruments apply to the product level, thus ruling out an equivalent BTA at that same level.

Furthermore, an ECC prevents carbon leakage, i.e. a shift in production from a country with strict legislation on GHG emissions (such as the EU with the EU ETS) to a country where legislation is more lenient. This is particularly relevant from a European policy perspective. With carbon leakage, carbon emissions are therefore not reduced, but merely transferred elsewhere. By implementing an ECC, EU job opportunities can be maintained while achieving higher carbon emission cuts.

Cost-efficient carbon emissions reduction

An ECC gives industry greater flexibility to reduce the carbon footprint of their products by not only aiming at emissions reduction in their own production facilities but throughout the entire supply chain. This makes it possible to choose the most cost-efficient emission reduction strategy for each individual final product. The extent of the advantage that can be achieved in the marketplace because of this flexibility depends on the industry concerned and supplier diversity.

Moreover, if individual companies can lower their ECC charge rate by reducing their carbon emissions (using MRV), an ECC will stimulate low-carbon innovation as producers are rewarded for lower emissions. This is likely to incentivise innovation via increased carbon productivity, similar to how the tax on labour has incentivised labour productivity.

Impact of EU policy goes beyond European borders

By implementing an ECC the EU can have a greater impact on GHG emissions reduction than with the EU ETS or an EU-wide carbon or energy tax. Under the latter policies, the extreme case could entail EU industry achieving net zero CO_2 eq. emissions while all non-EU suppliers were still major emitters. The ECC, in contrast, also targets non-EU emissions associated with European consumption.

In 2016, for example, total direct carbon emissions in the Netherlands were approximately 232 Mt CO_2 eq. (CBS, 2018). As can be seen from Table 16, however, 176 Mt of these were due to export-related production, while there were 182 Mt associated with products imported for Dutch consumption (CBS, 2018). These roughly cancel one another out, yielding a net figure of 239 Mt CO_2 eq. for the country's total consumption footprint. This means only about a quarter of the Netherlands' domestic consumption footprint originates from national production, with around three-quarters occurring abroad. When industries invest in reducing the carbon footprint of their own production process, they will most likely do so not only for products consumed in the EU but for all their products. This means that besides the direct GHG emissions (232 Mt CO_2 eq.) the foreign emissions associated with consumption (182 Mt CO_2 eq.) will also be targeted by the ECC, almost doubling its impact in comparison with the ETS.

Table 16 – Dutch carbon emissions (Mt CO_2 eq.)

Direct emissions	**232**
Emissions due to imports	182
Emissions due to exports	176
Emissions of trade balance	*-7*
Consumption footprint	239

Information function: insight into carbon footprint

Many climate policy instruments provide no insight into the carbon footprint of individual products or the production phase of the product contributing most to the footprint. An ECC, in contrast, does provide this information to final consumers and companies. This enables consumers, including governments, to pursue sustainable purchasing and procurement practices and opt for the product with the smallest footprint. It is also makes it easier for companies to target the carbon hotspots in their supply chain in the most efficient manner, as described above under the heading '*cost-efficient carbon emissions reduction*'.

Polluter-pays principle

Lastly, most other policy instruments result in the costs of climate change being paid for by producers or governments, in the latter case generally in the form of subsidies, and indirectly by the taxpayers. The consumer is usually spared, although it is their demand that is triggering the carbon emissions. By implementing an ECC, the costs will be borne by consumers (and not by citizens). An ECC is thus in line with the polluter-pays principle, with consumers paying for the emissions associated with their purchases. The polluter-pays principle is a fundamental principle of the EU's climate policy and is specified in the TFEU.

4.1.2 Disadvantages

Target-setting

Since an ECC works with a carbon price, the resultant GHG emission cuts will be determined by the laws of the marketplace, which provides no certainty as to their magnitude. The EU ETS, on the other hand, sets a cap on GHG emissions falling under the EU ETS, providing a clear figure for the level of reduction, but uncertainty as to costs. A carbon tax and subsidies have the same disadvantage over the EU ETS as an ECC.

Implementation time

The time required to implement a carbon tax, subsidies, EU ETS+ and an ECC of equivalent scope differ. Table 17 shows which implementation aspects are relevant for each instrument. These are discussed briefly below.

Table 17 – Implementation aspects per policy instrument

	Carbon tax	Subsidies	EU ETS+	ECC
Calculation method: CO_2 eq. per location	Yes	No	Yes	Yes
Calculation method: CO_2 eq. per product	No	No	No	Yes
Calculation method: CO_2 eq. per measure	No	Yes	No	No
Calculation method: 'unprofitable component'	No	Yes	No	No
Setting a SPEF per product	No	No	No	Yes
Setting a charge level/emission cap/subsidy budget	Yes	Yes	Yes	Yes
Designing a verification procedure	Yes	Yes	Yes	Yes

As the table indicates, an ECC differs from the other instruments in the following respects:
- It requires a more extensive calculation method to arrive at the CO_2 eq. per product (rather than per installation), compared with a carbon tax and EU ETS+. The calculation method for subsidies is also extensive, as it needs to identify both the CO_2 eq. and the so-called 'unprofitable component' of the investment[12] to determine a cost efficiency per tonne CO_2 eq. avoided for the various measures possibly eligible for subsidy.
- It requires a CO_2 eq. SPEF to be determined for each product.

[12] The fraction of the investment in a carbon emission reduction measure that cannot be recuperated within a pre-determined period.

These difficulties imply that the implementation time for an ECC is likely to be longer than for the other policy instruments with an equivalent scope. This is particularly true for a carbon tax and EU ETS+.

Designing a calculation guideline for CO_2 eq. per location

A calculation guideline will need to be developed to ensure CO_2 eq. emissions from production are calculated in a consistent manner. This will need to include emissions from fuel use and all other direct emissions associated with the production process. While calculation guidelines exist for industries covered by the EU ETS, not all industries are currently under its scope. This means that for many sectors, including agriculture, new guidelines will need to be developed. Furthermore, calculation guidelines on how to handle carbon capture and utilisation (CCU) are not currently available under the EU ETS.

Calculation guidelines will need to be developed for the following three policy instruments: carbon tax, EU ETS+ and ECC.

Designing a calculation guideline for CO_2 eq. per product

Knowing how to calculate GHG emissions for a production location is not the same as knowing the CO_2 eq. per product or the carbon added per production step. This calculation guideline will need to provide clarity on the allocation of inputs and emissions across different products when a range of products are produced at the same production site. Such a guideline is only necessary for an ECC and not for the other policy instruments described.

Subsidies: designing a calculation guideline for CO_2 eq. per measure and for the 'unprofitable component' of the investment

Unlike the other three policy measures, a calculation guideline is needed for both the CO_2 eq. of an investment and the 'unprofitable component' in the case of a subsidy. This is necessary in order to determine the cost efficiency per tonne CO_2 eq. avoided of the different possible investments. Cost curves can aid in making efficient choices on what to spend the subsidy budget on, as is presently the case, for example, for the SDE+ renewable energy subsidy in the Netherlands.

Determining an SPEF per product

For companies not wishing to perform MRV as part of an ECC procedure, SPEFs would have to be established. These SPEFs are not necessary in the case of a carbon tax, subsidies or EU ETS+, since it is unlikely that BTAs are legally feasible with these instruments.

Setting a charge level/emission cap/subsidy

For all policy instruments a goal, price or maximum expenditure will need to be agreed upon with all the parties involved. This means implicitly that political agreement within the EU will be required in all cases.

Designing a verification procedure

Lastly, once an ECC has been developed there will also be a need for a verification procedure in order to prevent fraud. This will not only need to involve verification of the inventory, however, but also verification of the CO_2 eq. added per product. Although details will differ, verification is also necessary in the case of a carbon tax, subsidy or EU ETS+.

Continuous costs - government

All national governments will incur costs for implementing an ECC at the national level and integrating it into national law. Furthermore, costs for verification will be continuously incurred to verify companies' previous-year accounts and settle the tax rate for the current year (CE Delft, 2015). The additional costs that would not be incurred when implementing one of the other policy measures are:
- designing a calculation guideline for CO_2 eq. product footprint
- implementing and updating product SPEFs
- verifying the CO_2 eq. emissions per product reported by companies (i.e. a check that calculation guidelines have been correctly applied).

Continuous costs - companies

The monetary value of the burden the ECC puts on companies can be divided into investments (one-off costs) and continuous, i.e. annual costs. The additional costs that would not be incurred when implementing one of the other policy measures are:
- costs associated with calculating a CO_2 eq. product footprint
- costs of collecting data on CO_2 eq. emissions per product downstream
- costs of reporting CO_2 eq. emissions per product.

Risk of retaliation

Even if the ECC were designed in compliance with WTO rules, non-EU countries might not be happy with the taxation of their industries and 'indirect access restrictions' to the EU market. Retaliation is a real risk, especially in light of the current tit-for-tat regarding trade between the USA and its major trading partners.

Risk of fraud

The types of fraud that are feasible under the four policy instruments are shown in Table 18. A carbon tax has the lowest risk of fraud.

Table 18 – Types of fraud feasible per policy instrument

Type of fraud	EU ETS+	Subsidies	Carbon tax	ECC
Charge/subsidy basis	Yes	Yes	Yes	Yes
Deductions	Yes	No	No	Yes
False promises	No	Yes	No	No

The risk of fraud relating to the charge/subsidy basis exists for all four policy instruments. For EU ETS+, the carbon tax and the ECC this implies fraud in the carbon emissions per location, while in the case of subsidies it will concern the cost efficiency of the proposed measure. If erroneous data are purposely submitted about the charge/subsidy basis this can lead either to undertaxation (carbon tax, CEC, EU ETS) or to oversubsidisation (subsidies).

Both the EU ETS+ and the ECC are at risk of fraud relating to deductions. Large-scale VAT fraud has occurred in the past with the EU ETS. Because some EU countries see ETS allowances as a material product, whereas others see it as a financial product, VAT could be reclaimed in one member state by transferring rights from one member state to another.

For the ECC, similar fraud could occur as a result of the BTAs, with more money being reclaimed at the point of export than was paid during the foregoing process.

Lastly, subsidies are susceptible to fraud due to false promises, with the received subsidy funds not in fact being used to reduce carbon emissions.

4.2 Review per alternative instrument

4.2.1 EU ETS+

An EU ETS+ is an EU ETS with the same scope as an ECC, i.e. covering the same sectors and emissions. As this is broader than the existing EU ETS we term it EU ETS+.

Advantages over an ECC

An EU ETS+ has three main advantages over an ECC:
- it can put a direct cap on GHG emissions
- there is no risk of retaliation as long as no obligation is established to surrender allowances from firms operating outside it
- it takes less time to implement and verification and monitoring cost less, to an extent depending on the exact ECC variant.

Firstly, since an ECC works with a carbon price, the resultant GHG emission cuts will be determined by the laws of the marketplace. There is therefore no certainty that a desired emissions reduction will indeed be achieved. The EU ETS, on the other hand, provides certainty in terms of emissions cuts by setting an emissions cap.

Secondly, since an EU ETS+ (without a BTA) would impinge solely on the European market, there is no risk of retaliation from other countries by way of trade restrictions.

Lastly, in principle all sectors can be included under an EU ETS+. This will require significant changes to the EU ETS, especially when it comes to including sectors for which LULUCF emissions are relevant. Such an EU ETS+ will require substantial implementation time as well as continuous costs for companies and governments in relation to an extended MRV scheme. However, these costs as well the implementation time may be higher with an ECC, depending on the variant adopted.

Disadvantages over an ECC

The greatest disadvantage of an EU ETS if implemented without a BTA is its negative impact on the competitiveness of European industry and the ensuing carbon leakage. With an ECC, a level playing field ensures that charge rates higher than current EU ETS prices are feasible. Analysts deem it unlikely that the EU ETS can attain prices higher than € 50/tonne CO_2 eq. without political pressure to accommodate initiatives that would lower costs for internationally operating companies (see e.g. (Lewis, 2018)). This means an EU ETS cannot achieve the same level of climate change mitigation as would be feasible with an ECC.

In the current EU ETS, compliance is monitored by the EU. If the ETS were to be expanded to also include foreign producers (e.g. through a BTA), the question arises who would monitor producers abroad and decide how much carbon the industries may produce? Furthermore, as the EU ETS is not a tax but a cap-and-trade scheme, it is impossible to impose a border *tax* adjustment. Rather, applying ETS to foreign producers would imply the imposition of requirements on imported products to be produced according to the EU ETS. The case of aviation under the EU ETS highlights the difficulty, as general international law precludes countries from applying and enforcing their own laws in other countries. When it was announced that all flights arriving in and departing from the EU would be included in the EU ETS, the USA enacted the European Union Emissions Trading Scheme Prohibition Act of 2011, which prohibits US carriers from participating in the ETS. China threatened with a similar act. Ultimately, this resulted in only intra-EEA flights falling under the scope of the EU ETS.

A second major disadvantage is that implementing an EU ETS with BTAs is likely to be legally challenging. This was identified by (Quick, 2011), who investigated whether or not the ETS could be extended based on the Future Allowance Import Requirement (FAIR), a drafted legislative text on how to extend the ETS to imports (although it was not incorporated in the Commission's final proposal). Under FAIR not all imports would be subject to BTA adjustments. Only imports from countries that have not introduced a comparable emission trading system or that have not taken comparable emission reduction actions would be subject to BTAs. (Quick, 2011) concludes that such BTAs would probably be considered WTO-incompatible, despite many political statements about GATT-compatibility. What sets the ECC apart from the ETS is that the latter is levied at installation level, rather than product level, and that it is not a clear direct tax. Both these aspects imply that a different conclusion could be reached for an ECC.

Other disadvantages of the EU ETS over an ECC are that:
- it does not lead to cost-efficient CO_2 eq. emission reduction in the supply chain, since it only targets emissions located within the EU
- it does not influence production outside the EU
- it does not provide insight into products' carbon footprints.

4.2.2 Subsidies

Subsidies can be awarded to firms implementing measures to reduce carbon emissions. The subsidy scheme we envision has the same scope as an ECC. This means that all sectors and all GHG emissions fall under the subsidy scheme and that subsidies are granted to measures reducing GHG emissions in the most cost-efficient manner in the entire economy.

Advantages over an ECC

The greatest advantage of subsidies over an ECC from an industry perspective is that they improve the competitiveness of EU industry compared with non-EU counterparts. Furthermore, the continuous costs for industry (in applying for subsidies) are likely to be lower than those associated with an ECC.

Comparable with an ECC

Since a subsidy scheme can improve the competitiveness of EU industry, other countries may retaliate, by creating trade barriers or matching subsidies, for example. Under an ECC scheme retaliation is also possible.

Disadvantages over an ECC

Given the imperfect information flow between government and industry it is almost impossible to set subsidies at the level needed to ensure that costs are covered but there is no oversubsidisation. Oversubsidising can lead to technological lock-in for technologies originally intended to be merely transitional. Overall, subsidies are arguably not the most cost-efficient way to reduce emissions.

In principle, all sectors can be included in a subsidy scheme. An all-encompassing scheme will take a significant time to implement (especially if serious attempts are made to determine the cost-effectiveness of measures) as well as involving continuous costs for government to monitor and evaluate the scheme. In these respects it is likely to be more costly than an ECC.

Other disadvantages of subsidies over an ECC are:
- subsidies do not influence production outside the EU
- subsidies do not generate insight into products' carbon footprint
- subsidies do not adhere to the polluter-pays principle, since the government (and thus indirectly the tax payer) rather than the end-consumer pays for the pollution.

4.2.3 Carbon tax

The carbon tax considered here is a tax levied at the location where the carbon is emitted (source taxation), with the same scope as an ECC. This means that a carbon tax is levied at every plant where direct greenhouse gas emissions occur.

Advantages over an ECC

A carbon tax has three advantages over an ECC. First, there is no risk of retaliation (via trade barriers, for instance), since a carbon tax (without a BTA) influences only the European market.

Second, in principle all sectors can be included under a carbon tax. Such a tax will require significant implementation time as well as substantial continuous costs for companies and governments for an extensive MRV scheme, although both may be lower than for an ECC, depending on the variant adopted.

Third, the risk of fraud is likely to be lower for a carbon tax than for an ECC because no BTAs are involved, which means there is no possibility of tax reclamation.

Disadvantages over an ECC

The biggest disadvantage of a carbon tax (as described in the introduction) is that without BTAs it will have a negative impact on the competitiveness of European industry.
Other disadvantages of a carbon tax over an ECC are:
- it does not lead to cost-efficient carbon emission reduction in the supply chain, since it only targets emissions within the EU
- it does not influence production outside the EU
- it does not create insight into the products' carbon footprints.

4.2.4 Energy tax

The energy tax considered here is levied at the location where the energy is produced (source taxation). This differs from the energy tax currently in force in the Netherlands and Sweden, where taxation occurs at the point of redistribution and sale of e.g. electricity.

Advantages over an ECC

The advantage of an energy tax over an ECC is that there is no risk of retaliation. Since an energy tax (without a BTA) influences only the EU market, there is no risk of retaliation from other countries by means of trade barriers, etc.

Disadvantages over an ECC

The biggest disadvantage of an energy tax is that not all carbon emissions within the EU originate from energy use. There are numerous direct emissions such as methane from agriculture and CO_2 emissions from calcination that are not associated with fossil fuel use for energy production. The envisioned ECC does include these emissions. An energy tax is therefore not comparable in scope to an ECC.

An energy tax can be extended to imported energy, too. Sweden, for instance, taxes importers, distributors and large consumers of fuel according to the tonnage of carbon produced in their combustion plant. A similar logic would apply to an electricity tax, provided it is not levied at the point of production but at the point of redistribution or sale. Since the tax is only levied when it is sold to the end-consumer, no BTA is necessary. However, if an energy tax is levied at the location where the energy is produced, a BTA would be necessary for imported products in order to create a level playing field. Such a BTA would not in line with WTO agreements because an energy tax is not taxed at product level.

Other disadvantages of an energy tax over an ECC are:
- it does not lead to cost-efficient carbon emissions reduction, as it only targets emissions within the EU and excludes non-energy related emissions
- it does not influence production outside the EU
- it does not create insight into products' carbon footprint.

4.3 Conclusions

An energy tax is not comparable in scope to an ECC nor to any of the other policy instruments considered, since it only includes GHG emissions related to energy use. We therefore only compare the ECC to policy instruments that are (theoretically) comparable in scope.

Comparing an ECC with the other instruments, we can conclude it has advantages as well as disadvantages. These can be summarised as follows:

1. Given the scope for imposing BTAs (for both imports and exports of goods and services) the ECC has the advantage of maintaining a level playing field for EU industry, while also having an impact beyond EU borders. The disadvantages that come with a BTA are the longer implementation time compared with the other policy instruments and the associated continuous costs for monitoring tax adjustments and setting SPEFs (also to prevent fraud). Furthermore, there is a risk of retaliation, which is less likely under an EU ETS+ or an EU-wide carbon tax.
2. Because the ECC imposes a charge on GHG emissions throughout the supply chain, it has the benefits of cost-efficient GHG emission reduction while adhering to the polluter-pays principle. The disadvantages accompanying these benefits are the longer implementation time compared with the other instruments and the high continuous costs for the MRV of the CO_2 footprint per product.

5 Implementation of an ECC

There are three options available for implementing an ECC, as shown schematically in Figure 9. On this page we first summarise the three options and then continue after the figure by describe the various constituent steps outlined in the figure.

5.1 Option 1: As a product-labelling scheme

One way to implementing the ECC concept, perhaps initially, is as a voluntary labelling scheme, in line with European developments like the EU Ecolabel and the Product Environmental Footprint pilots. The benefit of this voluntary option is that consumers will have access to information on the carbon footprint of their purchases and allow them to improve their behaviour accordingly without burdening companies and governments with a taxation system. Product-labelling can be:
- combined with a ‘CO_2 bank’ (Option 1a)
- introduced on its own (Option 1b).

in Option 1a there would be a ‘CO_2 bank’ to which companies and individual consumers could voluntarily pay the ECC to compensate for their greenhouse gas emissions. The appropriate ECC would be indicated on product labels. The bank would then invest the incoming ECC in local initiatives to reduce emissions, such as solar panels. Such CO_2 banks already exist in the Dutch provinces of Utrecht and Zuid-Holland.

A relevant question here is whether or not product-labelling, as a simple information stream, indeed changes consumer behaviour. Unfortunately, this is far from clear. An earlier (non-public) analysis by CE Delft shows that the willingness-to-pay reported by consumers for sustainably labelled products is significantly greater than the actual market shares of these products. In this context, see for example (Kahneman, et al., 1990).

5.2 Option 3: As a sustainable procurement tool

Implementation of the ECC concept as a sustainable procurement tool is a second voluntary route. In this option the government could specify that in all public tendering the sustainability aspect ‘climate change’ must be duly taken into account. The benefit of introduction like this is that all government agencies and semi-government bodies would apply the method in the same way without burdening each individual company with an ECC.

The decision as to how to weigh climate change impact relative to the basic price can be pre-set on the basis of a minimum price per CO_2 equivalent based on SPEFs. In the latter case the virtual price on which the tender will be awarded is calculated as follows.

€ virtual price = € basic tender price + € / tonne CO_2 eq. * tonne CO_2 eq. of tender.

5.3 Option 2: As a charge

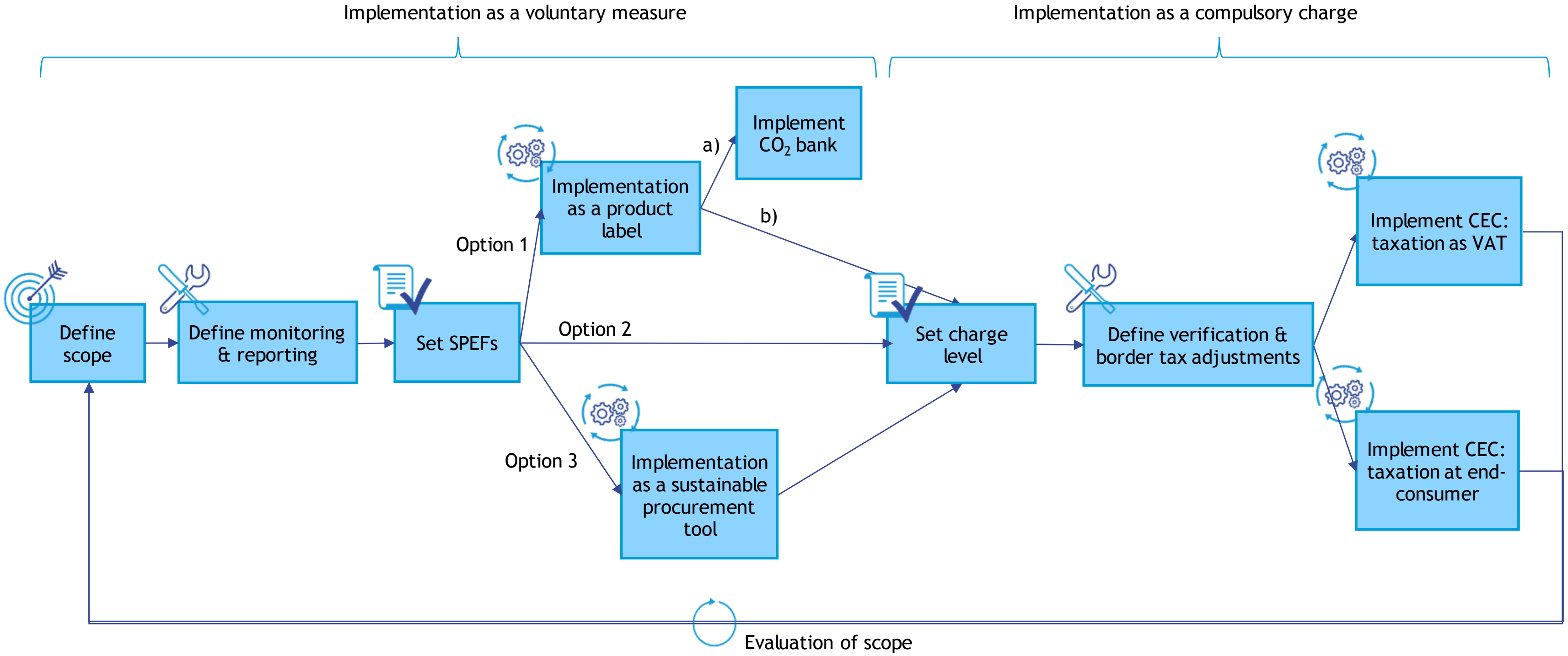
An ECC could also be implemented without it first being introduced voluntarily, since there are two possible downsides to voluntary measures:

1. The overall implementation process may take longer when carried out in two phases.
2. The voluntary measures, which can be seen as a test phase, do not have the same influence on all the (industrial) sectors within the scope of the instrument[13].

Figure 9 shows the various options for implementing the ECC concept. If it is rolled out as a compulsory charge, it can either be paid and collected by all the companies in the supply chain, which settle it as they do VAT, or the upstream companies only register the carbon added, with only the charge only being collected by the retailer selling the product to the end consumer. The latter option significantly limits the burden on a large number of the companies in the supply chain as well as the potential for fraud.

[13] The bulk of the carbon associated with government procurement derives from infrastructure and energy. The chemical industry and agricultural sector are therefore scarcely targeted by this measure.

Figure 9 - Options for implementing the CEC concept



SPEF = Standard Product Environmental Footprint.

Textbox 4 - Sustainable procurement: the case of the N470 and N211

One illustration of sustainable procurement are the European tenders for the N470 and N211: two roads in the province of Zuid-Holland. Traffic growth meant that both roads needed to be renewed and it was decided that this work should help improve the local environment by implementing new and innovative (technological) solutions to reduce the impact of construction, use and maintenance. In the study phase of the tender processes a baseline measurement was therefore carried out using the DuboCalc software package to quantify the impact of road construction and maintenance on climate change (CO_2 eq. emissions).

The awarding of the contract was based on four (qualitative) criteria, in addition to price: CO_2-neutrality, visibility of innovations, intention to scale up and exemplary test case. In the case of the N211 these award criteria accounted for 75% of the total rating. Companies needed to calculate to what extend their proposal was CO_2-neutral. With the N470 all companies were 150% CO_2-neutral (providing 50% more energy than consumed during construction and maintenance) and consequently this criterion played only a minor role in the decision.

Even though a CO_2 eq. price was not used in the assessment criteria, the N470 and N211 tender processes illustrate how sustainable procurement based on an ECC might be applied.

Implementation steps

The geographical boundaries of an initial iteration of an ECC and which industries to include are issues that will need defining in the scoping phase. It may be best to start with a limited scope in either or both respects, i.e. a limited geographical region and/or a limited number of sectors. One drawback of applying the ECC to a limited number of sectors, though, is that the idea of including the carbon emissions all the way down the supply chain is lost. If this option is chosen it is therefore recommended to start with sectors that have high Scope 1 and 2 emissions (as a percentage of total emissions embodied in the end-product), such as the iron, steel or cement industry. This approach is recommended in order to better observe the impact of an ECC. For these sectors the ECC could then replace the EU ETS.

If the ECC concept is introduced as a voluntary measure, no verification method or settling procedure is required. However, a calculation method will still need to be specified to ensure that every company included in the scope follows the same monitoring procedure. How reporting and inclusion of carbon footprints in a public tender or on a label (the reporting) are to be carried out will also need to be defined.

For all companies unable to provide information on certain steps in the life cycle of their product, a standard product environmental footprint (SPEF) can be used. These SPEFs will need to be defined in the case of voluntary ECC schemes, too. To move towards full-scale implementation of the ECC, a compensation rate, verification scheme (to complete the MRV procedure) and border tax adjustments will need defining.

Revenues

If there is full-scale implementation of an ECC, the question arises what the ensuing revenues are to be used for. The ECC is based on the polluter-pays principle and aims to facilitate calculation of the investment costs of green technology so these can be included in the market price of products. This means that companies are supported, but a burden is placed on consumer-citizens.

While the use of ECC revenues is beyond the scope of this study, there are a number of options available, some of which would provide a degree of compensation to consumers. Revenue use would also have to duly allow for diminishing income over time, as carbon emissions decline.

The options include:
- subsidies for sustainable household heating and cooling[14]
- investments in climate change adaptation measures
- subsidies for the 'unprofitable component' of technologies that cannot be financed with the ECC charge level adopted
- recycling the revenues to lower VAT.

[14] The transition to sustainable heating is estimated to cost Dutch households € 1,000/year more than conventional heating. With 7.8 million households this amounts to € 7.8 billion/year. The estimated revenue from an ECC implemented in the Netherlands on all greenhouse gases ranges from € 6 billion (€ 25/t CO_2 eq.) to € 60 billion (€ 250/t CO_2 eq.), a similar order of magnitude to these costs.

6 Conclusions

An External Costs Charge has a number of advantages compared with other climate policy instruments (EU ETS, energy tax, carbon tax). These include:

1. A level playing field for (European) industry, preventing carbon leakage.
2. Cost-efficient carbon emissions reduction, by allowing flexibility as to where in the supply chain the greatest emissions reduction can be achieved at lowest cost.
3. The ability for industry to pass on the cost of emissions reduction to the final consumer, implying that the instrument adheres to the polluter-pays principle.
4. The impact going beyond EU borders and is likely to result in emission cuts in non-EU countries as well.
5. The informative function by giving insight into products' carbon footprint.
6. The possibility to encompass all EU carbon emissions.

These advantages come with the disadvantages that an ECC may take longer to implement than the possible alternatives and have higher continuous costs (monitoring, reporting and determining standard product environmental footprints).

However, several variants of the ECC are feasible that differ in their implementation time, administrative costs (for industry as well as government) and susceptibility to fraud. The two main variants identified in this study are:

- an ECC modelled after VAT, i.e. charged at every step in the supply chain
- an ECC charged only by the firm selling to the final consumer.

All in all, we conclude that the ECC has many advantages as a policy instrument but with several drawbacks that will require further study. There are two routes to implementing an ECC: initial roll-out as a voluntary instrument, or immediate roll-out as a mandatory charge. A mandatory ECC appears to be possible both nationally in the Netherlands and across the EU. Both the voluntary and mandatory pathway will need to be explored further in the future. For the mandatory ECC we propose starting that exploration by considering implementation in the Netherlands.

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A Impact of an ECC on product prices

This appendix reviews the percentage impact of an ECC on the consumer price of an illustrative range of consumer products at three charge levels: € 25, 100 and 250 per tonne CO_2 equivalent. It is to be noted that the percentage price rise is highest when the product's carbon content is relatively high compared with its present price. This holds on the one hand for products generally having a relatively high carbon content, such as animal products, and on the other for low-priced products like matches. In most cases producers will take steps to reduce the carbon content and thus the price rise of their products. Most such measures will cost less than € 250/ t CO_2 eq.

Table 19 - Increase in consumer price (excl. VAT) of illustrative products at three different ECC rates

Category	€ 25/tCO$_2$ eq.	€ 100/tCO$_2$ eq.	€ 250/tCO$_2$ eq.
Matches & candles	53%	149%	341%
Butter	20%	61%	144%
Natural gas	37%	83%	176%
Solid & liquid fuels	36%	79%	166%
Electricity	35%	77%	161%
Salad oil	19%	59%	139%
Rice	19%	57%	134%
Petrol, oil for cars & motor cycles	30%	58%	114%
Eggs	16%	44%	101%
Meat products not otherwise specified	15%	43%	99%
Cream	15%	40%	91%
Nuts	14%	39%	89%
Fish	14%	39%	89%
Calorgas & propane gas	28%	48%	89%
Animal pets	28%	47%	86%
Cheese	14%	36%	81%
Fruit & vegetable juices	14%	36%	81%
Frying fats	13%	35%	79%
Potatoes & tomatoes	12%	30%	66%
Milk	12%	30%	66%
Dried vegetables	12%	29%	64%
Apples	12%	29%	64%
Onions	12%	28%	61%
Frozen vegetables	12%	28%	61%
Chocolate spreads	12%	28%	61%
Margarine	11%	27%	59%
Ready-to-use meat dishes	11%	27%	59%
Yoghurt	11%	27%	59%
Wheat-meal	11%	27%	59%
Potato-flour & starch	11%	27%	59%
Spinach	11%	27%	59%

Category	€ 25/tCO_2 eq.	€ 100/tCO_2 eq.	€ 250/tCO_2 eq.
Cacao	11%	27%	59%
Carrots, endive & lettuce	11%	26%	56%
Pears, melons & oranges	11%	26%	56%
Cake, biscuits & pastries	11%	26%	56%
Toys	25%	35%	56%
Grapes, mandarins, cherries, peaches & bananas	11%	25%	54%
Sugar	11%	25%	54%
Bacon, ham & poultry	11%	25%	54%
Pottery & glassware	24%	34%	54%
Toilet paper	24%	34%	54%
Indoor plants & cut flowers	11%	24%	51%
Bread	11%	24%	51%
Sprouts & green beans	11%	24%	51%
Salt, spices & condiments	11%	24%	51%
Berries & raspberries	11%	24%	51%
Jams & marmalades	11%	24%	51%
Confectionery	11%	24%	51%
Men's shoes	24%	33%	51%
Infant & baby footwear	24%	33%	51%
Cauliflower	10%	23%	49%
Ice cream	10%	23%	49%
Ladies' shoes	24%	32%	49%
Blankets	24%	32%	49%
Detergents	24%	32%	49%
Other non-alcoholic beverages	10%	22%	46%
Board games	24%	31%	46%
Sheets & pillow-cases	24%	31%	46%
Refrigerators & freezers	24%	31%	46%
Lamps & armatures	24%	31%	46%
Sports goods	24%	31%	46%
Musical instruments	24%	31%	46%
Televisions & radios	24%	31%	46%
Bicycles	24%	31%	46%
Honey	10%	21%	44%
Coffee & tea	10%	21%	44%
All-inclusive holiday trips	23%	30%	44%
Clocks	23%	30%	44%
Sailing boats & motorboats	23%	30%	44%
Washing machines & tumble driers	23%	30%	44%
Clothes	23%	29%	41%
Jewellery & watches	23%	29%	41%
Mattresses	23%	29%	41%
Sanitary towels	23%	29%	41%
Cars	23%	29%	41%
Beer	23%	29%	41%
Cosmetics & perfumes	23%	28%	39%
Mopeds, motorcycles & scooters	23%	27%	36%
Wine	23%	27%	36%
Cigars	22%	26%	34%
Mineral & soda water	9%	17%	34%

Category	€ 25/tCO_2 eq.	€ 100/tCO_2 eq.	€ 250/tCO_2 eq.
Cigarettes	22%	25%	31%
Telephones	22%	25%	31%
Newspapers & weekly papers	9%	16%	31%
Freight services	3%	12%	30%
Tapped Water	8%	15%	29%
Driving lessons	22%	24%	29%
Spirits & liqueurs	22%	24%	29%
Chiropodists, manicurists & beauty salons	22%	24%	29%
Postal expenses	22%	23%	26%
Sports club contributions	8%	14%	26%
Beverages in restaurants, etc.	8%	13%	24%
Meals, delivered & take-away	8%	13%	24%
Journals, periodicals & magazines	8%	13%	24%
Taxis	8%	13%	24%
Train & other public transport	8%	13%	24%
Books	8%	13%	24%
Entrance fees for concerts, theatre, etc.	8%	13%	24%
Domestic staff wages	21%	22%	24%
Window-cleaning services, etc.	7%	9%	14%
Hairdressers	7%	9%	14%
Music, dancing & sports lessons	7%	9%	14%
Rent	1%	3%	8%
Babysitting, nurseries, etc.	1%	3%	8%
Course fees	1%	3%	8%
Insurance	0%	2%	5%